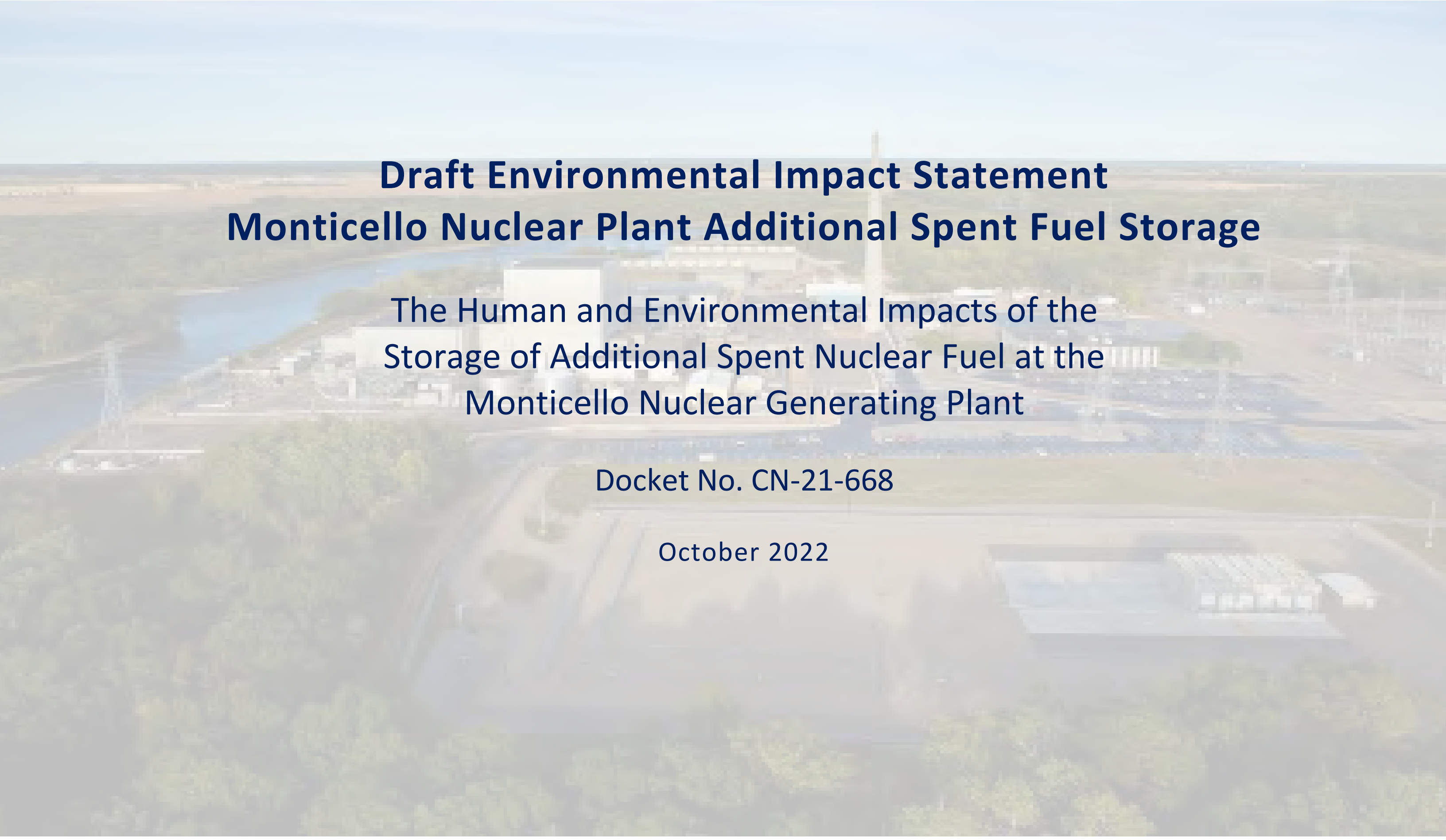

Draft Environmental Impact Statement
Monticello Nuclear Plant Additional Spent Fuel Storage

The Human and Environmental Impacts of the
Storage of Additional Spent Nuclear Fuel at the
Monticello Nuclear Generating Plant

Docket No. CN-21-668

October 2022

COMMERCE
DEPARTMENT

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Abstract

Xcel Energy owns and operates the Monticello nuclear generating plant (MNGP) in Monticello, Minnesota. Spent nuclear fuel from the plant is stored on site in an independent spent fuel storage installation (ISFSI). The Minnesota Public Utilities Commission (Commission) has authorized storage of spent nuclear fuel in the MNGP ISFSI sufficient to allow operation of the MNGP through 2030.

Xcel Energy is now proposing to store additional spent fuel in the MNGP ISFSI sufficient to extend the operating life of the MNGP by 10 years – from 2030 to 2040. This additional storage requires installation of a second concrete support pad within the existing ISFSI. A modular concrete storage system would be placed on the new pad. The spent nuclear fuel would be stored in steel canisters, with the canisters then being placed in the concrete storage system.

Xcel Energy's proposed additional storage of spent nuclear fuel in the MNGP ISFSI requires a certificate of need (CN) from the Commission. Xcel Energy applied to the Commission for a CN on September 1, 2021. To aid the Commission in its decision-making, the Minnesota Department of Commerce (Department) must prepare an environmental impact statement (EIS) for the proposed project.

This draft EIS addresses the issues and mitigation measures identified in the Department's scoping decision of March 2, 2022. It evaluates the potential human and environmental impacts of the Xcel Energy's proposed additional storage of spent fuel in the MNGP ISFSI and possible mitigation measures for these impacts.

This draft EIS was issued on October 4, 2022. It has been issued in draft form so that it may be improved by public comment. Comments on the draft EIS will be accepted through November 11, 2022. Comments should be sent by email, facsimile, or U.S. mail to:

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Following the comment period, the draft EIS will be revised to incorporate comments and a final EIS will be issued. The final EIS will be used by the Commission in determining whether to grant a CN authorizing Xcel Energy's proposed additional storage.

Documents related to this project are available on (1) the Department's website: http://mn.gov/commerce/energyfacilities, select *Power Plants* and then *Monticello Nuclear Plant Additional Spent Fuel Storage* and (2) the Commission's website: http://mn.gov/puc, select *eDockets* and enter the year (21) and docket number (668) and select *Search*.

This document can be made available in alternative formats (i.e., large print or audio) by calling 651-539-1530 (voice).

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Acronyms and Abbreviations

BRC	Blue Ribbon Commission
CFR	U.S. Code of Federal Regulations
CISF	Consolidate Interim Storage Facility
cfs	Cubic Feet per Second
CN	Certificate of Need
Commission	Minnesota Public Utilities Commission
CTV	Cask Transportation Vehicle
Department	Minnesota Department of Commerce
DNR	Minnesota Department of Natural Resources
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DTS	Dry Transfer System
EERA	Department of Commerce Energy Environmental Review and Analysis
EIS	Environmental Impact Statement
ISFSI	Independent Spent Fuel Storage Installation
MnDOT	Minnesota Department of Transportation
MNGP	Monticello Nuclear Generating Plant
MPCA	Minnesota Pollution Control Agency
mrem	Millirem
MRS	Monitored Retrievable Storage
MW	Megawatt
NDT	Nuclear Decommissioning Trust Fund
NRC	Nuclear Regulatory Commission
NTSF	National Transportation Stakeholders Forum
NUREG	U.S. Nuclear Regulatory Report
NWPA	Nuclear Waste Policy Act
PIC	Pressurized Ion Chamber
RGU	Responsible Governmental Unit
SHPO	State Historic Preservation Office
TLD	Thermoluminescent Dosimeter
USACE	U.S. Army Corp of Engineers
USFWS	U.S. Fish and Wildlife Service
WCR	Waste Confidence Rule

Summary

Xcel Energy owns and operates the Monticello nuclear generating plant (MNGP) in Monticello, Minnesota. Spent nuclear fuel from the plant is stored on site in an independent spent fuel storage installation (ISFSI).

Xcel Energy is requesting to store additional spent fuel in the MNGP ISFSI sufficient to extend the operating life of the MNGP by 10 years – from 2030 to 2040. This additional storage requires installation of a second concrete support pad within the existing ISFSI. A modular concrete storage system would be placed on the new pad. The spent nuclear fuel would be stored in steel canisters, with the canisters then being placed in the concrete storage system.

Xcel Energy's proposed additional storage of spent nuclear fuel in the MNGP ISFSI requires a certificate of need (CN) from the Minnesota Public Utilities Commission (Commission). Xcel Energy applied to the Commission for a CN on September 1, 2021. To aid the Commission in its decision-making, the Minnesota Department of Commerce (Department) must prepare an environmental impact statement (EIS) for the proposed project.

Project Need

Xcel Energy indicates that additional storage at the MNGP ISFSI is necessary to support operation of the MNGP through 2040. Xcel Energy believes that operation of the MNGP through 2040 is a reasonable approach to ensuring the adequacy, reliability, and efficiency of Minnesota's energy supply. If the Commission does not grant a CN for additional storage, Xcel Energy would cease operating the MNGP in 2030, and the electrical energy produced by the MNGP would need to be supplied or otherwise accounted for by other means.

Human and Environmental Impacts

This EIS finds that the non-radiological impacts of additional spent fuel storage in the MNGP ISFSI are anticipated to be minimal. The additional storage would occur in a developed, industrial site which avoids and minimizes potential impacts.

The EIS also finds that the radiological impacts of additional spent fuel storage in the MNGP ISFSI are anticipated to be minimal, provided that monitoring and maintenance of the spent fuel storage canisters continues until such time as the spent fuel can be transported to an offsite facility. The radiation dose to the public with additional spent fuel in the MNGP ISFSI is anticipated to be minimal and indistinguishable from background radiation. Further, additional spent fuel storage in the MNGP ISFSI would not change the performance of the ISFSI during accident conditions. Potential radiological impacts to the public under accident conditions would not be significant and would be within NRC standards.

Cumulative Impacts

Cumulative impacts are impacts to the environment that result from the incremental effects of a project in addition to past, present, and reasonably foreseeable future projects regardless of who undertakes these projects. Two projects that are reasonably foreseeable because they are connected to Xcel Energy's request for additional spent fuel storage are discussed in the EIS: (1) continued operation of the MNGP through 2040, and (2) use of the MNGP ISFSI to facilitate decommissioning of the MNGP after cessation of operations in 2040.

The EIS finds that potential impacts to the human and natural environment as a result of MNGP operations through 2040 are anticipated to be minimal. Potential non-radiological impacts are related to use of cooling water from the Mississippi River. These impacts are anticipated to be minimal. Potential radiological impacts are related to regulated releases of radioactive effluents from the MNGP; these impacts are also anticipated to be minimal.

Potential impacts resulting from use of the MNGP ISFSI to facilitate decommissioning are anticipated to be minimal, provided that monitoring and maintenance of the ISFSI continues until such time as the spent fuel can be transported to an offsite facility. If monitoring and maintenance do not continue, radiological impacts are anticipated to be significant.

Alternatives to the MNGP ISFSI

It's possible that the additional spent fuel generated by MNGP operations through 2040 is not stored in canisters within the MNGP ISFSI. The EIS finds that storing additional spent fuel in the existing spent fuel pool is not feasible; storage in a new spent fuel pool is prohibitively expensive and not feasible. Storage of spent fuel in casks within the MNGP ISFSI (rather than canisters) is feasible but more expensive than canisters.

Spent fuel storage in Yucca Mountain, the proposed federal, geologic repository, is not currently feasible. The use of Yucca Mountain as a repository for spent nuclear fuel has been, and continues to be, politically and socially charged. Spent fuel storage in private, consolidated interim storage facilities (CISFs) is not currently feasible. There are currently two CISFs being developed in the United States – one in Texas and one in New Mexico. There are several legal and political challenges to storing spent fuel in the CISFs, and these challenges will likely play out over an extended period of time.

Alternatives to Continued Operation of the MNGP

The Commission could deny Xcel Energy's request for additional storage of spent fuel in the MNGP ISFSI. If the Commission did so, and absent other alternatives for storing the spent fuel, Xcel Energy would cease operating the MNGP in 2030. If the MNGP ceased operation in 2030, Xcel Energy would need to replace the capacity and energy provided by the MNGP in order to maintain reliable operation of the electric transmission system.

Xcel Energy modeled two scenarios for replacing the MNGP in 2030. Both of the replacement scenarios have greater aesthetic and land use impacts than continued operation of the MNGP. Additionally, both scenarios will have relatively greater impacts on fauna, specifically birds and bats. Xcel Energy's modeling indicates that both replacement scenarios are more expensive on a social cost basis and have greater carbon emissions than continued operation of the MNGP.

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1 Introduction

This environmental impact statement (EIS) has been prepared by the Minnesota Department of Commerce (Department) for Xcel Energy's proposed additional storage of spent nuclear fuel in the independent spent fuel storage installation (ISFSI) at the Monticello nuclear generation plant (MNGP) in Monticello, Minnesota.

This EIS evaluates the potential human and environmental impacts of the project and possible mitigation measures. The EIS is not a decision-making document, but rather a guide for decision makers. The EIS is intended to facilitate informed decisions, particularly with respect to the goals of the Minnesota Environmental Policy Act — "to create and maintain conditions under which human beings and nature can exist in productive harmony and fulfill the social, economic, and other requirements of present and future generations of the state's people."[1]

1.1 Background

The MNGP is a 671 megawatt electric generating plant in Monticello, Minnesota. The plant is powered by a boiling water nuclear reactor. The plant has been in operation since 1971. Spent nuclear fuel from the plant is stored on site in the MNGP ISFSI.

The plant is currently licensed by the Nuclear Regulatory Commission (NRC) for operation through 2030. The Minnesota Public Utilities Commission (Commission) has authorized storage of spent nuclear fuel in the MNGP ISFSI sufficient to allow operation of the MNGP through 2030.

1.2 Proposed Project

Xcel Energy is requesting to store additional spent nuclear fuel in the MNGP ISFSI sufficient to extend the operating life of the MNGP by 10 years – from 2030 to 2040.[2] This additional storage requires installation of a second concrete support pad within the existing ISFSI. A modular concrete storage system would be placed on the new pad. Xcel Energy indicates that spent fuel will be stored in steel canisters, with the canisters then being placed in the concrete storage system. Xcel Energy notes that it has not identified a specific canister technology or vendor, and that it will conduct a competitive bidding process to select the technology and vendor.[3] Xcel Energy indicates that the canister technology selected for the project will be licensed for storage and transport by the NRC.[4]

Xcel Energy estimates that approximately 14 additional spent fuel storage canisters (12 to 15 canisters) will be needed for operation through 2040. The exact number of canisters will be determined by the amount of fuel needed to operate through 2040, how much fuel is loaded into the MNGP reactor each fuel cycle, and the number of fuel assemblies that can be stored in the canister that is ultimately selected by Xcel Energy for the project.[5] Xcel Energy notes that the new concrete storage pad and concrete storage system will be able to accommodate approximately 36 canisters without changing the ISFSI size or security perimeter.[6]

1.3 Project Need

Xcel Energy indicates that additional storage of spent fuel in the MNGP ISFSI is necessary to support operation of the MNGP through 2040. Xcel Energy believes that operation of the MNGP through 2040 is a reasonable approach to ensuring the adequacy, reliability, and efficiency of Minnesota's energy supply.[7]

If the Commission does not approve additional storage, and absent other alternatives for storing the spent fuel, Xcel Energy would cease operating the MNGP in 2030. If the MNGP ceased operation in 2030, Xcel Energy would need to employ other means to replace the capacity and energy provided by the MNGP in order to maintain reliable operation of the electric transmission system.

1.4 State of Minnesota Review Process

Xcel Energy's proposed additional storage of spent nuclear fuel in the MNGP ISFSI requires a certificate of need (CN) from the Commission.[8] Xcel Energy applied to the Commission for a CN on September 1, 2021. In considering Xcel Energy's CN application, the Commission must determine whether the proposed project is needed, or whether some other project would be more appropriate for the state of Minnesota, for example, a project of a different type or size, or a project that is not needed until further into the future.

To help the Commission with its decision-making and to ensure a fair and robust airing of the issues, the state of Minnesota has set out a process for the Commission to follow in making a CN decision. This process requires the Department to prepare an EIS for the project. It also requires public hearings before an administrative law judge. The goal of the EIS is to describe the potential human and environmental impacts of the project ("the facts"); the goal of the hearings is to advocate, question, and debate what the Commission should decide about the project ("what the facts mean"). The entire record developed in this process—the EIS and the report from the administrative law judge, including all public input and testimony—is considered by the Commission when it makes its decision regarding Xcel Energy's CN application.

This EIS has been issued in draft form so that it can be improved through public comment. Based on public comments, the Department will prepare and issue a final EIS.

1.5 Organization of EIS

This EIS addresses the issues identified in the Department's scoping decision of March 2, 2022 (Appendix A), and is organized as follows:

Chapter 1	Introduction	Provides an overview of the proposed project, the state of Minnesota's review process, and this EIS.
Chapter 2	Regulatory Framework	Describes the regulatory framework associated with the project, including federal oversight, the Commission's oversight, and environmental review.
Chapter 3	Proposed Project – Additional Spent Fuel Storage	Describes the proposed project, including the MNGP ISFSI and proposed canister system for storing spent fuel.
Chapter 4	Potential Impacts – Non-Radiological	Describes potential non-radiological impacts of the project to human and natural resources and possible mitigation measures.
Chapter 5	Potential Impacts – Radiological	Describes potential radiological impacts of the project to human and natural resources and possible mitigation measures.
Chapter 6	Cumulative Impacts	Describes potential impacts to human and natural resources resulting from operation of the MNGP through 2040 and from using the MNGP ISFSI to decommission the MNGP.
Chapter 7	Alternatives to the MNGP ISFSI	Describes alternatives to the storage of spent fuel in the MNGP ISFSI.
Chapter 8	Alternatives to Continued Operation of the MNGP	Describes alternatives to the continued operation of the MNGP.

1.6 Sources of Information

The primary sources of information for this EIS are:

- Xcel Energy's CN application.
- The scoping environmental assessment worksheet (EAW) prepared for Xcel Energy's proposed additional spent fuel storage in the MNGP ISFSI.[9]
- New and additional information from Xcel Energy regarding its CN application.[10]
- The 2005 Monticello Nuclear Generating Plant ISFSI Final EIS.[11]

All information sources are indicated in chapter endnotes.

Notes

[1] Minnesota Statute 116D.02.

[2] Certificate of Need Application for Additional Dry Cask Storage at the Monticello Nuclear Generating Plant Independent Spent Fuel Storage Installation, Xcel Energy, September 1, 2021, eDockets Numbers 20219-177630-01 (through -10) [hereinafter CN Application].

[3] CN Application, Executive Summary and Chapter 8.

[4] Id.

[5] Id. Xcel Energy estimates that approximately 800 fuel assemblies will need to be stored to facilitate operation of the MNGP through 2040. The number of fuel assemblies and how many assemblies can be stored in each canister will determine the total number of spent fuel canisters required. See Xcel Energy Additional Information Provided to Aid Preparation of Draft EIS, eDockets Number 20229-188940-01 [hereinafter Xcel Energy Additional Information].

[6] Id.

[7] CN Application, Executive Summary and Chapter 4.

[8] Minnesota Statute 116C. 83, Subd. 2.

[9] Scoping Environmental Assessment Worksheet, Monticello Nuclear Generating Plant Independent Spent Fuel Storage Installation Expansion Project, December 27, 2021, eDockets Number 202112-180998-01 [hereinafter Scoping EAW].

[10] Xcel Energy Additional Information.

[11] Monticello Nuclear Generating Plant Independent Spent Fuel Storage Installation Final Environmental Impact Statement, March 2006, CN-05-123, eDockets Number 51145 [hereinafter 2005 Monticello EIS].

2 Regulatory Framework

Xcel Energy's proposed additional storage of spent fuel in the MNGP ISFSI requires review by federal and state regulators. The NRC determines whether on-going and proposed future operation of the MNGP, as well as the storage of spent nuclear fuel in the MNGP ISFSI, can be conducted safely. Xcel Energy must obtain a subsequent license renewal (SLR) from the NRC to continue operation of the MNGP. Additionally, Xcel Energy must notify the NRC of its intention to use an NRC-certified cask in the MNGP ISFSI and must document that use of the cask is consistent with NRC conditions on its use.

On behalf of the state of Minnesota, the Commission determines as an economic and policy matter whether it is in the public interest to allow additional storage of spent nuclear fuel in the MNGP ISFSI to facilitate MNGP operation through 2040. To store additional spent fuel in the MNGP ISFSI, Xcel Energy must obtain a certificate of need (CN) from the Commission.

2.1 Federal Regulation

Federal regulations preempt state regulation of engineering, health, and safety standards applicable to nuclear generating plants and spent nuclear fuel storage. The NRC is responsible for regulating the use of radioactive materials from their source, through their uses, to their storage and disposal. The MNGP and MNGP ISFSI are considered part of the nuclear fuel cycle and are regulated by the NRC.

Subsequent License Renewal

The MNGP received an initial 40-year operating license for the MNGP in 1970. In 2006, the NRC extended the initial operating license for 20 years, allowing operation of the MNGP through 2030. In order to operate beyond 2030, Xcel Energy must request and obtain a license extension, a subsequent license renewal (SLR), from the NRC.

SLRs are available from the NRC solely for terms of 20 years. Thus, if Xcel Energy obtains an SLR for the MNGP, it will allow the MNGP to operate through 2050. Xcel Energy notes that, at the state level, it is asking the Commission for permission to store additional spent fuel to facilitate operation of the MNGP through 2040.[1]

Xcel Energy anticipates that it will submit an SLR application to the NRC in 2023.[2] The application must address the technical aspects of plant aging and describe how these aspects will be managed; it must also address potential environmental impacts of plant operations for another 20 years. The NRC will review the application and evaluate potential safety and environmental issues. The NRC review process will last approximately 18 months. The NRC's review process includes public meetings and opportunities for public comment.

Use of NRC-Certified Canisters in MNGP ISFSI

Xcel Energy has a general license from the NRC to store spent nuclear fuel in the MNGP ISFSI.[3] The license is not tied to a specific storage technology; it allows for the use of any

NRC-certified storage technology as long as the MNGP holds an NRC operating license.[4] Xcel Energy must demonstrate to the NRC that any storage technology used in the MNGP ISFSI can be appropriately deployed, consistent with the conditions and specifications associated with the technology.[5]

Currently, spent nuclear fuel from the MNGP is stored in steel canisters in horizontal concrete vaults on the ISFSI pad (NUHOMS-61BT storage system). Each steel canister holds 61 spent fuel assemblies. There are currently 30 canisters stored in vaults on the ISFSI pad.

Xcel Energy estimates that approximately 14 additional spent fuel storage canisters (12 to 15 canisters) will be needed for operations through 2040. Xcel Energy has proposed that it conduct a competitive bidding process to select the technology and vendor it will use for these additional canisters.[6] Through this process, Xcel Energy may or may not select to continue with its current NUHOMS storage system. Xcel Energy indicates that the canister technology selected for the project will be licensed for storage and transport by the NRC.[7]

Assuming that Xcel Energy conducts a bidding process and selects a canister technology, Xcel Energy must demonstrate that the technology can be properly used in the MNGP ISFSI. Xcel Energy would need to make documentation available to the NRC demonstrating that the technology's use in the MNGP ISFSI would be consistent with the conditions in the canister's NRC certificate of compliance.[8] In addition, Xcel Energy would need to review its security program, emergency plan, quality assurance program, training program, and radiation protection program, and make any necessary changes to incorporate the canister technology into the MNGP ISFSI.[9]

2.2 State Regulation

Storage of spent nuclear fuel in the MNGP ISFSI is regulated by the Commission, whose decisions may be reviewed by the Minnesota Legislature.[10] In order to store additional spent fuel in the MNGP ISFSI, Xcel Energy must obtain a CN from the Commission.[11]

Certificate of Need

In deciding whether to grant a CN, the Commission must determine whether Xcel Energy's proposed project is needed or if another project would be more appropriate for the state of Minnesota. Minnesota Rules part 7855.0120 provides the criteria that the Commission must use in determining whether to grant a CN:

- 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;
- 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;

- 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 CN;
- 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 governments.

If the Commission determines that Xcel Energy has met these criteria, the Commission will issue a CN for the project. The Commission could place conditions on the granting of a CN; likewise, it has discretion to approve the project as proposed or with modifications.[12] If the Commission denied the CN, this would indicate that the Commission believes that not building the project (the "no-build alternative," see Chapters 7 and 8) is a more reasonable and prudent alternative.

Environmental Review

The Minnesota Environmental Policy Act (MEPA) requires that an environmental impact statement (EIS) be prepared for major governmental actions with the potential to create significant environmental impacts.[13] An EIS is intended to facilitate informed decision-making by entities with regulatory authority over a project. It also assists citizens in providing guidance to decision-makers regarding the project. An EIS describes and analyzes the potential human and environmental impacts of a project and possible mitigation measures, including alternatives to the project. It does not advocate or state a preference for a specific alternative. Instead, it analyzes and compares alternatives so that citizens, agencies, and governments can work from a common set of facts.

The Department is the responsible governmental unit (RGU) for conducting environmental review of spent nuclear fuel storage in an ISFSI.[14] The Department is required to prepare an EIS.[15]

This EIS has been issued in draft form so that it can be improved through public comment. Based on public comments, the Department will prepare and issue a final EIS. The Commission will consider the final EIS and the entire record in making a decision on Xcel Energy's CN application.

EIS Scoping

Scoping is the first step in the development of an EIS. Department staff gathered input on the scope of this EIS through public meetings and an associated comment period.

Department staff held a public meeting regarding Xcel Energy's proposed additional storage of spent fuel on January 25, 2022, in Monticello, Minnesota. Five people attended this meeting; one person provided a public comment. The following evening, January 26, 2022, Department staff held a virtual public meeting. Approximately six people attended this meeting; two people provided public comments. Comments addressed the scope of potential impacts that will be analyzed in the EIS and the possible reprocessing of spent nuclear fuel in the United States.

Following the public scoping meetings, written comments were received from the U.S. Army Corps of Engineers (USACE), the Minnesota Department of Natural Resources (DNR), the Minnesota Pollution Control Agency (MPCA) and the city of Monticello. The USACE indicated that the project would not require a USACE permit. The DNR noted the presence of bald eagle nests near the project and recommended that Xcel Energy confer with the U.S Fish and Wildlife Service regarding potential impacts to eagles. The MPCA noted that it had no comments regarding the project at this time. The city of Monticello indicated its support for the project.

The Department issued a scoping decision for the EIS on March 2, 2022 (Appendix A). This EIS has been prepared in accordance with the scoping decision.

Public Hearing

After issuance of the final EIS, public hearings will be held by an administrative law judge (ALJ) from the Office of Administrative Hearings (OAH).[16] The hearings will address the need for the project. At the hearing, citizens, agencies, and governmental bodies will have an opportunity to submit comments, present evidence, and ask questions. Citizens can advocate for or against the granting of a CN; they may suggest conditions that they believe are appropriate should the Commission grant a CN. After the hearings, the ALJ will submit a report to the Commission with findings of facts, conclusions of law, and recommendations regarding a CN for the project.

Commission Decision

After considering the entire record, including the final EIS, input received during the public hearings, and the ALJ's report, the Commission will determine whether to grant a CN for the project. The Commission may grant a CN for the project as proposed, grant a CN contingent upon modifications to the project, or deny the CN. The Commission may also place conditions on the granting of a CN. A decision by the Commission regarding Xcel Energy's CN application is anticipated in summer 2023.

Integrated Resource Plan

Xcel Energy is required to regularly file an integrated resource plan (IRP) with the Commission. A resource plan details the projected need for electricity in a utility's service territory for a forecasted period of time, and the utility's plans for meeting this projected need.[17] The Commission may approve, reject, or modify a proposed resource plan.

Xcel Energy filed its initial 2020-2034 Upper Midwest integrated resource plan in 2019. The company filed a subsequent plan and an alternate plan in 2020 and 2021, respectively.[18] In its alternate plan, Xcel Energy proposed the continued operation of the MNGP through 2040. The Commission approved Xcel Energy's alternate plan, with conditions, on April 14, 2022.[19] Though this approval indicates the Commission's agreement that continued operation of the MNGP through 2040 is an appropriate part of Xcel Energy's resource plan, Xcel Energy must still obtain a CN for its proposed additional storage of spent fuel in the MNGP ISFSI.

Casks That Facilitate Transportation of Spent Fuel

In addition to the requirements for a CN and an IRP, the Minnesota Legislature has directed the Commission to ensure that spent nuclear fuel stored in Minnesota is capable of being transported to offsite storage facilities, when such facilities are available. Minnesota Statute 116C.776 provides, in part:

> If the Public Utilities Commission determines that casks or other containers that allow for transportation as well as storage of spent nuclear fuel exist and are economically feasible for storage and transportation of spent nuclear fuel generated by the Prairie Island nuclear power generating plant, the commission shall order their use to replace use of the casks that are only usable for storage, but not transportation.[20]

The statute's text does not explicitly address spent fuel stored at the MNGP; however, Department staff interprets the statute to express a concern that extends to the MNGP. The canisters currently used in the MNGP ISFSI, the NUHOMS-61BT canisters, are certified by the NRC for transportation.[21] Xcel Energy indicates that any spent fuel storage technology selected in its competitive bidding process for the MNGP ISFSI will also be certified by the NRC for transportation.[22] Thus, all spent fuel storage canisters used in the MNGP ISFSI will allow for transportation of the fuel to offsite storage facilities.

2.3 Other Permits and Approvals

A building permit from the city of Monticello may be required for the project.[23] The city will determine if a permit is needed after plans for the project have been finalized.[24]

2.4 Issues Outside the Scope of this EIS

In accordance with the scoping decision for this EIS (Appendix A), the following topics are not addressed in this document:

- The appropriateness of NRC regulations for spent nuclear fuel storage technology.
- Potential impacts associated with the nuclear fuel cycle.
- Potential impacts associated with the transportation of spent nuclear fuel from the MNGP ISFSI.

- ISFSI sites outside the MNGP plant boundary. The Commission's authority is limited to the storage of spent nuclear fuel generated by a Minnesota nuclear generation facility and stored on the site of that facility.
- Economic analysis of generation alternatives. Economic analysis in the EIS will be limited to alternatives discussed in Xcel Energy's CN application.
- The appropriateness of NRC regulations and standards for radiation exposure. The EIS may reference certain standards promulgated by the NRC; however, the EIS will not address the adequacy of these standards.

Notes

[1] CN Application, Executive Summary. Any additional spent fuel storage for operation beyond 2040 would require a CN from the Commission.

[2] CN Application, Chapter 3.

[3] Xcel Energy Additional Information.

[4] Id.

[5] Spent Fuel Storage Licensing, NRC, https://www.nrc.gov/waste/spent-fuel-storage/licensing.html.

[6] CN Application, Executive Summary and Chapter 8.

[7] Id.

[8] 10 CFR 72, Subpart K; Spent Fuel Storage Licensing, NRC, https://www.nrc.gov/waste/spent-fuel-storage/licensing.html.

[9] Id.

[10] Minnesota Statute 116C.83, Subd. 3.

[11] Minnesota Statute 116C.83, Subd. 2.

[12] For example, as a condition of granting a CN, the Commission could require Xcel Energy to file the results of its competitive bidding process for spent fuel technology with the Commission. See Department Comments Regarding a Change in Spent Fuel Storage Technology at the Prairie Island Nuclear Generating Plant, June 24, 2022, Docket No. E-002/CN-08-510, eDockets Number 20226-186862-01.

[13] Minnesota Statute 116D.04.

[14] Minnesota Statute 116C.83, Subd. 6(b)

[15] Id.

[16] First Prehearing Order, Office of Administrative Hearings, May 19, 2022, eDockets Number 20225-185920-01.

[17] Minnesota Statute 216B.2422; Minnesota Rules 7843.

[18] Order Approving Plan with Modifications and Establishing Requirements for Future Filings, April 15, 2022, Docket No. E-002/RP-19-368, eDockets Number 20224-184828-01.

[19] Id.

[20] Minnesota Statute 116C.776.

[21] CN Application, Chapter 8.

[22] Id.

[23] Scoping EAW, Section 9.

[24] Xcel Energy Additional Information.

3 The Proposed Project – Storing Additional Spent Nuclear Fuel

To store additional spent nuclear fuel in the MNGP ISFSI, Xcel Energy proposes to install a second concrete support pad within the existing ISFSI. Xcel Energy would conduct a competitive bidding process to select storage technology that would be used in the ISFSI. Xcel Energy would select an NRC-certified steel canister to hold the spent fuel, with the canisters housed in a concrete storage system in the ISFSI. Xcel Energy estimates that approximately 14 additional spent fuel storage canisters (12 to 15 canisters) will be needed for operation through 2040.

3.1 Monticello ISFSI

The MNGP is located on the western bank of the Mississippi River in Wright County within the city limits of Monticello, Minnesota. The MNGP site is owned by Xcel Energy and consists of approximately 2,150 acres.[1] The MNGP ISFSI is located about 500 feet west of the plant (Figure 1). The spent fuel storage area within the ISFSI is approximately 460 feet long and 200 feet wide.[2] Two fences surround the facility with a monitored, clear zone between the fences.[3] The site is monitored with cameras and other security devices. Within the ISFSI, spent fuel canisters are stored in a concrete storage system on a reinforced concrete pad.

Figure 1. Monticello Nuclear Generating Plant and ISFSI[4]

3.2 Installation of a Second Concrete Support Pad

Xcel Energy proposes to install a second concrete support pad within the MNGP ISFSI (Figure 2). When the ISFSI was initially constructed, the area proposed for the second concrete support pad was excavated, filled with 48 inches of a granular base, and then covered with 30 inches of Class 6 gravel.[5] These preparations were made in anticipation of expanded storage of spent nuclear fuel within the ISFSI.

To construct a second concrete support pad, Xcel Energy would first remove the 30 inches of Class 6 gravel at the pad location.[6] Xcel Energy would then conduct soil testing to confirm soil conditions. The concrete support pad would then be poured – a 30 inch thick concrete pad.[7] The pad would abut the exiting support pad and be separated from the pad by an expansion joint.[8]

Concrete approach aprons and asphalt drive surfaces would provide access to the pad.[9] For these surfaces, only 15 inches of Class 6 gravel would be excavated.

Figure 2. Proposed Second Concrete Support Pad Within Existing MNGP ISFSI

3.3 Selection and Use of a Spent Fuel Storage Canister System

Spent nuclear fuel is highly radioactive and must be properly handled and stored. All spent fuel storage technology must be certified by the NRC and meet NRC design criteria.[10] Among other criteria, spent fuel technology must: (1) contain the radioactive material so that it is not a danger to persons or the environment, and (2) provide radiation shielding so that radiation does not pose an undue danger to persons nearby (Appendix B).

The NRC has certified several technologies for spent nuclear fuel storage (Table 1). NRC-certified storage technologies generally take two approaches to containment and shielding – (1) an all-in-one metal cask that provides containment and shielding, or (2) a two-part system consisting of a metal canister that contains the spent fuel and a concrete overpack that provides radiation shielding (canister system).

Table 1. Technologies Certified by the NRC for Storage of Spent Nuclear Fuel[11]

Manufacturer	Design Model
Westinghouse Electric Co. LLC	VSC-24
Orano (TN Americas LLC)	NUHOMS®-24P, NUHOMS®-52B, NUHOMS®-61BT, NUHOMS®-32PT, NUHOMS®-24PHB, NUHOMS®-24PTH, NUHOMS®-32PTH1, NUHOMS®-37PTH, NUHOMS®-61BTH, NUHOMS®-69BTH
Holtec International	HI-STAR 100
Holtec International	HI-STORM 100
Holtec International	HI-STORM FW
Holtec International	HI-STORM UMAX
Orano (TN Americas LLC)	TN-32
NAC International, Inc.	NAC-UMS
NAC International, Inc.	NAC-MPC
Westinghouse Electric Co. LLC	FuelSolutions
Orano (TN Americas LLC)	TN-68
Orano (TN Americas LLC)	Advanced NUHOMS®-24PT1, Advanced NUHOMS®-24PT4
Orano (TN Americas LLC)	NUHOMS®-HD-32PTH
NAC International, Inc.	MAGNASTOR
Orano (TN Americas LLC)	NUHOMS® EOS

Xcel Energy has indicated that it will conduct a competitive bidding process to select a canister system for the MNGP ISFSI. Xcel Energy will not solicit bids for a cask technology. Thus, the discussion here focuses solely on canister systems for spent fuel storage.

Canister systems use canisters – large stainless steel vessels, approximately one-half to one inch thick – to contain spent fuel (Figure 3). Spent fuel assemblies are place in a canister, and then the canister is welded shut. Two lids are welded in place for a redundant seal.

Figure 3. Spent Fuel Canister – End View with Basket for Spent Fuel Assemblies

Sealed canisters are then placed in a vertical or horizontal concrete overpack. Vertical canister systems use a thick-walled concrete cylinder to provide radiation shielding (Figure 4). A gap between the canister and concrete overpack facilitates airflow for heat removal. Openings in the concrete cylinder at the top and bottom allow air convection to aid cooling.

Horizontal canister systems place sealed canisters in a rectangular concrete module (Figure 5). Canisters are place in the module like letters in a mail slot. Similar to vertical systems, air ducts are provided to allow air convection to remove heat.

Vertical concrete overpacks and horizontal concrete modules can be pre-fabricated or constructed on-site. Vertical concrete overpacks are generally constructed on site due to challenges in transporting them. The horizontal concrete module used in the MNGP ISFSI was fabricated off-site and assembled in the ISFSI.[12]

Figure 4. Vertical Canisters in Concrete Overpack

Figure 5. Horizontal Canisters in Concrete Module

The MNGP ISFSI currently uses a horizontal canister system – the NUHOMS-61BT canister system.[13] In this system, 61 fuel assemblies are loaded into each canister. Each canister weighs about 45,400 pounds empty and 88,400 pounds when loaded with spent fuel.[14] The canisters are then stored horizontally in a concrete storage module in the MNGP ISFSI. Each vault in the storage module is 10 feet wide, 10 feet high, and 20 feet long.[15] Thus, each vault resembles a shortened tractor trailer (see right-hand side of Figure 2). There are currently 30 canisters in concrete vaults in the MNGP ISFSI.

Though the MNGP ISFSI currently uses a horizontal canister system, Xcel Energy could select a vertical or a horizontal canister system for additional spent fuel storage in the ISFSI. The second concrete support pad in the ISFSI could hold up to 36 canisters using the current NUHOMS-61BT system.[16]

Xcel Energy estimates that it will need to store approximately 800 spent fuel assemblies in the MNGP ISFSI to facilitate operation of the MNGP through 2040.[17] Depending on this number and the number of fuel assemblies that can be stored in each canister selected by Xcel Energy for use in the ISFSI, approximately 14 canisters (12 to 15 canisters) will be required for operation of the MNGP through 2040. If Xcel Energy selects a system similar to the existing NUHOMS-61BT system, this would leave space on the second support pad equivalent to about 22 vaults in a concrete storage module.

3.4 Handling Spent Fuel Canisters

Spent nuclear fuel is initially stored in a spent fuel pool at a reactor site. Storing the spent fuel in a water-filled pool allows the fuel to cool, both thermally and radioactively. After cooling for several years, the spent fuel is loaded into a canister for transport to the ISFSI pad.

Loading of a spent fuel canister begins with lowering the canister into the spent fuel pool (Appendix C). It's not possible to lower a concrete overpack into the pool as well; thus, a transfer cask (a temporary metal overpack) is used to maneuver the canister and provide radiation shielding (Figure 6).[18] Once the fuel assemblies are loaded, a first canister lid is put in place. The lid is not welded underwater; rather, the cask is removed from the spent fuel pool, decontaminated, and dried, and then the lid is welded into place.[19] The canister is filled with helium; after filling, a second lid is welded into place. Welding is performed by an automated welding machine. The canister lid welds are inspected using non-destructive testing methods to ensure the quality of the welds.[20]

To move a loaded canister to its concrete overpack, the transfer cask is again used. The transfer cask facilitates movement of the canister and provides shielding until shielding can be provided by the concrete overpack. The transfer cask for the NUHOMS-61BT is constructed from two concentric steel shells.[21] The space between these shells is filled with lead to provide gamma radiation shielding.[22] The cask also includes an outer stainless steel jacket that is filled with water for neutron radiation shielding.[23]

Figure 6. Canister and Transfer Cask Being Decontaminated

For vertical canister systems, the canister is transferred from its transfer cask to a concrete overpack. The entire package – canister plus concrete overpack – is moved to the ISFSI pad using a specialized crawler (Figure 7).

For horizontal canister systems, the canister is moved to the ISFSI while still in the transfer cask. The canister is aligned with an opening in the concrete storage module (Figure 8). The canister is then pushed, using a hydraulic ram, into the storage module vault and a shielding door is bolted into place.

Figure 7. Canister and Vertical Concrete Overpack on ISFSI Pad

Figure 8. Canister Being Placed in Horizontal Concrete Storage Module

3.5 Monitoring and Maintenance of Spent Fuel

Spent fuel canisters and their concrete overpacks, both vertical and horizontal, require monitoring and periodic maintenance to ensure their safe operation. All ISFSIs must have a radiation monitoring program to verify radiation levels are below regulatory limits and that radiation shielding does not deteriorate over time.

Canisters rely on air flow around the canister for cooling and therefore typically require routine monitoring to ensure the airflow is not degraded due to blockage of the inlet or outlet vents. This is accomplished either by routine visual inspection or by monitoring of the outlet air temperature.

3.6 Project Schedule and Costs

Xcel Energy estimates that installation of a second concrete support pad within the ISFSI and the construction of vertical concrete overpacks or horizontal concrete vaults would take approximately six months.[24] Xcel Energy notes that this construction would occur in a 2026-2027 timeframe.[25]

Based on the results of its competitive bidding process, canisters for the spent fuel would be ordered, and fabrication of the canisters would likely begin in 2026.[26] All fourteen canisters would be loaded and placed in the ISFSI in 2028.[27] Each canister would take approximately five days to load – from spent fuel pool to the ISFSI pad.[28] The loading and placement of all 14 canisters is anticipated to take about four months.[29]

Xcel Energy estimates that the total cost of additional storage of spent fuel in the MNGP ISFSI will be $72.1 million (Table 2).

Table 2. Estimated Project Costs (2020 dollars)

Project Component	Cost ($ millions)
Regulatory Processes	2.5
Engineering, Design, and Construction	9.6
Canisters, Storage Modules, and Fuel Loading	60.0
Total	**72.1**

Notes

[1] Scoping EAW, Section 6b.

[2] CN Application, Chapter 1.3.

[3] Id.

[4] View looking east. Existing ISFSI is in the foreground; plant in the background.

[5] Scoping EAW, Section 11a.

[6] Scoping EAW, Section 6b.

[7] Id.

[8] Id.

[9] Id.

[10] 10 CFR 72, Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level, Radioactive Waste, and Reactor-Related Greater than Class C Waste, https://www.nrc.gov/reading-rm/doc-collections/cfr/part072/full-text.html#part072-0120.

[11] Dry Spent Fuel Storage Designs: NRC Approved for General Use, https://www.nrc.gov/waste/spent-fuel-storage/designs.html.

[12] CN Application, Chapter 8.12.

[13] Id. The NUHOMS-61BT system is certified by the NRC for storage and transportation of spent nuclear fuel.

[14] 2005 Monticello EIS, Chapter 3.3.

[15] CN Application, Chapter 1.3.

[16] Scoping EAW, Section 6b.

[17] CN Application, Chapter 8.5.

[18] CN Application, Chapter 8.8.

[19] Id.

[20] Id.

[21] 2005 Monticello EIS, Chapter 3.3.

[22] Id.

[23] Id.

[24] Scoping EAW, Section 6b.

[25] Id.

[26] CN Application, Chapter 8.12.

[27] Id.

[28] Id.

[29] Id.

4 Potential Non-Radiological Impacts

Xcel Energy's proposed additional spent fuel storage could impact human or environmental resources near the MNGP. The construction of a concrete storage pad and concrete overpacks could create non-radiological impacts. The handling and storing of spent fuel, as a physical activity, could create non-radiological impacts.

Because the project will take place within the MNGP site, and in an ISFSI that has been designed for the additional storage of spent fuel, the non-radiological impacts of additional spent fuel storage in the MNGP ISFSI are anticipated to be minimal.

4.1 Describing Potential Impacts and Mitigation

This EIS analyzes potential impacts of the project on various resources. Impacts are given context through discussion of their duration, size, intensity, and location. This context is used to determine an overall resource impact level. Impact levels are described using qualitative descriptors. These descriptors are not intended as value judgments, but rather as a means to ensure a common understanding among readers.

- **Minimal** – If a project will not considerably alter the condition or function of a resource, the project impact is considered minimal. Minimal impacts are generally not obvious, but, for some resources and at some locations, may be noticeable to an average observer. Generally, impacts to common resources over a short term are considered minimal.
- **Moderate** – If a project will alter the condition or function of an existing resource in a manner that is generally noticeable or predictable for the average observer, the project impact is considered moderate. Moderate impacts may be spread out over a large area, making them difficult to observe, but can be estimated by modeling or other means. Moderate impacts may be long term or permanent to common resources, but are generally short- to long-term for rare and unique resources.
- **Significant** – If a project will alter the condition or function of an existing resource to the extent that the resource is severely impaired or cannot function, the project impact is considered significant. Significant impacts are typically noticeable or predictable for the average observer. Significant impacts may be spread out over a large area making them difficult to observe, but can be estimated by modeling. Significant impacts can be of any duration and may affect common as well as rare and unique resources.

This EIS also discusses ways to avoid, minimize, or mitigate specific impacts. These actions are collectively referred to as mitigation.

- **Avoid** – Avoiding an impact means that the impact is eliminated altogether by moving or not undertaking parts or all of a project.

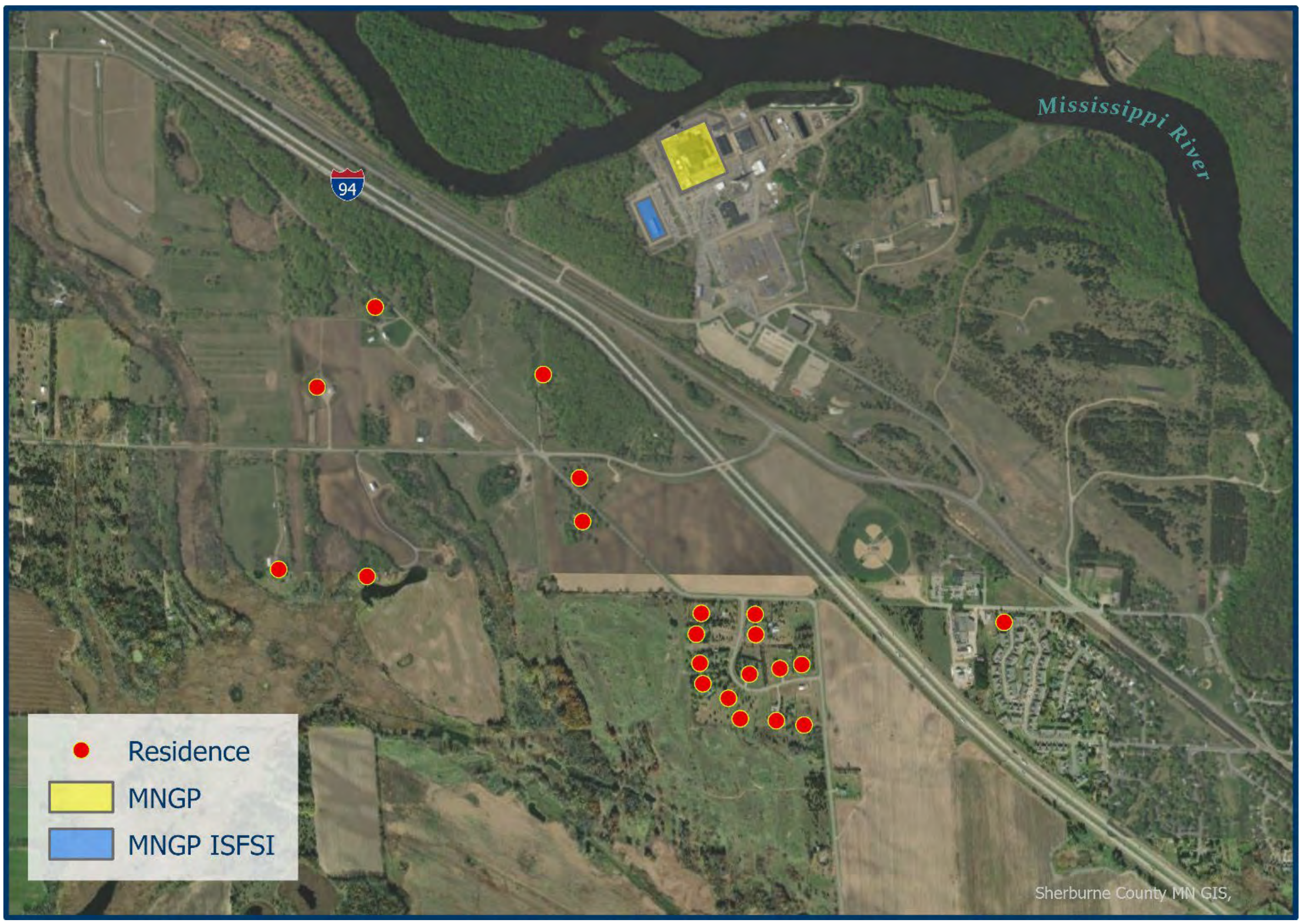
- **Minimize** – Minimizing an impact means that the intensity of the impact is limited by reducing the project size or moving a portion of the project from a given location.
- **Mitigate** – Impacts that cannot be avoided or minimized could be mitigated. Impacts can be mitigated by repairing, rehabilitating, or restoring the affected environment, or compensating for it by replacing or providing a substitute resource elsewhere.

4.2 Environmental Setting

The MNGP is located on the western bank of the Mississippi River in Wright County, Minnesota. The MNGP site is owned by Xcel Energy and consists of approximately 2,150 acres.[1] The MNGP ISFSI is located about 500 feet west of the plant (Figures 1 and 9).

Though located within the city limits of Monticello, the MNGP is in a rural, agricultural landscape. The MNGP site is approximately 3.2 miles northwest of the Monticello city center; the city has a population of about 14,000 persons.[2] There are 21 residences within one mile of the MNGP ISFSI; the closest residence is 0.36 miles from the ISFSI (Figure 9).[3]

Figure 9. Residences Within One Mile of MNGP ISFSI



The MNGP site is bordered on the west by U.S. Interstate 94. The site is bordered on the north and the east by the Mississippi River. The site is industrial and most all surfaces are concrete, asphalt, or gravel. There are a limited number of trees both east and west of the site, along the Mississippi River.

4.3 Potential Impacts to the Human Environment

There are relatively few persons that live near the MNGP who could experience non-radiological impacts. Further, the additional spent fuel storage project will occur within the MNGP site, a developed industrial site. Thus, potential impacts to the human environment as a result of the project are anticipated to be minimal.

Aesthetics

Aesthetics refers to the visual quality of a landscape as perceived by a viewer. Aesthetics are subjective, meaning their relative value depends upon the perception and philosophical or psychological responses unique to individuals. Landscapes which are, for the average person, harmonious in form and use are generally perceived as having greater aesthetic value. Infrastructure which is not harmonious with a landscape or negatively impacts existing features of a landscape could negatively impact the aesthetics of the area.

The proposed additional spent fuel storage within the MNGP ISFSI is harmonious with the industrial nature of the MNGP site. The ISFSI currently contains spent nuclear fuel; the addition of a second concrete pad and spent fuel canisters will not change the aesthetics of the site. Additionally, there are few persons, outside of MNGP employees, who will perceive any change in the MNGP site as a result of the project. The project will not be visible to local residences or to persons passing through the area (e.g., driving on I-94). Thus, aesthetics impacts of the project are anticipated to be minimal.

Noise

Noise can be defined as any undesired sound. It is measured in units of decibels on a logarithmic scale. The A-weighted scale (dBA) is used to duplicate the sensitivity of the human ear. A three dBA change in sound is barely detectable to average human hearing, whereas a five dBA change is clearly noticeable.

Because sounds levels are measured on a logarithmic scale, they are not directly additive. For example, if a sound level of 50 dBA is added to another sound level of 50 dBA, the total sound level is 53 dBA, not 100 dBA. This change in sound level (three dBA) would be barely detectible.

All noises produced by the project must be within state noise standards (Table 3).[4] Noise standards in Minnesota are based on noise area classifications (NAC) that correspond to the location of the listener—referred to as a receptor. NACs are assigned to areas based on the type of land use activity occurring at that location.

Noise standards are expressed as a range of permissible dBA over a one-hour period. An L_{10} noise standard may be exceeded 10 percent of the time, or six minutes per hour, while an L_{50} standard may be exceeded 50 percent of the time, or 30 minutes per hour. Standards vary between daytime and nighttime hours.

Table 3. Minnesota Noise Standards

Noise Area Classification	Daytime (7:00 a.m. to 10:00 p.m.)		Nighttime (10:00 p.m. to 7:00 a.m.)	
	L_{10}	L_{50}	L_{10}	L_{50}
1 - Residential	65	60	55	50
2 – Retail, Business	70	65	70	65
3 - Manufacturing	80	75	80	75

Potential noise impacts of the project would result from the use of equipment to construct a second concrete support pad in the ISFSI and to construct concrete overpacks for spent fuel canisters. Xcel Energy anticipates that construction will last for approximately six months.[5] During this time, the project will use a variety of construction equipment – e.g., excavators, backhoes, cranes, bulldozers, trucks.[6] This equipment produces a range of sound levels, typically from 55 to 85 dBA.[7]

There are few noise receptors near the MNGP site. There are 21 residences within one mile of the site, the closest being 0.36 miles from the MNGP ISFSI (Figure 9). Existing ambient noise levels at these receptors are due primarily to traffic on I-94. Noise modeling conducted for the project estimates construction noise levels at these residences to be in the range of 39 to 54 dBA L_{50}.[8] These levels are 0.7 to 2.3 dBA greater than current ambient noise levels at the residences and would not be discernable.[9] Additionally, the construction noise levels would be within state noise standards for residences during daytime hours (Table 3).

In sum, noise impacts resulting from the project are anticipated to be minimal.

Traffic

Access to the MNGP site is controlled by Xcel Energy. Approximately 500 MNGP employees commute to and from the site each day. Construction activities for the project will slightly increase the number of persons commuting each day.

Xcel Energy estimates that about 40 construction workers will be required for the project, with an average of about 8 workers employed each week.[10] In addition to workers, the project will result in additional deliveries of materials by truck. Xcel Energy estimates that construction workers will add about 16 additional commuting trips per day, and that deliveries will add about seven additional trips each day.[11] These additional projected trips (23 per day in total) are less than a five percent increase in daily traffic at the MNGP. Thus, potential traffic impacts resulting from the project are anticipated to be minimal.

Land Use

The MNGP site is zoned by the city of Monticello as industrial.[12] The addition of a second concrete support pad and concrete overpacks in the MNGP ISFSI is consistent with this zoning. No impacts to zoning are anticipated.

Land use in the surrounding area is primarily agricultural, excepting the city of Monticello. The Mississippi River, as it proceeds past the MNGP, is part of the Mississippi River Scenic Byway Corridor.[13] The Mississippi River Trail Bikeway follows County Road 75 just to the southwest of the MNGP site.[14] The project would have no impacts on land uses outside of the MNGP site including agriculture, businesses within Monticello, and recreational activities.

Public Health and Safety

Access to the MNGP site is controlled by Xcel Energy. Thus, non-radiological health and safety impacts to the general public are not anticipated.

Health and safety impacts could occur to workers constructing the project. Additionally, the MNGP is an industrial facility. There are risks to plant personnel typical of an industrial facility, e.g., falls, burns, machinery injuries. Xcel Energy implements safety programs to reduce the impact of such risks. Construction of a second ISFSI pad and the placement of additional spent fuel canisters are not anticipated to increase risks or introduce new risks to plant personnel that are not managed by these safety programs.

Socioeconomics

The MNGP is located in Wright County, Minnesota, and within the city of Monticello. The primary economic activities in the county include retail sales, manufacturing, and wholesale sales.[15] The MNGP is an economic resource in the area; property taxes on the MNGP provide a substantial portion of the city of Monticello’s tax revenues.[16]

Per-capita income in the project area is similar to, and slightly less than, per-capita income for the State of Minnesota (Table 4). The project is anticipated to have minimal impacts on existing socioeconomics in the project area. The project may introduce minor benefits related to construction expenditures, e.g., short-term housing, foods, supplies. The project is not anticipated to change demographics in the area.

Table 4. Demographic Comparisons for Project Area[17]

Location	Per-capita Income (dollars)	Minority Population (percent)	Individuals Below the Poverty Line (percent)
Minnesota	$37,625	20.9	9.0
Wright County	$36,260	8.3	5.2
Monticello	$28,965	13.9	6.6

If the Commission authorizes the storage of additional spent fuel in the MNGP ISFSI, thus facilitating operation of the MNGP through 2040, then the city of Monticello will maintain a relatively high and stable source of tax revenue. Additional spent fuel storage is not anticipated to significantly change the value of the MNGP; thus, tax revenues for the city are not anticipated to change should the MNGP continue operation through 2040. If the Commission does not authorize the storage of additional spent fuel in the MNGP ISFSI, and absent the ability to ship spent fuel to an offsite facility, Xcel Energy would cease operating the MNGP. A cessation of operations would negatively impact tax revenues for the city of Monticello.

Environmental Justice

Environmental justice is a commitment that all persons, regardless of race, color, national origin, or income, are provided fair treatment and meaningful involvement in the development and implementation of environmental laws and policies.[18] The goal of this commitment is to ensure that no persons bear a disproportionate share of the negative environmental consequences of a proposed project.

The first step in ensuring that a commitment to environmental justice is fulfilled is to examine whether there are populations within the project area – populations that may find it difficult to be meaningfully involved in the State of Minnesota's review of Xcel Energy's project – that could bear a disproportionate share of the impacts of the project. Populations that have historically been challenged to be involved in the state's review process and that have borne disproportionate human and environmental impacts include low-income and minority populations.

A community with a low-income percentage or minority group percentage that exceeds 50 percent, or is meaningfully greater than in the general populace, is a community for which there exists environmental justice concerns. For the discussion here, a difference of 10 percentage points or more is used as the threshold to distinguish whether a meaningfully greater low-income or minority population resides in project area.

For potential non-radiological impacts, the appropriate extent of the project area is the census tract. Data for the census tract in which the MNGP is located indicates that, with respect to non-radiological impacts, there are no populations for which the storage of additional spent fuel in the MNGP ISFSI raises environmental justice concerns (Table 5). Both the low-income and minority percentage in the project area are substantially less than 50 percent. Further, they are not meaningfully greater than the population of Wright County or the State of Minnesota. Thus, no environmental justice impacts are anticipated.

Table 5. Environmental Justice Comparisons for Project Area[19]

Location	Minority Population (percent)	Individuals Below the Poverty Line (percent)
Census Tract 1002.03	5.0	7.9
Wright County	8.3	5.2
Minnesota	20.9	9.0

4.4 Potential Impacts to the Natural Environment

Xcel Energy's proposed additional spent fuel storage project will occur within the MNGP site, a developed industrial site. There are relatively few natural resources within the site. Thus, potential impacts to the natural environment as a result of the project are anticipated to be minimal.

Water Resources

There are no surface waters or wetlands within the MNGP site. The Mississippi River flows past the MNGP, about 600 feet northwest of the MNGP ISFSI.[20] Groundwater generally flows beneath the MNGP site to the Mississippi River. Borings conducted by Xcel Energy prior to construction of the ISFSI indicate that groundwater is about 35 feet below the ISFSI surface.[21]

Stormwater

Construction of a second concrete storage pad and of concrete overpacks will require removal of existing gravel cover within the ISFSI and the pouring of concrete. Xcel Energy indicates that less than one acre of land will be disturbed by the project.[22] Thus, the project would not require a construction stormwater permit from the Minnesota Pollution Control Agency (MPCA).[23] Xcel Energy notes that it will implement best management practices to ensure stormwater does not leave the MNGP site or flow to the Mississippi River.[24] Practices would include the use of silt fences or straw wattles.

Once additional storage within the ISFSI is constructed, stormwater from the ISFSI will flow into a stormwater retention basin. The basin handles stormwater for the entire MNGP site.[25] The additional surface introduced by a second concrete storage will have a minimal impact on stormwater quantity handled by the basin.[26]

In sum, impacts to water resources within and near the MNGP site are anticipated to be minimal.

Flora and Fauna

The MNGP site is an industrial site with impervious surfaces (buildings, concrete, gravel). There is no habitat within the site for flora or fauna. Birds and raptors may fly over the site and may use the site for nesting (see discussion, below). No impacts to these species are anticipated as a result of the project. No impacts to flora and fauna are anticipated.

Rare and Unique Natural Resources

Though there is no habitat for flora or fauna within the MNGP site, the site is surrounded by a riparian and agricultural landscape that supports rare and unique natural resources. The MNGP site is within the Monticello Savana, a site of high biodiversity significance.[27] The Savanna abuts the west side of the MNGP site along the Mississippi River. The site is also within a Minnesota native plant community – a pin oak and burr oak woodland system.[28]

There are two Minnesota species of special concern in and near the MNGP site. Peregrine falcons nest on the MNGP's emissions stack, and black sandshell mussels are found in the Mississippi River.[29] There are seven rare federal species near the MNGP site – northern long-eared bats, bald eagles, and five migratory bird species.[30] Bald eagles nest within one mile of the MNGP.[31] The are no known roost trees or hibernacula for northern long-ear bats in Wright County.[32]

No impacts to rare and unique resources are anticipated as a result of the project. Construction activities could increase noise levels that antagonize nesting falcons. However, the falcons nest at the MNGP and are accustomed to the noise and activities associated with the plant. The Minnesota Department of Natural Resources (DNR) recommends that Xcel Energy coordinate with the U.S. Fish and Wildlife Service (USFWS) regarding bald eagles that are nesting near the MNGP.[33]

Climate Change

Minnesota's climate is getting warmer and wetter due to anthropogenic greenhouse gas (GHG) emissions.[34] Heavy rainfall events are more common, as are flooding and convective storm damage (e.g., high winds, hail).[35] The most common GHGs emitted from human activities include carbon dioxide, methane, and nitrous oxide.

Impacts of the Project on Climate Change

The construction and operation of additional spent fuel storage in the MNGP ISFSI will result in GHG emissions. Construction of a second concrete support pad and of concrete overpacks will require the use of heavy equipment (e.g., excavators, bulldozers, trucks). This equipment will emit GHGs. Total GHG emissions for construction activities are estimated to be about 267 tons of carbon dioxide (CO_2).[36] For context, a typical passenger car in the United States emits approximately 5.1 tons of CO_2 per year.[37] GHG emissions for construction of the project are less than those of other energy facility projects recently permitted by the Commission.[38] Total GHG emissions for the state of Minnesota in 2018 were approximately 161 million tons.[39] Thus, GHG emissions for construction of the project are an insignificant amount relative to the state's overall annual emissions.

Operation of an expanded ISFSI is anticipated to have minimal GHG emissions. There are no emissions associated with the operation of additional spent fuel canisters or their concrete overpacks. There would be emissions from the specialized crawler that transported spent fuel canisters from the MNGP spent fuel pool to the ISFSI. These emissions are anticipated to be substantially less than those for construction of the project.

On whole, construction and operation of the project is anticipated to have a minimal impact on climate change.

Impacts of Climate Change on the Project

A warmer and wetter future climate is not anticipated to impact operation of the project. A wetter climate could result in larger and more frequent floods. Estimates of potential flooding at the MNGP site accounting for climate change indicate that the MNGP ISFSI would not experience flooding due to its elevation relative to the Mississippi River.[40] Flooding is not projected to occur even during 100-year and 500-year storm events.[41]

Heavier rainfall events could also impact stormwater management. Stormwater from the MNGP ISFSI is directed to, and managed by, the larger MNGP site stormwater system. The stormwater retention basins for the MNGP site are sized to accommodate potentially heavier rainfall events associated with climate change.[42] Thus, impacts to stormwater management are not anticipated.

In sum, climate change is not anticipated to impact non-radiological functioning of additional spent fuel storage in the MNGP ISFSI.

4.5 Cumulative Potential Effects

Cumulative potential effects are effects on the environment that result from other projects near the MNGP site that might reasonably be expected to affect the same environmental resources. There are projects planned near the MNGP site; however, because the MNGP site is a controlled industrial site, cumulative potential effects are anticipated to be minimal.

The city of Monticello has several planned projects including residential stormwater improvements, roadway improvements, and development projects.[43] The city is currently developing the "Chelsea Commons," a mixed-used development four miles southeast of the MNGP site.[44]

The MNGP is near the Mississippi River Trail Bikeway as it travels on County Road 75 southwest of the MNGP site.[45] In planning for expansion and improvements to the bikeway and the Great River Regional Trail, the MNGP site has been identified as a constraint.[46] It is unclear, at this point, how bikeways or trails near the MNGP will be developed in the future.

The Minnesota Department of Transportation (MnDOT) is currently improving I-94 near the MNGP site.[47] The project includes adding travel lanes, rebuilding bridges, and resurfacing deteriorating pavement.

In sum, there are a number of projects planned near the MNGP site – in Monticello, along the Mississippi River, and along I-94. However, none of these projects will impact resources within the MNGP site. With respect to resources and potential impacts outside of the MNGP site (e.g., traffic, noise, GHG emissions), these incremental impacts are anticipated to be minimal. There is some uncertainty in this characterization. Of the projects discussed here, the city of Monticello's development plans likely have the greatest potential to impact traffic, noise, and GHG emissions near the MNGP site. However, on whole, cumulative potential effects are anticipated to be minimal.

Notes

[1] Scoping EAW, Section 6b.

[2] Scoping EAW, Section 22.1.

[3] Residences identified using aerial photography and geographic information systems; see also Scoping EAW, Section 22.1.

[4] A Guide to Noise Control, Minnesota Pollution Control Agency, https://www.pca.state.mn.us/sites/default/files/p-gen6-01.pdf.

[5] Scoping EAW, Section 19.

[6] Id.

[7] Id.

[8] Id.

[9] Id.

[10] Scoping EAW, Section 20.

[11] Id.

[12] Scoping EAW, Section 10.

[13] Id.

[14] Id.

[15] Scoping EAW, Section 22.1.

[16] Scoping EAW, Section 10.

[17] Scoping EAW, Section 22.1; 2019 U.S. Census.

[18] Environmental Justice, U.S. Environmental Protection Agency, https://www.epa.gov/environmentaljustice;

[19] U.S. Environmental Protection Agency, Environmental Justice Screening and Mapping Tool (Version 2.0), https://ejscreen.epa.gov/mapper/

[20] Scoping EAW, Section 12.

[21] Id.

[22] Id.

[23] Construction Stormwater, MPCA, https://www.pca.state.mn.us/water/construction-stormwater.

[24] Id.

[25] Id.

[26] Id. The Class 6 gravel currently within the ISFSI is considered an impervious surface. Changing this surface to concrete would have no discernable impact on stormwater runoff.

[27] Scoping EAW, Section 14.

[28] Id.

[29] Id.

[30] Id.

[31] Minnesota Department of Natural Resources, Scoping Comment Letter, February 9, 2022, eDockets Number 20222-182824-02 [hereinafter DNR Scoping Comment Letter].

[32] Scoping EAW, Section 14.

[33] DNR Scoping Comment Letter.

[34] Climate Change and Minnesota, Minnesota Department of Natural Resources, https://www.dnr.state.mn.us/climate/climate_change_info/index.html.

[35] Id.

[36] Scoping EAW, Section 18.

[37] Greenhouse Gas Emissions from a Typical Passenger Vehicle, U.S. Environmental Protection Agency, https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle (4.6 metric tons = 5.07 U.S. tons).

[38] See, e.g., Hayward Solar Project Environmental Assessment, March 2022, Chapter 4.7.1, eDockets Number 20223-183372-01 (noting that construction of the 150 MW solar project would result in the emission of approximately 5,119 tons of CO_2).

[39] Greenhouse Gas Emissions Data, Minnesota Pollution Control Agency, https://www.pca.state.mn.us/air/greenhouse-gas-emissions-data.

[40] Scoping EAW, Section 7.

[41] Id.

[42] Scoping EAW, Section 12.

[43] Scoping EAW, Section 21a.

[44] Id.

[45] Id.

[46] Id.

[47] I-94 Maple Grove to Clearwater, Minnesota Department of Transportation, https://www.dot.state.mn.us/i94-mg-clearwater/index.html.

5 Potential Radiological Impacts

Xcel Energy's proposed additional spent fuel storage could impact the health of persons near the MNGP and its ISFSI through exposure to radiation. Radiation can cause direct and long-term health impacts. Spent nuclear fuel is highly radioactive. Thus, spent nuclear fuel must be properly handled and stored to avoid radiological health impacts.

Potential radiological impacts to the public and to workers at the MNGP are anticipated to be minimal. Additional spent fuel storage in the MNGP ISFSI will incrementally increase radiation levels within the ISFSI; however, these levels will have minimal impact on the general public and on workers at the MNGP.

5.1 Radiation and Health Effects

All inhabitants of the planet are regularly exposed to radiation from natural and man-made sources. The average American receives approximately 620 millirem (mrem) of radiation each year.[1] Approximately half of this dose comes from natural sources, e.g., gases produced by radioactive decay (Table 6). The other half comes primarily from medical procedures. Doses due to occupational and industrial exposures make up less than one percent of the average annual dose.

Table 6. Background Radiation Sources[2]

Source	Approximate Annual Dose (mrem/yr.)	Percentage of Annual Dose
Natural Sources		
Radon and Thoron	228	37
Cosmic Radiation	33	5
Ingested Radioactive Minerals	29	5
Terrestrial Radioactive Minerals	21	3
Man-Made Sources		
Computed Tomography	147	24
Nuclear Medicine	77	12
Interventional Fluoroscopy	43	7
Conventional Radiography	33	7
Consumer	13	2
Occupational	0.5	< 1
Industrial	0.3	< 1

Radiological health effects result from the deposition of radiation energy within the human body. This energy causes cellular damage, which may or may not be able to be repaired by normal cellular repair mechanisms. If cellular damage does occur, health effects may also occur. The primary low-dose health effect of concern is cancer.

The best estimate of the relationship between radiation doses and incidences of cancer is provided by the National Academy of Sciences' BEIR VII Report.[3] This report recommends that estimates of additional cancers due to long-term, low-level radiation doses be calculated using a risk coefficient of 1 E-06 (i.e., 1 in a million) incident cancers per person-mrem received.[4] Some examples of this risk coefficient in use may be helpful:

- If 100 persons receive a dose of 10 mrem in a year, the risk of additional cancers in this group of 100 persons due to the radiation dose is 1 in 1,000 (100 persons X 10 mrem X 1 E-06 additional cancers per person-mrem).

- If 1,000 persons receive a dose of 10 mrem per year for 50 years, the risk of additional cancers in this group of persons due to the radiation dose is 0.5 (1,000 persons X 10 mrem per year X 50 years X 1 E-06 additional cancers per person-mrem). That is, we would expect 0.5 additional cancers in this group over 50 years than would otherwise occur due to the radiation dose.

Thus, additional incidences of cancer due to low-level radiation exposure can be mitigated by: (1) reducing the radiation dose received, and (2) limiting the number of persons that receive a dose.

5.2 Radiation Monitoring

Radiation monitoring is conducted at the MNGP and MNGP ISFSI by Xcel Energy and the Minnesota Department of Health (MDH).

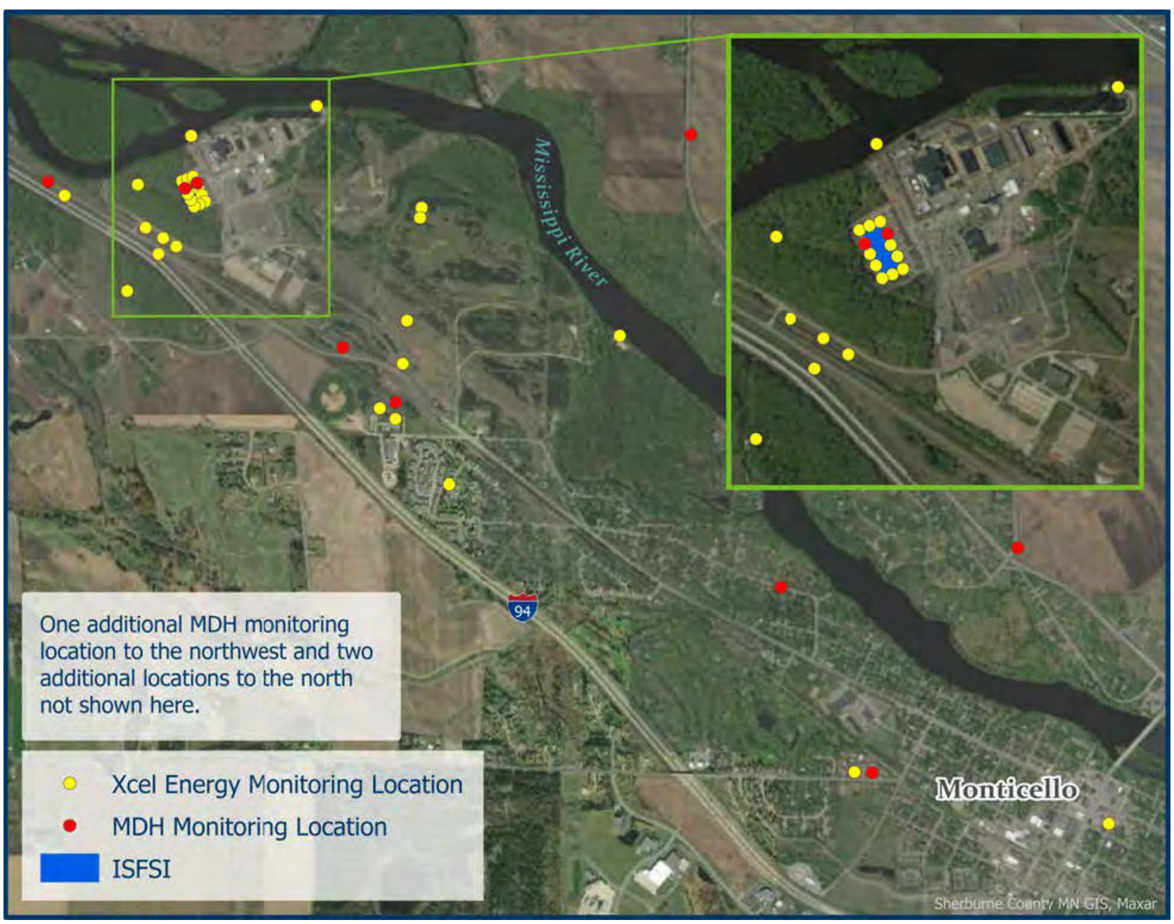
Xcel Energy's monitoring program has been developed in accordance with and is required by NRC regulations. As an NRC licensee, Xcel Energy must control, monitor, evaluate, and report all radiological effluents discharged into the environment.[5] Xcel Energy must operate the MNGP such that radiation doses to members of the public and to workers are within NRC standards (Table 7).[6]

Xcel Energy ensures that radiation doses are within NRC regulations through sampling and monitoring on and around the MNGP site (Figure 10). Xcel Energy samples air, surface water, drinking water, and groundwater.[7] It samples agricultural products from nearby farms.[8] It uses thermoluminescent dosimeters (TLDs) to monitor direct radiation on site and around the plant.[9]

Table 7. Radiation Dose Limits – NRC Standards

Federal Radiation Dose Standards – Applicability	Radiation Dose Limit (mrem/year)	Regulation
General Public; licensed operations	100	10 CFR 20
General Public; uranium fuel cycle operations	25 – whole body 75 – thyroid 25 – any other organ	40 CFR 190
General Public; normal ISFSI operations	25 – whole body 75 – thyroid 25 – any other organ	10 CFR 72
General Public; ISFSI design basis accident conditions	5,000	10 CFR 72
Workers; occupational exposure	5,000	10 CFR 20

Figure 10. Radiation Monitoring Locations



Environmental monitoring by the MDH includes air, surface water, and milk sampling (Figure 10).[10] Ambient radiation dose levels are monitored using optically stimulated luminescence dosimeters (OSLDs).[11] MDH also monitors the MNGP ISFSI with two Geiger-Mueller tube-based dose rate monitors (DRM).[12] The DRM continuously measure and report levels of gamma radiation within the ISFSI.

5.3 Potential Radiological Impacts to the Public

Radiation doses to the general public from MNGP ISFSI operations result from skyshine radiation.[13] Skyshine radiation is gamma and neutron radiation that travels upward from the spent fuel canisters, through their concrete overpacks, and is reflected off the atmosphere back to the ground.

The annual dose from skyshine radiation to the residence closest to the MNGP ISFSI (0.36 miles) is estimated to be 0.4 mrem per year.[14] This estimate assumes that there are 44 spent fuel canisters in the MNGP ISFSI stored in a horizontal concrete module system – the 30 canisters currently stored in the ISFSI plus 14 additional canisters to facilitate operations through 2040.[15] This dose level is within NRC standards and is indistinguishable from background radiation (Tables 6 and 7). The dose from skyshine radiation decreases with distance from the ISFSI. Members of the public at a distance greater than 0.36 miles would receive less than 0.4 mrem per year.

Monitoring programs corroborate the ISFSI dose estimate and its near-background level. Xcel Energy monitoring indicates that radiation dose levels near the MNGP, as measured by TLDs in the area, are indistinguishable from background radiation levels.[16] Monitoring by the MDH indicates that radiation dose levels are indistinguishable from background radiation levels.[17]

Health impacts to the general public resulting from ISFSI skyshine radiation are anticipated to be minimal. The primary health concern is cancer. Cancer incidences due to skyshine radiation are anticipated to be minimal because (1) there are few persons living near the MNGP ISFSI that could be impacted by the radiation, and (2) the estimated radiation dose is near background radiation levels. There are 21 residences within one mile of the MNGP.[18] If we assume that these residences represent 84 persons, and that these persons receive 0.4 mrem per year, continuously for 70 years, it's estimated that an additional 0.0024 persons, among this group of residents, would be diagnosed with cancer.[19] By comparison, it's estimated that 26 residents would be diagnosed with cancer over this time period from all causes of cancer.[20]

It is possible that, over time, more residents will live near the MNGP ISFSI. For example, the city of Monticello is planning for growth northwest of the city center, nearer to the MNGP site.[21] This growth may lead to more persons being impacted by skyshine radiation, at least for part of the day. Even with an increase in the number of persons that could be impacted by skyshine radiation, potential health impacts are anticipated to be minimal. Assuming that the population of Monticello increases by 50 percent by 2040, and that these additional 7,000 persons reside near the MNGP ISFSI such that they receive the same annual dose as the nearest residence (0.4 mrem per year) for 70 years, it's estimated that an additional 0.20 persons, among these 7,000 persons, would be diagnosed with cancer.[22] By comparison, it's estimated that 2,166 of these 7,000 residents would be diagnosed with cancer during this time period from all causes of cancer.[23]

The above discussion assumes that monitoring and maintenance of the spent fuel canisters continues until such time as the spent fuel can be transported to an offsite facility. Monitoring and maintenance ensure the integrity of the spent fuel canisters such that radiation doses to the general public are solely the result of skyshine radiation. If monitoring and maintenance do not continue, radiological impacts are anticipated to be significant (see Chapter 6.2).

The above discussion also assumes the use of a canister system with a horizontal concrete overpack, similar to the NUHOMS system currently used in the MNGP ISFSI. As all NRC-certified canister systems must meet the same design criteria, including criteria for radiation shielding, the above characterizations of potential health impacts to the general public would hold true for any NRC-certified canister system selected by Xcel Energy for use in the MNGP ISFSI.

Off-Normal Conditions

All NRC-certified spent fuel technologies must meet the same design criteria. These criteria include protection against natural phenomena, e.g., earthquake, tornado, flood, and man-made phenomena, e.g., fire, explosion.[24] Accordingly, when these technologies are appropriately deployed in an ISFSI, potential radiological impacts to the general public during off-normal conditions are anticipated to be minimal and within NRC standards.

Canister storage systems use steel canisters that are welded shut. These welds are inspected and must meet applicable quality standards. They are considered leak-tight. Thus, in order for there to be a radiological release during off-normal operating conditions, the phenomenon would need to cause the canister to fail – either the canister itself or the welds sealing the canister. The discussion here references the final safety analysis report (FSAR) for the NUHOMS system currently used in the MNGP ISFSI.[25] Other canister storage systems that could be used by Xcel Energy in the MNGP ISFSI would have similar analysis submitted to and reviewed by the NRC.

Earthquake

The NUHOMS canister system currently used in the MNGP ISFSI is designed to withstand a design basis earthquake.[26] The design basis earthquake is projected to cause accelerations of 17 percent of gravity horizontally and 25 percent vertically.[27] This is roughly equivalent to an earthquake of magnitude 5.4 on the Richter scale. Analysis of the NUHOMS canister system indicates that the canisters would not be compromised as a result of a design basis earthquake.[28] Accordingly, there would be no radiological impacts to the public.

Tornado

The design basis tornado is a tornado with winds of 360 miles per hour. Analysis of the NUHOMS canister system indicates that the canisters would not be compromised as a result of a tornado.[29] An additional hazard considered in this scenario is the impact of an object which is picked up in the tornado. Such an object, impelled by the wind, would act as a missile against the concrete overpack and canister. Analysis indicates that such missiles would not compromise the spent fuel canisters.[30] Thus, no radiological impacts are anticipated.

Flood

The NUHOMS canister system is designed to withstand flood conditions. The design basis flood is a flood with pressures equivalent to a 50 foot head of water and with a maximum water flow velocity of 15 feet per second.[31] The MNGP ISFSI is located outside of the 500-year floodplain.[32] The ISFSI concrete support pad is at 943 above mean sea level (MSL); the maximum probable flood elevation for a 500-year flood is 939.2 feet MSL.[33] Thus, no flooding of the ISFSI or radiological impacts are anticipated.

Fire or Explosion

There are few fuel sources in the MNGP ISFSI that could support a fire or explosion. For purposes of analysis, the NUHOMS FSAR assumes that the fuel tank for the canister transport vehicle ruptures and spill up to 300 gallons of gasoline, which then ignites.[34] Analysis of the temperatures and pressures associated this fire indicate that spent fuel canisters would not be compromised by the fire.[35] Thus, there would be no radiological impacts to the public.

Transfer Cask Mishandled

Spent fuel canisters require handling to load them and to transport them to a concrete overpack on an ISFSI pad. It is possible that a canister could be mishandled during this process. The NUHOMS FSAR examines the possible dropping of a transfer cask enroute to the ISFSI pad.[36] The scenario assumes a loaded canister within the transfer cask. The analysis also assumes that water in the transfer cask used for neutron shielding leaks out.[37]

The analysis finds that the spent fuel canister would not be compromised by a transfer cask drop. The analysis assumes that some spent fuel rods would be damaged and would be forced downward to the bottom of the canister. Under this scenario, the FSAR estimates the dose rate for a person at 2,000 feet from the ISFSI (about the distance of the residence nearest to the MNGP ISFSI) to be about 0.39 mrem per day, until such time as shielding, particularly neutron shielding, can be restored. This does rate is within NRC standards for an off-normal or accident scenario (Table 7).

Terrorism

The radiological risks resulting from a terrorist attack on the MNGP ISFSI are covered, to a great degree, by the risk analyses for natural and man-made phenomena. There are few forces that could be brought to bear on the canisters and their concrete overpacks by terrorists greater than those already examined, e.g., tornado, fire, mishandled transfer cask. It is possible that armaments could be used to attack the ISFSI, creating damage or a fire. An airplane could be commandeered to attack the ISFSI. These risks are difficult to assess and include substantial uncertainties. However, the risks and potential radiological impacts are likely similar to those from the natural and man-made phenomena discussed here.

Following the events of September 11, 2001, the NRC developed and required security enhancements for all ISFSIs. The NRC also initiated a classified review of the capability of nuclear facilities to survive a terrorist attack, including commercial aircraft attacks, vehicle bomb assaults, and ground assaults. This review indicated that the likelihood of a radioactive release with significant radiological impacts was very low. Nonetheless, the NRC has provided revised guidance to all licensees regarding security requirements against terrorism.[38] Xcel Energy has implemented security enhancements at the MNGP in accordance with NRC guidance and regulations.

Accident Conditions

Radiological impacts to the public from the MNGP ISFSI during normal and off-normal conditions are anticipated to be minimal. Analysis indicates that spent fuel canisters would not be compromised by natural or man-made phenomena. Thus, impacts to the public would be limited to skyshine radiation (discussed above). Nonetheless, it is possible that a canister could be compromised by some unknown means resulting in a release of radioactive materials.

The NRC has analyzed the potential impacts associated with a hypothetical release from an ISFSI (NUREG-1140).[39] The analysis assumes removal of the lids from a spent fuel canister with the subsequent release of radioactive gases including Krypton (Kr-85) and Iodine (I-129). The estimated dose from this release was 3 mrem to a person 100 meters from the ISFSI; persons at a greater distance would receive a smaller dose. A dose of 3 mrem is within NRC standards and indistinguishable from background radiation. The impacts of such a dose would be minimal.

As a nuclear power plant licensee, Xcel Energy is required to have an emergency response plan for the MNGP. The city of Monticello provides emergency services to the MNGP. CentraCare Health Monticello serves as the principal offsite medical facility for injuries related to an emergency or emergency response. The Wright County sheriff's office provides law enforcement services to the MNGP, including any services necessary during an emergency. If there were accident conditions at the MNGP, emergency responders would address the situation in an attempt to control any radiological release and to minimize radiological impacts to the public.

Emergency response planning for the MNGP extends beyond the city of Monticello. Response plans must include strategies to mitigate potential radiological impacts due to inhalation of radioactive particles – typically, a 10 mile emergency planning zone.[40] Plans must also account for possible ingestion of radioactive materials – typically, a 50 mile emergency planning zone.[41]

5.4 Potential Radiological Impacts to Workers

Workers at the MNGP, particularly workers who load spent fuel and handle spent fuel storage canisters, are exposed to greater radiation risks than the general public. Shielding, proper procedures, and training are used to avoid and mitigate these risks. NRC regulations require that radiation doses to workers are as low as reasonably achievable (ALARA). The NRC's occupational radiation dose limit is 5,000 mrem per year (Table 7).

The NRC requires the monitoring and reporting of worker radiation doses from all NRC-licensed facilities in the United States. This reporting is summarized annually in a report (NUREG-0713).[42] The latest version of the report (Volume 41) includes worker radiation doses through 2019.[43]

There are about 600 workers at the MNGP, though this number varies over time. During the 2010-2019 timeframe, the number of MNGP workers receiving a measurable dose each year ranged from about 270 persons to 1,900 persons.[44] This variability is due to, among other factors, the cyclical nature of removing spent fuel from the MNGP reactor and the loading of new fuel.

Though the number of workers receiving a measurable dose varies from year to year, the average annual dose is fairly constant. The average annual radiation dose for workers at the MNGP is 120 mrem.[45] This dose is within NRC standards, and impacts from this dose are anticipated to be minimal. The average annual collective worker dose at the MNGP is 99.8 person-rem.[46] If workers at the MNGP received this dose over a 40 year tenure at the MNGP, it is estimated that an additional 4 persons, among all MNGP workers, would be diagnosed with cancer.[47]

If Xcel Energy selects a different canister technology for the MNGP ISFSI, i.e., a vertical overpack system rather than a horizontal overpack, this technology could have an impact on radiation doses for workers. However, data from the MNGP and other U.S. nuclear plants indicates that radiation doses to workers does not vary significantly with the type of canister system used (Table 8). Data in Table 8 indicates that the radiation dose to workers is more dependent on the type of fuel being loaded (pressurized water reactor vs. boiling water reactor) rather than the canister technology.

Table 8. Worker Radiation Exposure for Different Canister Technologies[48]

Type of Cask / Canister	Type of Fuel	Average Cumulative Worker Exposure During Fuel Loading (person-mrem)
Canister – Vertical Overpack[1]	PWR[4]	220
Canister – Horizontal Overpack[2]	PWR	160
Canister – Horizontal Overpack[3]	BWR[5]	608

[1] Holtec data from 15 canisters.
[2] TN Americas data from four canisters.
[3] Monticello canister loading data.
[5] Pressurized water reactor.
[5] Boiling water reactor.

Accident Conditions

All NRC-certified spent fuel canisters must meet the same requirements for performance during accident conditions. Thus, the radiation risks associated with the spent fuel, should an accident occur, would be independent of the canister system used to store the fuel.

As discussed above (Chapter 5.3), no radiological impacts to the public are anticipated during off-normal operation of the MNGP ISFSI. There could be impacts to workers related to off-normal operations, e.g., additional monitoring and maintenance should an earthquake or tornado occur. Any additional radiation doses associated with this type of maintenance are difficult to estimate. Doses would be managed by Xcel Energy to remain within NRC standards.

Similarly, doses to workers should a hypothetical release occur at the ISFSI due to an accident are difficult to estimate. If we assume a hypothetical release similar to that analyzed in NUREG-1140 (discussed above), workers responding to the release would receive doses from Krypton and Iodine gas as well doses from the canisters themselves (direct gamma and neutron radiation). If we assume that 100 workers and/or emergency responders receive the maximum occupational radiation dose of 5,000 mrem during the accidental release, then this would result in an additional 0.5 cancer incidences among this group of 100 persons.[49] In responding to an accident, individual worker doses could vary significantly. Doses would be monitored and managed using time, distance, and shielding.

5.5 Potential Radiological Impacts to the Natural Environment

Radiation doses to flora and fauna from ISFSI operations are typically not estimated or monitored, except as these doses are indicative of potential impacts to humans (e.g., monitoring agricultural crops because they will be eaten by humans). Radiation exposure for flora and fauna is most likely similar to that of the general public, i.e., indistinguishable from background radiation, and thus there is no significant radiological impact. However, this assumption would not hold for two cases: (1) flora that is very near the ISFSI, and (2) fauna that lives in, moves through, or otherwise utilizes the ISFSI site or nearby habitat.

Radiation impacts to tall nearby flora, e.g., trees along the Mississippi River, are anticipated to be minimal but unavoidable. Radiation impacts to nearby fauna are mitigated by the fact that there is no potential habitat for fauna within the ISFSI or within the MNGP site generally. Birds may land near the ISFSI or fly through the ISFSI, but likely would not make a nest within the ISFSI. ISFSI operating procedures preclude use of the ISFSI by nesting animals. Accordingly, radiation impacts to fauna are anticipated to be minimal.

5.6 Climate Change

As discussed in Chapter 4.4, greenhouse gas emissions resulting from human activities are making Minnesota's climate warmer and wetter. In addition, the frequency of extreme storms, storms with extreme rainfall and high winds, is increasing. These changes in the climate could adversely impact the resilience of spent fuel canisters under accident conditions.

The NRC has taken climate change into account in its regulation and review of spent fuel storage systems.[50] The primary risks that are exacerbated by climate change are high winds and flooding.[51] The NRC indicates that current regulations are appropriate for a warmer, wetter, and more energetic climate.[52] Further, the NRC notes that any additional regulatory action that may be needed with respect to climate change can be taken in a timely manner to ensure the safe operation of spent fuel storage systems.

5.7 Environmental Justice

Environmental justice is a commitment that no persons bear a disproportionate share of the negative environmental consequences of a proposed project. In the United States, populations that historically have borne disproportionate human and environmental impacts include minority and low-income populations.

Analysis in Chapter 4.3 discussed environmental justice with respect to potential non-radiological impacts. The analysis used the census tract which contains the MNGP for purposes of identifying minority and low-income populations. This is appropriate because potential non-radiological impacts are limited in their extent; almost all impacts would occur within the census tract. This is not the case for potential radiological impacts. Radiological impacts, particularly impacts from accidents conditions at the ISFSI, could extend for several miles.[53]

The 2005 environmental report for the MNGP's NRC license extension used a study area with a 50-mile radius from the MNGP, rather than the census tract which contains the MNGP, for its environmental justice analysis.[54] The 50-mile radius included 21 Minnesota counties and 2,166 census tracts.

The report identified 587 census tracts within 50 miles of the MNGP that had minority populations.[55] Of these tracts, 581 were located in Hennepin and Ramsey counties. The report identified 91 census tracts with low-income populations; of these, 84 were located in Hennepin and Ramsey counties.[56]

The report concluded that the populations identified through its analysis as having potential environmental justice concerns are concentrated in an urban center with a high population density approximately 30 miles from the MNGP site (the Minneapolis-St. Paul metropolitan area).[57]

Based on the report's analysis, environmental justice impacts related to potential radiological impacts are anticipated to be minimal. There are census tracts in the study area with minority and low-income populations; however, these tracts make up 27 percent and 4 percent, respectively, of the census tracts in the study area. Though the number of persons in a census tract varies, the percentage of census tracts with minority and low-income populations is a fair estimate of the population percentages themselves. That is, based on the report's analysis, approximately 27 percent of the population in the study area is minority and 4 percent is low-income. These percentages are not meaningfully greater than the percentages for the State of Minnesota as a whole – 21 percent and 9 percent, respectively (see Table 5).

In sum, minority and low-income populations in the metropolitan area are not anticipated to bear a disproportionate share of any negative radiological consequences of Xcel Energy's proposed additional spent fuel storage. Environmental justice impacts are anticipated to be minimal.

Notes

[1] U.S. Environmental Protection Agency, Radiation Sources and Doses, https://www.epa.gov/radiation/radiation-sources-and-doses.

[2] Id.

[3] National Academy of Sciences, Beir VII: Health Risks from Exposure to Low Levels of Ionizing Radiation, https://www.nap.edu/resource/11340/beir_vii_final.pdf.

[4] Id.

[5] Radioactive Effluent and Monitoring Reports for Monticello, U.S. Nuclear Regulatory Commission, https://www.nrc.gov/reactors/operating/ops-experience/tritium/plant-specific-reports/mont.html.

[6] In addition to the radiation dose standards noted in Table 7, the NRC has promulgated standards for other dose scenarios, e.g., workers with planned special exposures (10 CFR 20) and workers during accident conditions (EPA-400-R-92-001).

[7] 2020 Annual Radiological Environmental Operating Report, Monticello Nuclear Generating Plant, https://www.nrc.gov/docs/ML2113/ML21133A495.pdf

[8] Id.

[9] Id.

[10] Environmental Monitoring, Minnesota Department of Health, https://www.health.state.mn.us/communities/environment/radiation/monitor/index.html; Environmental Monitoring Report, 2020 Data – July 1, 2021, https://www.health.state.mn.us/communities/environment/radiation/docs/monitor/2020envirorpt.pdf.

[11] Id.

[12] Id.

[13] There are no gaseous or liquid effluents from the spent fuel canisters under normal operation conditions; thus, there are no radiation doses associated with exposure to, of ingestion of, radioactive materials.

[14] Scoping EAW, Section 22.2. The closest residence is approximately 0.36 miles southwest of the MNGP ISFSI.

[15] Id.

[16] 2020 Annual Radiological Environmental Operating Report, Monticello Nuclear Generating Plant, https://www.nrc.gov/docs/ML2113/ML21133A495.pdf.

[17] Environmental Monitoring Report, 2020 Data – July 1, 2021, https://www.health.state.mn.us/communities/environment/radiation/docs/monitor/2020envirorpt.pdf.

[18] See Chapter 4.2.

[19] (84 persons) X (0.4 mrem/year) X (70 years) X (1 E-06 cancer incidences/person-mrem) = 0.0024 cancer incidences, or 240 cancer incidences per 100,000 persons. This estimate is conservative in that residents are not anticipated to be at home, outside, 24 hours a day, for 70 years.

[20] The cancer incidence rate in the United States for all cancers is 442 incidences per 100,000 persons per year; see Cancer Statistics, National Cancer Institute, https://www.cancer.gov/about-cancer/understanding/statistics. (84 persons) X (0.00442 incidences/person-year) X (70 years) = 26 cancer incidences.

[21] Monticello 2040 Comprehensive Plan, https://www.ci.monticello.mn.us/274/Monticello-2040.

[22] (7,000 persons) X (0.4 mrem/year) X (70 years) X (1 E-06 cancer incidences/person-mrem) = 0.196 cancer incidences.

[23] (7,000 persons) X (0.00442 incidences/person-year) X (70 years) = 2,166 cancer incidences.

[24] 10 CFR 72, https://www.nrc.gov/reading-rm/doc-collections/cfr/part072/full-text.html#part072-0120.

[25] Standardized NUHOMS Horizontal Modular Storage System for Irradiated Nuclear Fuel, Final Safety Analysis Report, Appendix K, Transnuclear, https://www.nrc.gov/docs/ML0510/ML051040569.pdf [hereinafter NUHOMS FSAR].

[26] Id.

[27] Id.

[28] Id.

[29] Id.

[30] Id.

[31] Id.

[32] Monticello 2005 EIS, Chapter 4.1

[33] NUHOMS FSAR.

[34] Id.

[35] Id.

[36] Id.

[37] Id.

[38] Backgrounder on Nuclear Security, U.S. NRC, https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/security-enhancements.html.

[39] A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensees, U.S. NRC, NUREG-1140, https://www.nrc.gov/docs/ML0620/ML062020791.pdf.

[40] Emergency Planning Zones, U. S. NRC, https://www.nrc.gov/about-nrc/emerg-preparedness/about-emerg-preparedness/planning-zones.html.

[41] Id.

[42] Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities (NUREG-0713), U.S. NRC, https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0713/index.html.

[43] Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities 2019, U.S. NRC, https://www.nrc.gov/docs/ML2211/ML22111A013.pdf.

[44] Id.

[45] Id. Average over 2010-2019 timeframe.

[46] Id.

[47] (99.8 person-rem/year) X (1000 mrem/rem) X (40 years) X (1 E-06 cancer incidences/person-mrem) = 3.99 cancer incidences.

[48] Prairie Island Final Supplement Environmental Impact Statement, Minnesota Department of Commerce, April 2022, Chapter 5, https://apps.commerce.state.mn.us/eera/web/file-list/14841.

[49] (100 persons) X (5,000 mrem) X (1 E-06 cancer incidences/person-mrem) = 0.5 cancer incidences.

[50] Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel, NUREG-2157, https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr2157/v1/index.html (see Section 4.18) [hereinafter NUREG-2157].

[51] Id.

[52] Id.

[53] See Chapter 5.3, noting that emergency response planning required by the NRC includes 10 mile and 50 mile emergency planning zones.

[54] Applicant's Environmental Report – Operating License Renewal Stage, Monticello Nuclear Generating Plant, Nuclear Management Company, March 2005, NRC Docket N0. 50-263, https://www.nrc.gov/docs/ML0508/ML050880250.pdf [hereinafter 2005 Environmental Report].

[55] Id.

[56] Id.

[57] Id.

6 Cumulative Impacts

Cumulative impacts are impacts to the environment that result from the incremental effects of a project in addition to past, present, and reasonably foreseeable future projects regardless of who undertakes these projects. Two projects that are reasonably foreseeable because they are connected to Xcel Energy's request for additional spent fuel storage are discussed here: (1) continued operation of the MNGP through 2040, and (2) use of the MNGP ISFSI to facilitate decommissioning of the MNGP after cessation of operations in 2040.

Potential impacts to the human and natural environment as a result of MNGP operations through 2040 are anticipated to be minimal. Potential impacts resulting from use of the MNGP ISFSI to facilitate decommissioning are also anticipated to be minimal, provided that monitoring and maintenance of the ISFSI continues until such time as the spent fuel can be transported to an offsite facility. If monitoring and maintenance do not continue, radiological impacts are anticipated to be significant.

6.1 Continued Operation of the MNGP Through 2040

Potential impacts to the human and natural environment as a result of MNGP operations through 2040 are anticipated to be minimal. Non-radiological impacts are related primarily to the use of river water for cooling. These impacts are anticipated to be minimal. Radiological impacts are related to regulated releases of radioactive liquids and gases as well as direct radiation. These impacts are also anticipated to be minimal.

Potential Non-Radiological Impacts

The MNGP is a 671 megawatt electric generating plant. The plant is powered by a boiling water nuclear reactor. Heat generated by the reactor is used to create steam which drives a turbine and electric generator. Water from the Mississippi River, in combination with cooling towers, is used in a circulating water system to reject heat.[1]

The MNGP site consists of several buildings including the reactor building and turbine building, which house the reactor and turbine-generator systems, respectively. The site includes an off-gas stack for regulated releases of gases.[2] Electricity generated at the plant is distributed to the electrical grid through a substation and switchyard, and seven interconnecting transmission lines.[3]

Impacts to the Human Environment

Continued operation of the MNGP through 2040 will introduce no new, non-radiological impacts to the human environment. The MNGP site is a developed, industrial site. No changes to the MNGP or associated facilities, other than regular maintenance and repair activities, are anticipated.

Continued operation of the MNGP will not change aesthetics in the area, create new noise impacts, or add to any existing traffic impacts.[4] Continued operation of the MNGP is consistent with existing and planned land uses.[5] Continued operation of the MNGP will not introduce new, non-radiological health or safety concerns.

As discussed in Chapter 4.3, the MNGP is an economic resource in the area. MNGP property taxes provide a relatively high and stable source of tax revenue for the city of Monticello. Continued operation of the MNGP would have a positive socioeconomic impact on the city of Monticello and local economies.

Impacts to the Natural Environment

Potential non-radiological impacts to the natural environment are related to the use Mississippi River water for heat rejection from the MNGP. Water from the river is withdrawn through an intake structure, circulated through the MNGP condenser and through cooling towers, and is then discharged back into the river.[6]

Impacts to fish can occur if they are injured or killed by screens and other filtering systems when water is withdrawn from the Mississippi River.[7] Fish can also be impacted by heat shock if the water discharged back into the river is at too high a temperature.[8] Analysis based on several years of sampling and monitoring fish communities in the Mississippi River indicates that impacts to fish communities in the river as a result of MNGP operations are minimal.[9] Sampling upstream and downstream of the plant show similar, stable populations of fish species.[10]

Xcel Energy is required by the Clean Water Act to use the best technology available to minimize adverse impacts related to its circulating water system at the MNGP.[11] Further, the MNGP has a national pollutant discharge elimination system (NPDES) permit from the MPCA that addresses potential impacts to fish communities in the Mississippi River (e.g., by limiting discharge water temperatures).[12] In sum, potential impacts to fish communities as a result of continued operation of the MNGP are anticipated to be minimal.

Fish and other species that rely on the Mississippi River could also be impacted by continued MNGP operations if evaporative losses of water due to the MNGP's circulating water system substantially reduced the flow of the river. However, this is not the case. The MNGP has a water appropriations permit from the DNR that limits water withdrawals from the Mississippi River.[13] Under worst case conditions, the evaporative loss of water from the MNGP circulating water system would be about 2.25 percent.[14] The represents about 14.5 cubic feet per second (cfs) of water flow from a river that has an annual average flow of 7,217 cfs.[15] Thus, impacts to fish and riparian species are anticipated to be minimal.

No impacts to terrestrial species are anticipated as a result of continued operation of the MNGP through 2040.[16] The MNGP site is a developed, industrial site with little to no habitat. Impacts to rare and unique natural resources are also not anticipated (see Chapter 4.4).

Impacts of the Project on Climate Change

The MNGP generates minimal greenhouse gases. Electric energy is generated at the MNGP from the heat produced by a controlled nuclear reaction; thus, the MNGP has no carbon emissions.[17] The conclusion that the MNGP generates minimal greenhouse gases is true considering both direct and lifecycle emissions (Appendix D). Analysis by the National Renewable Energy Laboratory indicates that electricity generated by nuclear power has lifecycle greenhouse gas impacts similar to solar farms and wind farms (Appendix D).

As continued operation of the MNGP would result in minimal greenhouse gas emissions, adverse climate impacts are not anticipated. Greenhouse gas emissions of alternatives to continued operation of the MNGP are discussed in Chapter 8.

Impacts of Climate Change on the Project

Minnesota's climate is getting wetter and warmer due to anthropogenic GHG emissions. These two trends may impact the ability of the MNGP to reject heat to the Mississippi River. If Minnesota's climate is wetter such that flow in the Mississippi River is stable or increases over time, no impacts to heat rejection are anticipated. If the climate is warmer such that the river flow decreases over time, the flow could reach a level that limits heat rejection and operation of the plant.

Historical river flow data (1971-2001) indicates that the flow of the Mississippi River at the MNGP is fairly stable.[18] The flow peaks in the spring and reaches a minimum during winter.[19] This stability argues that potential climate change impacts on operation of the MNGP will be minimal. However, it is possible that climate change creates greater variability with respect to precipitation and droughts.[20] Thus, it's possible that future flows may be limited by drought to an extent that impacts MNGP operations.

Finally, it's possible that climate change could result in the Mississippi River at the MNGP having an increased flow and increased temperature. This scenario would not impact heat rejection unless the water temperature increased to such an extent that heat could not effectively be rejected.[21] Though this is a possibility, it is not likely as the MNGP has the ability to use cooling towers to lower the temperature of cooling water.

On whole, climate change impacts on MNGP operations, particularly heat rejection, are anticipated to be minimal; however, there is uncertainty in this characterization due to the potential variability in Minnesota's future climate.

Potential Radiological Impacts

Potential radiological impacts from operation of the MNGP through are related to regulated releases of radioactive effluents and from direct radiation. As discussed in Chapter 5.3, direct radiation levels near the MNGP (including the MNGP and its ISFSI) are indistinguishable from background radiation levels. Thus, the discussion here focuses on potential impacts from radioactive effluents.

The nuclear chain reaction within the MNGP reactor produces neutron radiation which has the ability to activate other materials – gases, liquids, and solids – within the reactor system. Activation means that these materials absorb neutrons and become unstable; thus, they are induced to become radioactive themselves. Xcel Energy is required by the NRC to monitor and manage all radioactive wastes generated by the MNGP. The radioactive wastes must be collected and treated, and any releases to the environment must be within NRC regulations.[22] To accomplish this collection and treatment, there are separate gas, liquid, and solid radioactive waste systems at the MNGP.[23]

Radioactive gases generated at the MNGP are collected in a holding tank to allow for radioactive decay of short-lived radioisotopes.[24] Any particulates in the gases are removed; any gases that can be recombined to create liquids are removed. Finally, any remaining gases are filtered and released through the off-gas stack at the plant. The gas radioactive waste system operates continuously to keep all releases within NRC standards.[25]

Radioactive liquids generated at the MNGP are collected through equipment and floor drains and through water process systems at the plant. Liquids are processed and are (1) returned to the plant's condensate system for re-use, or (2) solidified and shipped as a solid to an offsite radioactive waste management facility.[26] Xcel Energy manages its liquid radioactive wastes with a goal of having no routine releases from the plant. In some years, radioactive liquids may be released from the MNGP; all releases are within NRC standards.[27]

Solid radioactive wastes generated at the MNGP include spent reactor control blades, resins, ion chambers, clothing, rags, filters, and solidified liquid wastes.[28] Wastes are stored in shielded storage to allow for radioactive decay. Solid wastes are then shipped to an offsite radioactive waste management facility.[29]

Potential Exposure Pathways and Impacts to the Public

Members of the public could receive a radiation dose from the MNGP's radioactive effluents by ingesting radionuclides or by inhalation of radionuclides in the air.[30] Radionuclides could be ingested by drinking water or by eating foods upon which radionuclides have been deposited. Potential doses from ingesting or inhaling radionuclides are estimated based on sampling near the MNGP and are calculated using an NRC-required dose calculation manual.[31] To demonstrate that doses are within NRC standards, Xcel Energy must file an annual radioactive effluent release report and an annual radiological environmental operating report with the NRC.[32]

Estimated radiation doses to the general public from radioactive effluents from the MNGP are minimal. For example, in 2020, for a postulated most-exposed member of the public, annual estimated doses are less than 1 mrem, indistinguishable from background radiation, and within NRC standards (Table 9).[33] Further, estimated radiation doses from MNGP effluents do not vary significantly over time.[34] Xcel Energy's 2020 environmental operation report shows that doses due to gaseous and liquid effluents are essentially stable over the 2009 – 2020 time period.[35]

Table 9. Estimated Dose to Most-Exposed Individual Due to MNGP Effluents, 2020[36]

Organ	Estimated Dose (mrem)	Dose Limit (mrem)
Whole Body	0.0108	25
Thyroid	0.0299	75
Maximum Other Organ (Bone)	0.0316	25

Monitoring and sampling by the MDH confirm that estimated radiation doses from MNGP operations are minimal and within NRC standards.[37] Thus, potential radiological impacts of continued operation of the MNGP through 2040 are anticipated to be minimal.

Potential Impact to Workers

Potential radiological impacts to workers at the MNGP are discussed in Chapter 5.4. As discussed there, potential impacts are anticipated to be minimal and do not vary significantly over time. Thus, potential radiological impacts to MNGP workers as a result of continued operation of the MNGP through 2040 are anticipated to be minimal.

Off-Normal and Accident Conditions

Assuming that monitoring and maintenance continue as currently performed at the MNGP, radiological impacts from any off-normal or accident conditions at the MNGP which might occur during an additional 10 years of operation (through 2040) are anticipated to be within NRC standards and are not anticipated to be significant.

The NRC has conducted a probabilistic risk assessment (PRA) for potential off-normal and accident scenarios at the MNGP.[38] The PRA examined potential off-normal and accident scenarios and estimated their frequency of occurrence and potential associated radiological impacts. Impacts to the general public would generally not occur unless there was a radiological release from the reactor containment building or associated facilities.

The PRA determined that the most likely accident scenario involving a containment failure would occur once every 25,000 reactor-years.[39] In this scenario, the MNGP reactor would release less than one percent of its radioactive cesium (a by-product of the nuclear chain reaction).[40] Additionally, the scenario assumes that a release would occur more than six hours after an emergency has been declared, thus giving time for emergency response measures, e.g., evacuation of the local populace.[41] This release would lead to a radiological dose of about 2,000 person-rem, similar to dose from the 1979 accident at the Three Mile

Island nuclear plant (discussed below).[42] This dose would result in an estimated 2.0 additional incidences of cancer in the local population.

The PRA estimated the frequency of a severe accident with a major radiological release (more than one-half of the radioactive cesium in the reactor core is released) as once in every 400 million reactor-years.[43] This is a low probability event; however, the radiological impacts of such an event would be significant, i.e., similar to the impacts of the 1986 Chernobyl nuclear plant accident.[44]

The NRC has also evaluated potential accidents at reactor sites in the United States in a generic EIS (NUREG-1437).[45] The EIS uses regression analysis to estimate the radiological impacts of potential accidents. Analysis in the EIS estimates the collective dose to the public from a severe accident at the MNGP to be 730 person-rem. This dose would result in an additional 0.73 incidences of cancer in the local population.

The most serious accident to occur at a commercial U.S. nuclear plant is the accident at the Three Mile Island plant in 1979.[46] Due to a loss of coolant, the reactor core at the plant suffered a partial meltdown. The estimated collective dose to the general public from the accident was approximately 2,000 person-rem.[47] This dose was within NRC standards and was indistinguishable from background radiation.[48]

Based on the PRA conducted for the MNGP, the NRC's generic EIS accident evaluation, and the accident at Three Mile Island, radiological impacts from any off-normal or accident conditions at the MNGP which might occur during an additional 10 years of operation are anticipated to be within NRC standards and are not anticipated to be significant.

Fukushima Daiichi Accident

On March 11, 2011, an earthquake off the coast of Japan created a tsunami which disabled cooling systems for three reactors at the Fukushima Daiichi nuclear plant.[49] The plant lost all direct and backup electrical power sources and was not able to maintain reactor cooling systems. Thus, the reactors suffered partial meltdowns. The reactors were boiling water reactors of a design similar to the MNGP.[50]

In response to the Fukushima Daiichi accident, the NRC requested information from reactor operators in the United States and subsequently issued a series of orders directing changes at reactor sites. These changes included new capabilities to ensure reactor cooling during a loss of power, to ensure reactor containment buildings can be vented during accidents, and to monitor spent fuel pool water levels.[51] Xcel Energy has made changes at the MNGP in response to the NRC orders.[52]

6.2 Use of the MNGP ISFSI to Facilitate Decommissioning

If the Commission authorizes operation of the MNGP through 2040, it is possible that the plant would cease operations at that time and undergo decommissioning.[53] Spent nuclear fuel would, in a step-wise process, be removed from the reactor, cooled in the spent fuel pool, and then moved to the MNGP ISFSI.[54] To accommodate the spent fuel associated with decommissioning, the MNGP ISFSI would need to be expanded or a second ISFSI constructed on the MNGP site. Xcel Energy estimates that an additional 36 spent fuel canisters would be needed to decommission the MNGP.[55] Thus, 80 canisters in total would be stored on the MNGP site.[56]

Alternatives to the storage of spent nuclear fuel in the MNGP ISFSI are discussed in Chapter 7. As is noted there, there is substantial uncertainty as to when an offsite storage facility will be available to accept spent nuclear fuel from the MNGP. Because of this uncertainty, the analysis here assumes the temporary, long-term storage of spent fuel in the MNGP ISFSI for up to 200 years. This assumption is strictly for analysis purposes and is used to bound the uncertainty associated with the eventual availability of an offsite storage facility.

Potential impacts resulting from use of the MNGP ISFSI to facilitate decommissioning are anticipated to be minimal, provided that monitoring and maintenance of the ISFSI continues until such time as the spent fuel can be transported to an offsite facility. If monitoring and maintenance do not continue, then radiological impacts are anticipated to be significant.

Potential Non-Radiological Impacts

To accommodate the spent fuel associated with decommissioning, the MNGP ISFSI would need to be expanded or a second ISFSI constructed on the MNGP site. Xcel Energy notes that the decision whether to expand the existing ISFSI or construct a second ISFSI would be made at the time of decommissioning.[57] Xcel Energy would conduct an engineering study to guide its decision.

A possible expanded ISFSI and a possible second ISFSI site are shown in Figure 11. The second ISFSI site is an alternative site proposed by Xcel Energy in 2005, prior to selecting and constructing the current ISFSI. Both an expanded ISFSI and the possible alternative ISFSI site have the advantage of being outside the floodplain for a projected maximum probable flood.[58]

Whatever location is selected to store the decommissioning canisters – an expanded ISFSI, the alternative site identified in 2005, or another location within the MNGP site – the construction process would be similar. After geo-technical and engineering analysis, the ISFSI site would be appropriately graded and filled. A heavy haul road would be constructed, and concrete pads would be poured. Electrical power would be extended to the site. The site would be tied into the MNGP's security monitoring system.

Figure 11. Possible Sites for Storage of Spent Fuel Associated with Decommissioning

The potential non-radiological human and environmental impacts associated with using an expanded MNGP ISFSI, or a second, newly-constructed ISFSI, for decommissioning are anticipated to be minimal. As discussed in Chapter 4, the MNGP site is a developed, industrial site. Use of the site to store additional spent fuel canisters associated with decommissioning would not impact human or environmental resources. Minimal impacts related to aesthetics, noise, traffic, and land use are anticipated. Minimal impacts to flora, fauna, and rare natural resources are anticipated.

Potential Radiological Impacts

Assuming that regular monitoring and maintenance continue as currently performed at the ISFSI, radiological impacts from operation of the MNGP ISFSI for up to 200 years are anticipated to be minimal and within NRC standards. Spent fuel canisters are passive systems that emit no radioactive effluents; thus, radiation exposure would occur solely through skyshine radiation (see Chapter 5.3).

The estimated annual radiation dose to the nearest residence with 80 spent fuel canisters in the MNGP ISFSI is 0.7 mrem.[59] This dose is indistinguishable from background radiation and within NRC standards. There are 21 residences within one mile of the MNGP ISFSI. If we assume that these residences represent 84 persons, and that these persons receive 0.7 mrem per year, continuously for 200 years, it's estimated that an additional 0.012 persons, among this group of residents, would be diagnosed with cancer.[60]

Looking out 200 years, and assuming that the population of Monticello increases by 200 percent, and that these additional 28,000 persons reside near the MNGP ISFSI such that they receive the same annual dose as the nearest residence (0.7 mrem per year) for 200 years, it's estimated that an additional 3.9 persons, among these 28,000 persons, would be diagnosed with cancer over these 200 years.[61]

Radiological impacts to MNGP workers during and after decommissioning are anticipated to be minimal. Canisters would no longer need to be loaded and placed on the ISFSI pad. Canisters would still need to be monitored and maintained until moved to an offsite storage facility; thus, this radiation exposure component would remain. It is assumed that plant staffing levels would drop with decommissioning. Thus, the collective plant worker dose would greatly decrease.

NRC Analysis of Continued ISFSI Storage

The NRC has analyzed the potential impacts of continued storage of spent nuclear fuel at ISFISs in the United States in a generic EIS (NUREG-2157).[62] The generic EIS analyzed three potential lengths of spent fuel storage in an ISFSI: (1) 60 years, (2) 160 years, and (3) indefinite storage.[63] Analysis in the EIS was based on a number of assumptions, including:

- Spent fuel canisters would be replaced every 100 years.
- To facilitate this replacement, a dry transfer system (DTS) would be constructed at each ISFSI to repackage spent fuel.
- ISFSI and DTS facilities would be replaced every 100 years.
- Institutional controls would remain in place for all analysis timeframes.

Analysis in the generic EIS indicated that most all potential human and environmental impacts of continued storage of spent nuclear fuel would be small.[64] Though the NRC analyzed a scenario in the EIS reflecting indefinite storage in an ISFSI, the NRC believes that the most likely scenario for spent fuel storage is the availability of a federal, geologic repository within 60 years of a reactor's licensed lifetime.[65] The generic EIS noted that the U.S. Department of Energy (DOE) anticipates the opening of a geologic repository for spent nuclear fuel by 2048.[66]

Monitoring, Maintenance and Institutional Control

Both the analysis in this EIS and that of NRC indicate that the potential radiological impacts of continued storage of spent nuclear fuel in the MNGP ISFSI will be minimal if monitoring and maintenance of the ISFSI continue over time. In order for this to occur, an entity responsible for the monitoring and maintenance must continue to function over time. Additionally, the social and political infrastructure that supports the MNGP ISFSI must continue to function. This continuation of social, political, and economic functioning is commonly known as institutional control.

Analysis in the EIS prepared for Yucca Mountain, the proposed federal, geologic repository for spent fuel, examined the storage of spent fuel in ISFSIs with and without institutional control.[67] In its evaluation of a no-action alternative, the EIS assumes that Yucca Mountain does not enter operation, and that commercial spent nuclear fuel is stored in ISFSIs at existing plant locations for 10,000 years. The EIS examines two scenarios – one in which institutional control exists for all 10,000 years (Scenario 1), and one in which institutional control ends after 100 years (Scenario 2). The analysis makes some simplifying assumptions including the replacement of ISFSIs every 100 years.

In Scenario 1, because institutional control exists for 10,000 years, ISFSIs function as designed and estimated doses to the general public are relatively low (≤ 1 mrem/year) and within NRC standards.[68]

In Scenario 2, institutional control ends after 100 years and this cessation leads to degradation of ISFSIs, their failure, and the eventual release of radionuclides into the environment. For facilities located in the Upper Midwest, the EIS estimates that precipitation will infiltrate the ISFSIs' concrete storage structures 70 years after the end of institutional control, leading to degradation of spent fuel canisters (by corrosion) and an initial release of radionuclides 1,000 years after the end of institutional control.[69] Radionuclides would be released to the air, soil, and surface waters causing chronic exposures and adverse health impacts. The EIS estimates approximately 3,700 additional cancer fatalities over the 10,000 year period, and projects that fatalities would peak about 3,400 years after the end of institutional control due to releases to the Mississippi River and its tributaries.[70] Individuals living near degraded ISFSIs are projected to suffer severe health impacts due to direct radiation and/or internal doses due to ingestion.

Analysis in the Yucca Mountain makes clear that without monitoring and maintenance of ISFSIs, without institutional control that supports this monitoring and maintenance, radiological impacts will be significantly adverse. If monitoring and maintenance do not continue at the MNGP ISFSI for the duration of spent fuel storage in the MNGP ISFSI then radiological impacts are anticipated to be significant.

Funding for Long-Term Storage

Funding mechanisms for the storage of spent nuclear fuel have been established at the federal and state level.

At the federal level, the Nuclear Waste Policy Act (NWPA) established a nuclear waste fund to pay for the development of a geologic repository for spent nuclear fuel. In accordance with the NWPA, nuclear reactor operators entered into contracts with the U.S. Department of Energy (DOE) for the removal and disposal of spent fuel.[71] DOE was to begin disposing of spent fuel by January 31, 1998.[72] DOE did not meet this deadline; subsequently, reactor operators filed lawsuits to recover costs for storing spent nuclear fuel.[73]

Xcel Energy has successfully sued DOE for costs associated with the continued storage of the MNGP's spent nuclear fuel. As storage at the MNGP ISFSI is on-going, likewise the recovery of costs has been on-going. On November 24, 2021, Xcel Energy reported its twelfth DOE settlement payment for spent fuel storage costs.[74] The Commission directs how payments received by Xcel Energy are used – e.g., payments can be invested, used to defray decommissioning costs, or returned to ratepayers.

At the state level, a nuclear decommissioning trust fund (NDT) has been established to cover the costs of decommissioning the MNGP and MNGP ISFSI.[75] The fund covers, among other expenses, the operation of the ISFSI after plant shutdown until all fuel is removed from the site and the removal of all ISFSI structures.[76] The NDT is funded through rates charged to Xcel Energy customers.[77] To the extent the NDT is used for storage of spent nuclear fuel in the ISFSI, DOE settlement payments may also be used to fund the NDT (or offset expenses).[78] The Commission reviews the NDT every three years; the NRC reviews the NDT every two years.[79]

Xcel Energy submitted its most recent NDT review to the Commission on December 1, 2020.[80] In its review, Xcel Energy notes that the two primary factors driving decommissioning costs are (1) when decommissioning activities take place (in the near term versus putting the plant into "safe storage" for years and then conducting decommissioning activities) and (2) how long spent fuel is stored in the ISFSI after shutdown of the plant.[81]

Though federal and state efforts to ensure funding for the safe, long-term storage of spent nuclear fuel are substantial, there are indirect funding requirements that are difficult to quantify and ensure. Safe, long-term storage of spent nuclear fuel requires institutional control that facilitates the monitoring and maintenance of spent fuel storage facilities. This institutional control assumes not only solvent and effective entities responsible for maintaining proper functioning of storage facilities (e.g., an ISFSI), but also solvent and effective socio-political institutions that provide a stable societal framework for these storage facilities. To paraphrase the 2009 Prairie Island EIS, for there to be institutional control of the MNGP ISFSI, the city of Monticello, Wright County, the State of Minnesota, and the United States of America all have to exist as functioning political entities.[82] Whether this functioning can be assured over the time that spent nuclear fuel will be stored in the MNGP ISFSI is an on-going concern.

Off-Normal and Accident Conditions

Assuming that regular monitoring and maintenance continue at the MNGP ISFSI, radiological impacts from off-normal and accident conditions at the ISFSI which might occur over 200 years are anticipated to be within NRC standards and minimal. The addition of 36 spent fuel canisters for decommissioning and the storage of the canisters for up to 200 years does not introduce any new phenomena, natural or man-made, that could compromise the canisters (see Chapter 5.3). The NRC is incorporating climate change risks into its regulation and certification of spent fuel storage systems (see Chapter 5.6).

As noted above, the ability of the MNGP ISFSI to provide safe storage of spent nuclear fuel depends to a great extent on institutional control that facilitates on-going monitoring and maintenance of the ISFSI. Without this control, with monitoring and maintenance, off-normal and accident conditions at the MNGP ISFSI would lead to significant radiological impacts.

Notes

[1] 2005 Environmental Report, Chapter 3.

[2] Id.

[3] Id.

[4] Scoping EAW, Section 21.c.i.

[5] Id.

[6] 2005 Environmental Report, Chapter 3.1.3. The circulating water system can be operated in a variety of modes depending on river levels and cooling requirements.

[7] 2005 Environmental Report, Chapter 4.

[8] Id.

[9] Id.

[10] Id.

[11] Id.

[12] Id.

[13] 2005 Environmental Report, Chapter 4.2.

[14] Id.

[15] Id.

[16] Environmental Report, Chapter 4.6.

[17] The MNGP does have carbon emissions associated with equipment used to maintain the MNGP, e.g., trucks, lifts. However, as noted in the text, these emissions are minimal.

[18] Environmental Report, Chapter 4.2.1.

[19] Id., Figure 2.2-1.

[20] Drought and Climate Change, The Center for Climate and Energy Solutions, https://www.c2es.org/content/drought-and-climate-change; Climate Trends, Minnesota Department of Natural Resources, https://www.dnr.state.mn.us/climate/climate_change_info/climate-trends.html.

[21] France to Curb Nuclear Output as Europe's Energy Crisis Worsens, Bloomberg, August 3, 2022, https://www.bloomberg.com/news/articles/2022-08-03/edf-to-curb-nuclear-output-as-french-energy-crisis-worsens.

[22] Scoping EAW, Section 21.c.i.

[23] Id.

[24] Id.

[25] Id.

[26] Id.

[27] Id.

[28] Id.

[29] Id.

[30] 2020 Annual Radioactive Effluent Release Report, Monticello Nuclear Generating Plant, https://www.nrc.gov/docs/ML2113/ML21133A496.pdf [hereinafter 2020 RERR].

[31] Id.

[32] Radioactive Effluent and Environmental Reports for Monticello, U.S. NRC, https://www.nrc.gov/reactors/operating/ops-experience/tritium/plant-specific-reports/mont.html.

[33] 2020 RERR.

[34] 2020 Annual Radiological Operating Report, Monticello Nuclear Generating Plant, https://www.nrc.gov/docs/ML2113/ML21133A495.pdf.

[35] Id.

[36] 2020 RERR, Table 6; regulatory dose limits established by 40 CFR 190.

[37] Environmental Monitoring, MDH, https://www.health.state.mn.us/communities/environment/radiation/monitor/index.html.

[38] 2005 Monticello EIS, Chapter 5.4.

[39] Id.

[40] Id.

[41] Id.

[42] Id.

[43] Id.

[44] Id.

[45] Generic Environmental Impact Statement for License Renewal of Nuclear Plants: Main Report (NUREG-1437, Volume 1), https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/v1/index.html.

[46] Backgrounder on the Three Mile Accident, U.S. NRC, https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html.

[47] Id.

[48] Id. The NRC estimates that approximately two million persons received a dose of one millirem.

[49] Fukushima Daiichi Accident, World Nuclear Association, https://world-nuclear.org/information-library/safety-and-security/safety-of-plants/fukushima-daiichi-accident.aspx.

[50] Id. The reactors were boiling water reactors with Mark I containment, similar to the MNGP.

[51] Backgrounder on NRC Response to Lessons Learned from Fukushima, U.S. NRC, https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/japan-events.html.

[52] Xcel Energy Additional Information.

[53] Alternately, Xcel Energy could request the Commission to authorize operation of the MNGP through a later date, e.g., 2050.

[54] Minnesota law requires that spent fuel from the MNGP be stored on the MNGP site unless and until it can be transported to an offsite storage facility; see Minnesota Statute 116C.83, Subd. 4.

[55] Scoping EAW, Section 21.c.ii. Xcel Energy would need to obtain a certificate of need from the Commission to store these additional 36 canisters.

[56] 30 canisters (2030) + 14 canisters (2040) + 36 canisters (decommissioning) = 80 canisters.

[57] Xcel Energy Additional Information.

[58] 2005 Monticello EIS, Figure 4-8.

[59] Scoping EAW, Section 21.c.ii. This dose estimate assumes all 80 canisters are placed within an expanded MNGP ISFSI. The estimate would not change significantly if the canisters were placed in the MNGP ISFSI and within a second, alternative ISFSI on the MNGP site.

[60] (84 persons) X (0.7 mrem/year) X (200 years) X (1 E-06 cancer incidences/person-mrem) = 0.012 cancer incidences.

[61] (28,000 persons) X (0.7 mrem/year) X (200 years) X (1 E-06 cancer incidences/person-mrem) = 3.92 cancer incidences. The annual collective dose (person-mrem per year) received by the public and the associated cancer risks will vary over a 200-year timeframe based on the number of residents receiving a dose and their proximity to the ISFSI. Dose rates will decrease with distance from the ISFSI and with time (due to radioactive decay of the spent fuel).

[62] Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel, NUREG-2157, https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr2157/v1/index.html [hereinafter NUREG-2157].

[63] Id.

[64] Id. For NUREG-2157, “small” impacts are “environmental effects [that] are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.”

[65] NUREG-2157, Appendix B.2.

[66] NUREG-2157, Section 1.2.

[67] EIS-0250 Final Environmental Impact Statement: Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada, October 2022, https://www.energy.gov/nepa/downloads/eis-0250-final-environmental-impact-statement [hereinafter Yucca Mountain EIS].

[68] Id. See Chapter 7, Environmental Impacts of the No-Action Alternative, Table 7-6, Table 7-11.

[69] Id.

[70] Id.

[71] Civilian Nuclear Waste Disposal, Congressional Research Service, September 17, 2021, https://sgp.fas.org/crs/misc/RL33461.pdf [hereinafter Civilian Nuclear Waste Disposal].

[72] Id.

[73] Id.

[74] Petition for Approval of a Credit Mechanism to Return to Customers Department of Energy Settlement Payments, Xcel Energy, November 24, 2021, Docket No. M-21-815, eDockets Number 202111-180145-01.

[75] 2009 Prairie Island EIS, Chapter 2, Section 3.4.

[76] Id.

[77] Id.

[78] Id.

[79] Id.

[80] Petition 2022-2024 Triennial Nuclear Plant Decommissioning Study & Assumptions, December 1, 2020, Xcel Energy, Docket No. M-20-855, eDockets Number 202012-168696-01.

[81] Id.

[82] 2009 Prairie Island EIS, Chapter 2, Section 5.4.

7 Alternatives to the MNGP ISFSI

Xcel Energy is requesting that the Commission approve additional storage of spent nuclear fuel in the MNGP ISFSI to facilitate operation of the MNGP through 2040. It's possible that the Commission will deny this request (a "no action" alternative); in this case, Xcel Energy would cease operating the MNGP in 2030. It's also possible that the spent fuel will, in the near future, be stored in a facility other than the MNGP ISFSI. These alternatives are discussed further here.

7.1 No Action Alternative

In a no action alternative, the Commission would deny Xcel Energy's request for additional storage of spent fuel in the MNGP ISFSI. The Commission would not issue a certificate of need for expansion of the ISFSI. Absent other alternatives for storing the spent fuel, Xcel Energy would cease operating the MNGP in 2030. Xcel Energy would need to request Commission approval for additional storage of spent fuel in the MNGP ISFSI to facilitate decommissioning of the MNGP. Spent fuel would be removed from the MNGP reactor, stored in the spent fuel pool, and eventually stored in an ISFSI on the MNGP site.

If the MNGP ceased operation in 2030, Xcel Energy would need to replace the capacity and energy provided by the MNGP in order to maintain reliable operation of the electric transmission system. Two possible replacement scenarios and their potential impacts are discussed in Chapter 8.

Human and Environmental Impacts

Xcel Energy estimates that it will require 36 additional spent fuel canisters to decommission the MNGP in 2030. Thus, there would be a total of 66 canisters in the MNGP ISFSI.[1] The MNGP ISFSI would likely need to be expanded to hold these canisters or a second ISFSI constructed.

The human and environmental impacts of decommissioning the MNGP in 2030 would be similar to those if the MNGP were decommissioned in 2040. These impacts are discussed in Chapter 6.2. These impacts are anticipated to be minimal. As the MNGP site is a developed, industrial site, non-radiological impacts will be minimal. The estimated annual radiation dose to the nearest residence with 66 spent fuel canisters in the MNGP ISFSI is 0.6 mrem.[2] This dose is indistinguishable from background radiation and within NRC standards. Health impacts associated with this dose rate are anticipated to be minimal.

Beyond impacts at the MNGP site, there may be impacts associated with the replacement of the capacity and energy provided by the MNGP – impacts that would occur if the MNGP ceased operation in 2030. For example, if the energy produced by the MNGP were replaced by energy produced with fossil fuels, there would be potential greenhouse gas and global warming impacts. These potential impacts are discussed in Chapter 8.

7.2 Additional Spent Fuel Pool Storage

Instead of storing spent fuel in an ISFSI, the fuel could be stored in a storage pool, similar to the existing storage pool at the MNGP. Additional space for spent fuel to facilitate operation through 2040 could be created by consolidating fuel in the existing pool or by building an additional pool at the MNGP. These spent fuel pool options are not feasible and have radiological impacts that are significantly greater than additional spent fuel storage in an ISFSI.

Consolidating Spent Fuel

Spent fuel in the MNGP spent fuel pool could be consolidated through two means – (1) fuel rod consolidation, a process which involves disassembling spent fuel assemblies and repackaging the assemblies into a smaller volume, or (2) re-racking, a process in which fuel assemblies are left intact and are placed in higher density storage racks.[3] Both processes are directed to using less space to store spent fuel in the pool. Using less space would free up space for additional spent fuel.

Industry experience with fuel rod consolidation has shown that it is not a feasible strategy for creating additional space in a spent fuel pool. The predicted space-savings in a pool were not able to be realized.[4] Additionally, radiation doses to workers were higher than predicted due to labor-intensive spent fuel handling.[5]

Re-racking spent fuel assemblies – moving from low-density to high-density racks within the spent fuel pool – is a possible strategy for creating additional space in a spent fuel pool. However, Xcel Energy estimates that re-racking in the MNGP spent fuel pool would result in additional storage of spent fuel to support less than six years of additional MNGP operation.[6] Thus, re-racking could not support operation of the MNGP through 2040 and is not a feasible option.

Adding a Spent Fuel Pool

An additional spent fuel pool at the MNGP could be constructed similar to the existing spent fuel pool. The pool would be licensed and regulated by the NRC. Unlike an ISFSI, a spent fuel pool uses an active cooling system; water is filtered and circulated within the pool. Pool components would include storage racks, a crane, fuel assembly handling tools, a building ventilation system, and radiation monitoring equipment.[7]

Though an additional spent fuel pool is a possible strategy for storing spent fuel, Xcel Energy's cost estimate indicates that it is significantly more expensive than an expanded ISFSI. Xcel Energy estimates that it will cost about $95 million (2020 dollars) to construct a new spent fuel pool.[8] The cost estimate for an expanded ISFSI is $72.1 million (see Chapter 3.6). In addition, the cost estimate for a spent pool fuel is solely for constructing the pool; it does not include costs for pool operation, nor does it include costs for loading spent fuel into canisters so that the fuel can eventually be moved to an offsite facility. Spent fuel canisters and their loading represent about 80 percent of Xcel Energy's proposed ISFSI expansion costs ($60 million; see Table 2). Adding this amount to the cost of the spent fuel pool results in a total cost of over $150 million, or about twice the cost of an expanded ISFSI. This cost makes an additional spent fuel pool prohibitively expensive and infeasible.

Beyond costs, and depending on the how spent fuel is managed in the spent fuel pools, radiation doses to workers would likely be higher for an actively managed pool system than for a passive ISFSI system.[9] If spent fuel was first placed in the current MNGP pool and then moved to a second, more long term spent fuel pool, this additional handling would introduce additional radiation doses for workers.

7.3 Alternative Spent Fuel Storage Technologies

The NRC certifies two basic types of spent fuel storage technology – casks and canisters (see Chapter 3). The MNGP currently uses canister technology. Xcel Energy has indicated that it will solicit bids solely for canister systems for additional storage in the MNGP ISFSI. Thus, the discussion in this EIS is focused on the use of canister systems.

This said, Xcel Energy could use a cask system for the storage of spent fuel in the MNGP ISFSI. As noted in Chapter 2, the Commission may grant a CN contingent on modifications to the project, e.g., use of a cask system rather than a canister system.

Advantages of a cask system include relatively less handling of spent fuel compared to a canister system and relatively lower radiation doses for workers.[10] Casks are bolted shut and thus do not require welding. Casks are all-in-one metal vessels; unlike canister systems, they do not require a transfer cask. Because cask system require relatively less spent fuel handling, worker radiation doses are relatively lower for cask systems.

Disadvantages of a cask system include cost, a relative lack of industry innovation, and potential obstacles in moving casks to an offsite storage facility. Casks are large metal vessels that require specialized equipment to fabricate and handle. Because there are only a few facilities that can manufacture casks and because of the amount of steel involved, casks are about twice as expensive as canisters.[11] Over time, canister systems have been adopted by the nuclear industry as the predominant method for storing spent nuclear fuel.[12] As a result, advances in canister systems can be shared among ISFSI operators. These advances are not available to cask systems. Thus, cask systems are not supported by spent fuel industry innovations or advances.

Xcel Energy notes that the only cask system currently available for the storage of spent fuel from a boiling water reactor (like the MNGP) is the TN-68 system manufactured by Orano, Inc.[13] Xcel Energy indicates that the TN-68 cask diameter is larger than the loading space in the MNGP spent fuel pool.[14] Thus, use of the cask would require moving spent fuel racks within the spent fuel pool. Further, the cask's weight exceeds the lifting capability of the plant's reactor building crane.[15] A crane with a greater lifting ability would be required to use the TN-68 cask.

Finally, interim storage facilities being developed in the United States (discussed below) are predicated on the storage of spent fuel canisters, not casks.[16] The NRC license applications for these facilities are based storing spent fuel canisters. In order to store casks, the facilities would need to amend their NRC licenses. Any amendments, if pursued by the facilities, would take additional time and push any casks awaiting transport and storage back in the queue. In contrast, spent fuel canisters could be transported and stored once the facilities are operational.

7.4 Federal Repository – Yucca Mountain

The NWPA, first enacted in 1982 and subsequently amended, governs efforts in the United States to manage spent nuclear fuel.[17] The NWPA:

- Requires DOE to establish a permanent geologic repository at Yucca Mountain, Nevada, for the storage of spent nuclear fuel.
- Allows DOE to construct a monitored retrievable storage (MRS) facility if DOE recommends to the President that a permanent repository can be constructed; further, construction of the MRS facility cannot begin until Yucca Mountain has received a construction permit.
- Establishes a nuclear waste fund to pay for development of a geologic repository.[18]

DOE completed an EIS for the Yucca Mountain repository in 2002. DOE submitted a license application for the Yucca Mountain repository to the NRC in 2008. In 2010, the Obama administration determined that the Yucca Mountain repository should not be opened and discontinued funding for the repository.[19] Subsequent administrations have (1) proposed funding for the repository but not received funding from Congress and (2) not requested funding for the repository.[20] Thus, the Yucca Mountain repository remains lodged in the NRC licensing process without funding to move forward.

At the same time that the Obama administration foreclosed the Yucca Mountain repository, it established a Blue Ribbon Commission (BRC) to recommend new spent fuel management strategies.[21] The BRC recommended that the NWPA be amended to adopt a consent-based approach to the siting of a geologic repository.[22] Additionally, the BRC recommended that the NWPA be amended to allow for multiple MRS facilities whose development could proceed independent of a repository.[23]

Since the BRC report, several bills have been introduced in Congress that address consent-based siting for MRS facilities and for a geologic repository. To date, none of these bills has been passed out of Congress or enacted into law.[24] Nonetheless, DOE anticipates that Yucca Mountain will open by 2048 (see Chapter 6.2).

Thus, Yucca Mountain remains a possible offsite storage facility for the MNGP's spent fuel, albeit at some time in the future. Yucca Mountain is not currently a feasible alternative to additional storage of spent fuel in the MNGP ISFSI.

7.5 Interim Off-Site Storage Facilities

As a federal repository remains undeveloped and spent nuclear fuel continues to accumulate at reactor sites throughout the United States, two companies have proposed privately developed and operated consolidated interim storage facilities (CISFs).

Interim Storage Partners LLC has proposed a CISF in Andrews County, Texas.[25] The CISF would be built in eight phases with each phase holding 5,000 metric tons of spent fuel, for a total of 40,000 metric tons.[26] The NRC issued a license for the first phase of the facility on September 13, 2021.[27]

Holtec International (Holtec) has proposed a CISF in Lea County, New Mexico.[28] The CISF would, ultimately, hold up to 173,600 metric tons of spent fuel in 10,000 spent fuel canisters.[29] Holtec's initial application to the NRC requested a license for 8,680 metric tons of spent nuclear fuel stored in Holtec spent fuel canisters.[30] The NRC is currently preparing a final EIS and a safety evaluation report for the project.

To date, neither the Interim Storage Partners CISF nor the Holtec CISF has accepted spent nuclear fuel for storage, and it is unclear when or whether they might accept such fuel. The state of Texas has enacted a law banning new storage sites for spent nuclear fuel within the state.[31] The state of New Mexico has filed a lawsuit to block the licensing of the Holtec CISF.[32]

Additionally, it is unclear whether private CISFs are compatible with the NWPA. The NWPA permits DOE to construct an MRS facility if Yucca Mountain has received a construction permit. It is unclear if DOE may contract with a private developer for the interim storage of spent fuel absent a Yucca Mountain construction permit.[33] In 2019, then DOE secretary Rick Perry indicated that current law prevents DOE from contracting for interim storage of spent fuel at a private facility.[34] Legislation authorizing DOE to enter into contracts with private CISFs was introduced in Congress several times in the 2015-2021 timeframe; however, none of the bills was enacted into law.[35]

CISFs are a possible offsite storage facility for the MNGP's spent fuel. As noted above (Chapter 7.3), these facilities are designed to store spent fuel canisters. The MNGP currently uses a canister system; Xcel Energy intends to solicit bids solely for canisters systems for the additional spent fuel required for MNGP operation through 2040. However, because there are several legal and political challenges to storing spent fuel in CISFs, and these challenges will likely play out over an extended period of time, CISFs are not currently a feasible alternative to additional storage of spent fuel in the MNGP ISFSI.

Notes

[1] 30 canisters (2030) + 36 canisters (decommissioning) = 66 canisters.

[2] Extrapolated from the estimated dose rate with 80 canisters in the MNGP ISFSI.

[3] CN Application, Chapter 9.1.2.

[4] Id.

[5] Id.

[6] Id.

[7] Id.

[8] Id. Xcel Energy's estimate was $50 million in 1991 dollars. This is equivalent to $95.03 million in 2020 dollars (see Inflation Calculator, Federal Reserve Bank of Minnesota, https://www.minneapolisfed.org/about-us/monetary-policy/inflation-calculator).

[9] Id.

[10] CN Application, Chapter 9.1.3; see also Table 7.

[11] 2022 Prairie Island Final Supplemental Environmental Impact Statement, Chapter 3.6, eDockets Number 20224-185119-01 [hereinafter 2022 Prairie Island SEIS].

[12] Id.

[13] CN Application, Chapter 9.1.3.

[14] Id.

[15] Id.

[16] 2022 Prairie Island SEIS, Chapter 1.3 and 3.6.

[17] Civilian Nuclear Waste Disposal.

[18] Id.

[19] Id.

[20] Id.

[21] Id.

[22] Blue Ribbon Commission on America's Nuclear Future, January 2012, https://www.energy.gov/sites/prod/files/2013/04/f0/brc_finalreport_jan2012.pdf.

[23] Id.

[24] Civilian Nuclear Waste Disposal.

[25] Civilian Nuclear Waste Disposal; Interim Storage Partners, https://www.nrc.gov/waste/spent-fuel-storage/cis/waste-control-specialist.html; the CISF would be located next to two existing low-level radioactive waste storage facilities.

[26] Civilian Nuclear Waste Disposal.

[27] Id.

[28] Civilian Nuclear Waste Disposal; Holtec International – HI-STORE CISF, https://www.nrc.gov/waste/spent-fuel-storage/cis/holtec-international.html.

[29] Civilian Nuclear Waste Disposal.

[30] Holtec International – HI-STORE CISF, https://www.nrc.gov/waste/spent-fuel-storage/cis/holtec-international.html.

[31] Civilian Nuclear Waste Disposal.

[32] Id.

[33] Id.

[34] Id.

[35] Id.

8 Alternatives to Continued Operation of the MNGP

In a no action alternative, the Commission would deny Xcel Energy's request for additional storage of spent fuel in the MNGP ISFSI. Absent other alternatives for storing spent fuel, Xcel Energy would cease operating the MNGP in 2030. If the MNGP ceased operation in 2030, Xcel Energy would need to replace the capacity and energy provided by the MNGP in order to maintain reliable operation of the electric transmission system.

Xcel Energy has modeled two scenarios for replacing the MNGP in 2030.[1] Both of the replacement scenarios have greater aesthetic and land use impacts than continued operation of the MNGP. Additionally, both scenarios will have relatively greater impacts on fauna, specifically birds and bats. Xcel Energy's modeling indicates that both replacement scenarios are more expensive on a social cost basis and have greater carbon emissions than continued operation of the MNGP.[2]

The two MNGP replacement scenarios modeled by Xcel Energy are the only two scenarios discussed in this EIS (Appendix A). Other replacement scenarios are possible.

8.1 Capacity and Energy

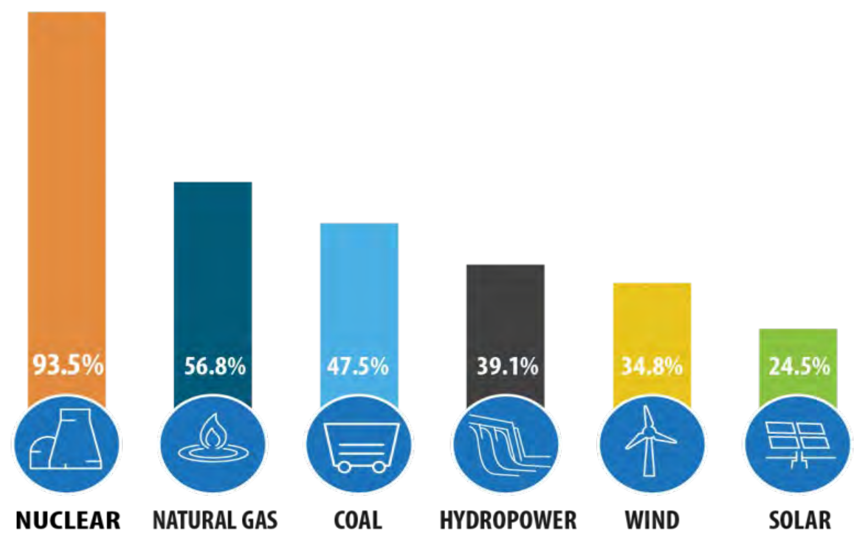
The MNGP provides both capacity and energy to the electrical system in Minnesota. Capacity is a measure of the maximum amount of electricity that a generator can produce.[3] For power plants, capacity is usually expressed in megawatts (MW). Thus, when the MNGP is noted as a 671 MW generating plant, it means that the plant can produce 671 MW when running at its maximum output.

Energy is a measure of the amount of electricity that a generator can produce over time. For power plants, energy is usually expressed in megawatt-hours (MWh). Energy takes into account that a generating plant may not be operating at its maximum output all of the time. The output of the plant may vary over time. For example, a solar generating plant produces electricity only when the sun is shining.

The MNGP provides a substantial portion of the electric capacity and energy generated in Minnesota. By capacity, it is the fifth largest generating plant in the state; by energy, it is the third largest generating plant.[4] In 2020, Minnesota utilities produced 40.2 MWh of energy; the MNGP produced 5.6 MWh, or about 14 percent of the energy produced in Minnesota.[5]

Nuclear power plants need to be refueled every 18 to 24 months. Thus, nuclear plants can be on-line, generating electricity for relatively long stretches of time.[6] This means that nuclear plants have a relatively high capacity factor – i.e., they are operating at their generating capacity almost all of the time. In 2019, nuclear plants in the U.S. were on-line and operating at capacity 93.5 percent of the time (Figure 12).

Figure 12. Capacity Factors by Energy Source – United States, 2019[7]



8.2 MNGP Replacement Scenario 1

Xcel Energy has modeled two scenarios for replacing the MNGP in 2030. In the first scenario (Scenario 1), the model is permitted to select generation resources of any type, including carbon-based resources (e.g., natural gas plant), to replace the capacity and energy provided by the MNGP. The model selects these resources with a goal of minimizing costs. Given these parameters, Scenario 1 adds natural gas-fired combustion turbines (750 MW), wind turbines (750 MW), and solar farms (200 MW) (Table 10).[8] In addition, Scenario 1 relies on additional purchases of energy from market sources.

Potential Impacts to the Human Environment

Scenario 1 places new generation facilities on the landscape – combustion turbines, wind turbines, and solar farms. These facilities, even with proper siting, will have impacts on the human environment. The facilities will have aesthetic impacts; such impacts are likely limited for combustion turbines and solar farms – combustion turbines due to their compactness and solar farms because of their relatively low height. However, wind turbines can be seen from a distance and impact the aesthetics of entire viewsheds. In comparison, continued operation of the MNGP would create no new aesthetic impacts.

All of the Scenario 1 facilities will generate noise. With proper siting, noise levels will be within state noise standards. However, compared with continued operation of the MNGP, Scenario 1 will introduce new noise sources on the landscape.

The Scenario 1 facilities will impact land use and agriculture. Wind farms require about 0.3 acres of land per MW; solar farms require 7 to 10 acres per MW.[9] Thus, compared with continued operation of the MNGP, Scenario 1 will impact about 225 additional acres of land for wind turbines and 1,400 acres of land for solar panels. A combustion turbine facility would add approximately an additional 45 acres.[10] The land used for wind turbines and solar panels could, at a future date, be returned to agricultural or other use. The land for combustion turbines would be relatively more difficult to remediate and repurpose.

Xcel Energy's modeling indicates that the reliability of the electricity supplied in Scenario 1 would be similar to continued operation of the MNGP.[11] Though wind farms and solar farms have relatively low capacity factors (see Figure 12), electrical energy from combustion turbines and from market sources bolster the reliability of Scenario 1.

Compared with continued operation of the MNGP, Scenario 1 is relatively more expensive on a social cost basis (i.e., when accounting for the costs of emissions, particularly carbon emissions) (Table 10).[12]

Table 10. Replacement Scenarios Compared to Continued Operation of MNGP over 2030 – 2040 Timeframe[13]

Characteristic	Scenario 1	Scenario 2
Resources selected to replace MNGP capacity and energy	• Combustion turbines (750 MW) • Wind turbines (750 MW) • Solar farms (200 MW) • Market purchases	• Wind turbines (950 MW) • Solar farms (700 MW) • Storage (300 MW) • Market purchases
Additional land use (acres)	1,670	5,215
Additional present value social cost (PVSC, $ million)	63	77
Additional bird and bat fatalities	22,500 (birds) 75,000 (bats)	28,500 (birds) 95,000 (bats)
Additional carbon emissions (short tons)	7,215,153	1,806,064

Potential Impacts to the Natural Environment

The Scenario 1 facilities will have a greater impact on flora and fauna than continued operation of the MNGP. Scenario 1 will impact additional acres of land (discussed above); though most of this land will likely be agricultural, some acres of non-agricultural flora would likely be impacted, e.g., woody vegetation, trees.

Scenario 1 will impact relatively more birds and bats due the scenario's wind turbines. Bird fatalities for wind turbines range from 3 to 6 fatalities per MW per year; bat fatalities range from 1 to 20 fatalities per MW per year.[14] As Scenario 1 includes 750 MW of wind turbines, this will result in approximately 2,250 bird fatalities and 7,500 bat fatalities per year (Table 10). It is uncertain whether these fatalities will have population level effects.[15] The fatalities would not occur with continued operation of the MNGP.

Scenario 1 would have relatively more greenhouse gas (CO_2) emissions than continued operation of the MNGP (Table 10). Xcel Energy estimates that Scenario 1 would result in the emission of approximately 7.2 million additional tons of carbon over a 2030-2040 timeframe. These additional carbon emissions are associated with the scenario's combustion turbines and purchases from market sources.

Total greenhouse gas emissions in Minnesota in 2018 were 160 million tons CO_2-e.[16] Electrical generation was responsible for about 16.4 percent of this total (26.2 million tons CO_2-e).[17] The additional greenhouse gases associated with Scenario 1 would exacerbate climate change impacts. These impacts include drought, storms and flooding, impacts to public health, and impacts to agriculture and ecosystem functions.[18]

Associated Infrastructure Impacts

Beyond the impacts discussed above, the Scenario 1 facilities would also have associated infrastructure impacts – i.e., impacts related to the interconnection of the facilities with the electric transmission grid. The MNGP is already connected to the grid; it does not need additional transmission lines to commute the power generated at the plant. Even with proper siting, the Scenario 1 facilities would require additional transmission lines to connect the facilities to the grid.

It is difficult to estimate the extent of potential transmission line impacts associated with the Scenario 1 facilities. Transmission lines have aesthetic impacts; they are visible at a distance. Transmission lines can impact existing and planned land uses. Transmission lines can also impact birds through electrocution and collision. Transmission line impacts are anticipated to be relatively less than those of the Scenario 1 facilities themselves; however, the impacts could be similar in magnitude, depending on the length of the transmission lines required.

8.3 MNGP Replacement Scenario 2

In the second MNGP replacement scenario (Scenario 2), the model is permitted to select generation resources of any type, except carbon-based resources, to replace the capacity and energy provided by the MNGP. As before, the model selects these resources with a goal of minimizing costs. Given these parameters, Scenario 2 adds wind turbines (950 MW), solar farms (700 MW), and storage (300 MW) (Table 10). In addition, Scenario 2 also relies on additional purchases of energy from market sources.

Potential Impacts to the Human Environment

Scenario 2 places new generation and storage facilities on the landscape – wind turbines, solar farms, and energy storage equipment. These facilities, even with proper siting, will have impacts on the human environment. The facilities will have aesthetic impacts; such impacts are likely limited for solar farms and storage – solar farms because of their relatively low height and storage because of its relative compactness. However, wind turbines can be seen from a distance and impact the aesthetics of entire viewsheds. In comparison, continued operation of the MNGP would create no new aesthetic impacts.

All of the Scenario 2 facilities will generate noise. With proper siting, noise levels will be within state noise standards. However, compared with continued operation of the MNGP, Scenario 2 will introduce new noise sources on the landscape.

The Scenario 2 facilities will impact land use and agriculture. Wind farms require about 0.3 acres of land per MW; solar farms require 7 to 10 acres per MW.[19] Thus, compared with continued operation of the MNGP, Scenario 2 will impact about 285 additional acres of land for wind turbines and 4,900 acres of land for solar panels. Energy storage facilities (other than pumped hydropower) are relatively new in the industry and in Minnesota. Thus, land impact estimates are more uncertain. A four-hour lithium ion storage system is anticipated to require about 0.1 acre per MW.[20] Accordingly, Scenario 2's 300 MW of storage would require about 30 acres. The land used for Scenario 2 facilities could, at a future date, be returned to agricultural or other use.

Xcel Energy's modeling indicates that the reliability of the electricity supplied in Scenario 2 would be less than that of continued operation of the MNGP.[21] Scenario 2 does not have the same level of firm, dispatchable capacity relative to continued operation of the MNGP.[22]

Compared with continued operation of the MNGP, Scenario 2 is relatively more expensive on a social cost basis (Table 10). This is due to facility costs and carbon emissions associated with purchases from market sources.[23]

Potential Impacts to the Natural Environment

The Scenario 2 facilities will have a greater impact on flora and fauna than continued operation of the MNGP. Scenario 2 will impact additional acres of land (discussed above);

though most of this land will likely be agricultural, some acres of non-agricultural flora would likely be impacted, e.g., woody vegetation, trees.

Scenario 2 will impact relatively more birds and bats due the scenario's wind turbines. Scenario 2 includes 950 MW of wind turbines; these turbines will result in approximately 2,850 bird fatalities and 9,500 bat fatalities per year (Table 10). It is uncertain whether these fatalities will have population level effects. These fatalities would not occur with continued operation of the MNGP.

Scenario 2 would have relatively more greenhouse gas emissions than continued operation of the MNGP (Table 9). This is so even though no carbon-based generation sources are explicitly selected in Scenario 2. Carbon emissions are due to market purchases of energy. Xcel Energy estimates that Scenario 2 would result in the emission of approximately 1.8 million additional tons of carbon. The additional greenhouse gases associated with Scenario 2 would exacerbate climate change impacts.

Associated Infrastructure Impacts

Scenario 2 facilities would require additional transmission line to connect the facilities to the electric transmission grid. The MNGP would require not additional transmission lines.

It is difficult to estimate the extent of potential transmission line impacts associated with the Scenario 2 facilities. Transmission lines have aesthetic impacts; they are visible at a distance. Transmission lines can impact existing and planned land uses. Transmission lines can also impact birds through electrocution and collision. Transmission line impacts are anticipated to be relatively less than those of the Scenario 2 facilities themselves; however, the impacts could be similar in magnitude, depending on the length of the transmission lines required.

Notes

[1] CN Application, Chapter 9.3.

[2] Id.

[3] What is Generation Capacity?, U.S. DOE, https://www.energy.gov/ne/articles/what-generation-capacity#.

[4] Minnesota Electricity Profile 2020, U.S. Information Administration, https://www.eia.gov/electricity/state/minnesota/.

[5] Id.

[6] The MNGP recently completed a run of 704 consecutive days of operation, see CN Application, Chapter 1.2.

[7] What is Generation Capacity?, U.S. DOE, https://www.energy.gov/ne/articles/what-generation-capacity#.

[8] CN Application, Chapter 9.3.

[9] Environmental Report for Buffalo Ridge Wind Project, Minnesota Department of Commerce, June 2020, eDockets Number 20206-164214-01 [hereinafter Buffalo Ridge Environmental Report].

[10] Acreage extrapolated from site permit application for the Elk River Peaking Station, Docket No. GS-07-715, June 2007, eDockets Number 4385349.

[11] CN Application, Chapter 9.3.

[12] Id; Xcel Energy Additional Information, Social Cost of Carbon Used in Scenario Modeling ($ per short ton):

Year	Social Cost of Carbon ($ per short ton)
2030	$27.60
2031	$28.15
2032	$28.71
2033	$29.28
2034	$29.87
2035	$30.47
2036	$31.08
2037	$31.70
2038	$32.33
2039	$32.98
2040	$33.64

[13] Id; Xcel Energy Additional Information, Modeled Xcel Energy Total System Carbon Emissions (short tons):

Year	MNGP Operation to 2040	Scenario 1	Scenario 2
2030	4,051,611	4,377,920	4,030,184
2031	3,815,490	4,721,370	3,839,791
2032	3,405,023	4,618,220	3,560,066
2033	4,159,886	5,063,810	4,190,585
2034	4,245,549	4,726,527	4,362,048
2035	4,603,999	5,247,524	4,939,397
2036	4,371,444	4,969,069	4,505,329
2037	4,124,715	4,640,214	4,258,441
2038	4,055,839	4,628,129	4,276,303
2039	3,685,889	4,196,495	4,022,472
2040	3,633,246	4,178,567	3,974,138
Total 2030-2040 Carbon Emissions (short tons)	44,152,691	51,367,844	45,958,755
Difference	---	**7,215,153**	**1,806,064**

[14] Buffalo Ridge Environmental Report.

[15] Bird fatalities due to wind turbines are relatively minimal compared with other anthropogenic risks, e.g., cats kept as pets, buildings, vehicles; see, e.g., Wind Turbines and Birds and Bats, Sierra Club, https://www.sierraclub.org/michigan/wind-turbines-and-birds-and-bats. However, see Bird Mortality at Renewable Energy Facilities have Population Level Effects, U.S. Geological Service, https://www.usgs.gov/news/science-snippet/bird-mortality-renewable-energy-facilities-have-population-level-effects#.

[16] Greenhouse Gas Emissions Data, Minnesota Pollution Control Agency, https://www.pca.state.mn.us/air/greenhouse-gas-emissions-data.

[17] Id.

[18] Climate Change 2022, Intergovernmental Panel on Climate Change, https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_SummaryForPolicymakers.pdf.

[19] Buffalo Ridge Environmental Report

[20] Midcontinent Independent System Operator Planning Estimate, Department personal communication with Invenergy staff.

[21] CN Application, Chapter 9.3.

[22] Id.

[23] CN Application, Chapter 9.3; the modeling also includes integration costs associated with the market uncertainty related to renewable energy forecasts.

Appendix A
EIS Scoping Decision

In the Matter of the Application of Northern States Power Company d/b/a Xcel Energy for a Certificate of Need for Additional Dry Cask Storage at the Monticello Nuclear Generating Plant Independent Spent Fuel Storage Installation

ENVIRONMENTAL IMPACT STATEMENT SCOPING DECISION

DOCKET NO. E002/CN-21-668

The above matter has come before the Commissioner of the Department of Commerce (Department) for a decision on the scope of the environmental impact statement (EIS) that will be prepared for Xcel Energy's proposed additional storage of spent nuclear fuel in the independent spent fuel storage installation (ISFSI) at the Monticello nuclear generating plant (MNGP) in the city of Monticello, Minnesota.

Introduction

The MNGP is a 671 megawatt electric generating plant in Monticello, Minnesota. The plant is powered by a boiling water nuclear reactor. The plant has been in operation since 1971. Spent nuclear fuel from the plant is stored on site in the MNGP ISFSI.

The plant is currently licensed by the Nuclear Regulatory Commission (NRC) for operation through 2030. The Minnesota Public Utilities Commission (Commission) has authorized storage of spent nuclear fuel in the MNGP ISFSI sufficient to allow operation of the MNGP through 2030.

Project Description

Xcel Energy proposes to extend the operating life of the MNGP to 2040. To accommodate the additional spent nuclear fuel associated with this extension, Xcel Energy proposes to expand storage within the MNGP ISFSI.[1] This additional storage requires installation of a second concrete support pad within the existing ISFSI. A modular concrete storage system will be placed on the new pad. Xcel Energy indicates that spent fuel will be stored in welded canisters, with the canisters then being placed in the concrete storage system. Xcel Energy notes that it has not identified a specific canister technology or vendor, and that it will conduct a competitive bidding process to select the technology and vendor.[2] Xcel Energy indicates that the canister technology selected for the project will be licensed for storage and transport by the NRC.[3]

[1] Certificate of Need Application for Additional Dry Cask Storage at the Monticello Nuclear Generating Plant Independent Spent Fuel Storage Installation, Xcel Energy, September 1, 2021, eDockets Numbers 20219-177630-01 (through -10) [hereinafter CN Application].
[2] CN Application, Executive Summary and Chapter 8.
[3] Id.

Xcel Energy estimates that approximately 14 additional spent fuel storage canisters will be needed for operations through 2040. Xcel Energy notes that the new concrete storage pad and concrete storage system will be able to accommodate approximately 36 canisters without changing the ISFSI size or security perimeter.[4]

Project Purpose

Xcel Energy indicates that additional storage at the MNGP ISFSI is necessary to support operation of the MNGP through 2040. Xcel Energy believes that operation of the MNGP through 2040 is a reasonable approach to ensuring the adequacy, reliability, and efficiency of Minnesota's energy supply.[5]

Regulatory Background

Additional storage of spent nuclear fuel in the MNGP ISFSI requires a certificate of need (CN) from the Commission.[6] Xcel Energy applied to the Commission for a CN on September 1, 2021. Additionally, an EIS must be prepared by the Department, as the responsible governmental unit (RGU), prior to the Commission's decision on a CN.[7]

Concurrent with Xcel Energy's application to the Commission for a CN, Xcel Energy submitted its 2020-2034 integrated resource plan (IRP) to the Commission for approval.[8] The IRP examines Xcel Energy's needs for electricity over a 15-year planning period and how these needs are best met. Xcel Energy's IRP recommends extending the operating life of the MNGP to 2040. At its meeting on February 8, 2022, the Commission approved Xcel Energy's IRP and authorized operation of the MNGP through 2040.[9]

Extending the operating life of the MNGP to 2040 requires the approval of the NRC.[10] Xcel Energy anticipates filing a request with the NRC for a license extension – a subsequent license renewal (SLR) – in 2023. Though NRC license extensions are for a period of 20 years, Xcel Energy indicates, at this time, that they do not anticipate operating the MNGP past 2040.

Scoping Process

Scoping is the first step in the development of the EIS. The scoping process has two primary purposes: (1) to gather public input as to the impacts and mitigation measures to study in the EIS and (2) to focus the EIS on those impacts and mitigation measures that will aid in the Commission's decision on Xcel Energy's proposed additional storage in the MNGP ISFSI.[11]

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[4] Id.
[5] CN Application, Executive Summary and Chapter 4.
[6] Minnesota Statute 116C.83, Subd. 2.
[7] Minnesota Statute 116C.83, Subd. 6(b).
[8] CN Application, Chapter 3; Commission Docket No. E002/RP-19-368.
[9] Commission Docket No. E002/RP-19-368, Order Pending.
[10] CN Application, Chapter 3.
[11] Minnesota Rule 4410.2100.

A scoping EAW was prepared for the project.[12] The EAW serves as an aid for commenters in formulating comments regarding the scope of the EIS.[13]

EERA staff gathered input on the scope of the EIS through public meetings and an associated comment period.[14] This scoping decision identifies the impacts and mitigation measures that will be analyzed in the EIS.

Public Scoping Meetings

EERA staff held a public scoping meeting regarding Xcel Energy's proposed additional spent fuel storage in the MNGP ISFSI on January 25, 2022, in Monticello, Minnesota. Five people attended this meeting; one person provided a public comment.[15] The following evening, January 26, 2022, EERA staff held a virtual public meeting. Approximately six people attended this meeting; two people provided public comments.[16] Comments addressed the scope of potential impacts that will be analyzed in the EIS and the possible reprocessing of spent nuclear fuel in the United States.

Public Comments

Following the public scoping meetings, written comments were received from the U.S. Army Corps of Engineers (USACE), the Minnesota Department of Natural Resources (DNR), the Minnesota Pollution Control Agency (MPCA) and the city of Monticello.[17] The USACE indicated that the project would not require a USACE permit. The DNR noted the presence of bald eagle nests near the project and recommended that Xcel Energy confer with the U.S Fish and Wildlife Service regarding potential impacts to eagles.[18] The MPCA noted that it had no comments regarding the project at this time. The city of Monticello indicated its support for the project. The city noted its longstanding relationship with Xcel Energy and the safe operation of the MNGP ISFSI to date.[19]

Having reviewed the matter, consulted with Department staff, and in accordance with Minnesota Rule 4410.2100, I hereby make the following scoping decision:

[12] Scoping Environmental Assessment Worksheet, Monticello Nuclear Generating Plant Independent Spent Fuel Storage Installation Expansion Project, December 27, 2021, eDockets Number 202112-180998-01.
[13] Minnesota Rule 4410.2100.
[14] Minnesota Rule 4410.2100; Notice of Environmental Impact Statement Scoping Meetings and Availability of Scoping Environmental Assessment Worksheet, December 28, 2021, eDockets Number 202112-181051-01.
[15] Oral Public Meeting Comments on Scope of EIS, eDockets Number 20222-182824-01.
[16] Id.
[17] Written Public Comments on Scope of EIS, eDockets Number 20222-182824-02.
[18] Id.
[19] Id.

MATTERS TO BE ADDRESSED

The issues outlined below will be analyzed in the EIS for Xcel Energy's proposed additional storage of spent nuclear fuel in the MNGP ISFSI.

I. GENERAL DESCRIPTION OF THE PROJECT

A. Project Description
B. Project Purpose
C. Project Costs

II. REGULATORY FRAMEWORK

A. Federal Approvals
B. State Approvals
C. Local Approvals

III. ENGINEERING, DESIGN, AND CONSTRUCTION

A. Canister Systems for Spent Fuel Storage
B. Canister Handling
C. Canister Monitoring
D. MNGP ISFSI

IV. POTENTIAL IMPACTS AND MITIGATIVE MEASURES – NON-RADIOLOGICAL

The EIS will include a discussion of human and environmental resources potentially impacted by the project. The EIS will discuss potential non-radiological impacts related to the proposed additional storage in the MNGP ISFSI.

A. Environmental Setting
B. Human Environment
   1. Noise, traffic, aesthetics, socioeconomics, land use, public health
C. Natural Environment
   1. Water resources, flora, fauna, rare and unique natural resources
   2. Climate change
D. Cumulative Impacts
   1. Potential human and environmental impacts of operation of the MNGP through 2040.
   2. Potential human and environmental impacts of using the MNGP ISFSI to facilitate decommissioning of the MNGP.

V. POTENTIAL IMPACTS AND MITIGATION MEASURES – RADIOLOGICAL

The EIS will discuss potential radiological impacts related to the proposed additional storage in the MNGP ISFSI.

A. Natural Background Radiation and Radiation Exposure
B. Radiological Monitoring at the MNGP and MNGP ISFSI
C. Potential Impacts to the Public

1. Normal conditions
2. Incident (non-normal) conditions

D. Potential Impacts to Workers
   1. Normal conditions
   2. Incident (non-normal) conditions
E. Climate Change
F. Environmental Justice
G. Cumulative Impacts
   1. Potential human and environmental impacts of operation of the MNGP through 2040.
      a) Normal conditions
      b) Incident (non-normal) conditions
   2. Potential human and environmental impacts of using the MNGP ISFSI to facilitate decommissioning of the MNGP.
      a) Normal conditions
      b) Incident (non-normal) conditions

VI. ISFSI ALTERNATIVES

A. No Action
B. Increased Spent Fuel Pool Capacity
C. Interim Off-Site Storage
D. Federal Geologic Repository, Yucca Mountain
E. Alternative Spent Fuel Storage Technologies

VII. MNGP ALTERNATIVES

A. Current MNGP Role in Minnesota Energy Supply
B. Alternatives to Continued Operation of the MNGP
   1. No Action
   2. Monticello Replacement Case 1 – Lowest Cost, Carbon Resources Can Be Used.[20]
   3. Monticello Replacement Case 2 – Lowest Cost, Renewables and Storage Only.[21]

VIII. DATA AND ANALYSIS

Data and analysis in the EIS will be commensurate with the importance of potential impacts and the relevance of the information to consideration of the need for mitigation measures.[22] EERA staff will consider the relationship between the cost of data and analyses and the relevance and importance of the information in determining the level of detail of information to be prepared for the EIS.

If relevant information cannot be obtained within timelines prescribed by statute and

[20] CN Application, Chapter 9.
[21] Id.
[22] Minnesota Rule 4410.2300.

rule, or if the costs of obtaining such information is excessive, or the means to obtain it is not known, EERA staff will include in the EIS a statement that such information is incomplete or unavailable and the relevance of the information in evaluating potential impacts.[23]

IX. STUDIES TO BE UNDERTAKEN

No studies will be undertaken in preparation of the EIS.

ISSUES OUTSIDE THE SCOPE OF THE EIS

The EIS will not address the following topics:

A. The appropriateness of NRC regulations for spent nuclear fuel storage technology.
B. Potential impacts associated with the nuclear fuel cycle.
C. Potential impacts associated with the transportation of spent nuclear fuel from the MNGP ISFSI.
D. ISFSI sites outside the MNGP plant boundary. The Commission's authority is limited to the storage of spent nuclear fuel generated by a Minnesota nuclear generation facility and stored on the site of that facility.[24]
E. Economic analysis of generation alternatives. Economic analysis in the EIS will be limited to alternatives discussed in Xcel Energy's CN application. Additional economic analysis will be provided during the Commission's CN proceedings by the Department of Commerce, Energy Regulation and Planning unit.
F. The appropriateness of NRC regulations and standards for radiation exposure. The EIS may reference certain standards promulgated by the NRC; however, the EIS will not address the adequacy of these standards.

SCHEDULE

A draft EIS is anticipated to be completed and available in the fall of 2022. A public meeting and comment period on the draft EIS will follow. Timely and substantive comments on the draft EIS will be responded to in a final EIS. The schedule for the draft and final EIS will be coordinated with the contested case hearing that will be held for Xcel Energy's CN application.

[23] Minnesota Rule 4410.2500.
[24] Minnesota Statue 116C.83

Signed this _2nd___ day of _March, 2022

STATE OF MINNESOTA
DEPARTMENT OF COMMERCE

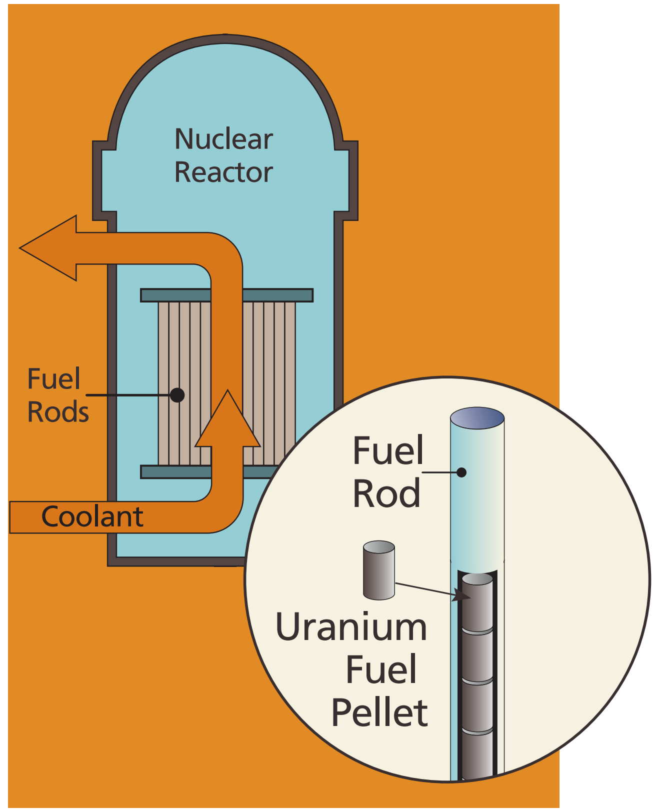
____
Katherine Blauvelt, Assistant Commissioner

Appendix B
Safety of Spent Fuel Storage, NUREG BR-0528

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Safety of Spent Fuel Storage

What Is Spent Fuel?



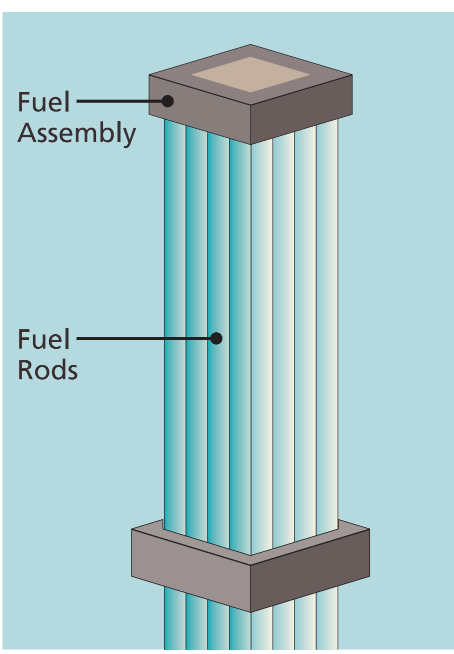
Nuclear reactors use uranium fuel rods bundled into fuel assemblies to generate the heat that turns generators. These generators produce electricity that powers people's homes.

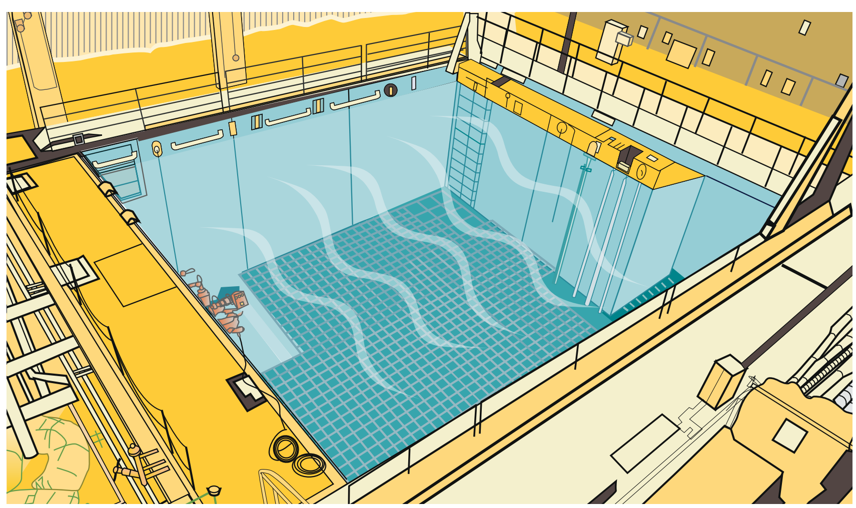
As it burns in the reactor, this fuel becomes very hot and very radioactive. After about 5 years, the fuel is no longer useful and is removed. Reactor operators have to manage the heat and radioactivity that remains in this spent fuel.

In the United States, every reactor site has at least one pool on site for spent fuel storage. Plant personnel move the spent fuel underwater from the reactor to the pool. Over time, spent fuel in the pool cools as the radioactivity decays away.

These pools were intended to provide temporary storage. The idea was that after a few years, the spent fuel would be shipped offsite to be reprocessed, or separated so usable portions could be recycled into new fuel. But reprocessing did not succeed in the United States, and the pools began to fill up.

In the early 1980s, reactor operators began to look for ways to increase the amount of spent fuel they could store onsite. They began to place fuel in dry casks that could be stored in specially built facilities on their sites. Most nuclear plants today use dry storage.





Spent fuel pool

Dry Cask Storage—The Basics

A dry cask storage system is a cylinder that operators lower into the pool and fill with spent fuel. They raise the cylinder, drain, and dry it, before sealing and placing it outdoors on a concrete pad. There are many varieties of spent fuel storage casks. They all need to:

- Maintain confinement of the spent fuel
- Prevent nuclear fission (the chain reaction that allows a reactor to produce heat)
- Provide radiation shielding
- Maintain the ability to retrieve the spent fuel, if necessary
- Resist earthquakes, tornadoes, floods, temperature extremes, and other scenarios.

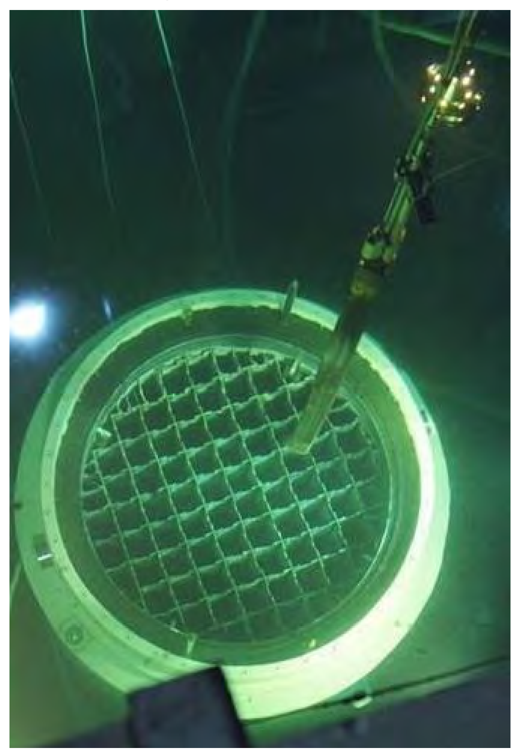
At least 23 feet of water covers the fuel assemblies in the spent fuel pool of Unit 2 at the Brunswick Nuclear Power Plant in Southport, NC.
(Courtesy: Matt Born/Wilmington Star-News)

Casks come in different sizes. They are tall enough to hold spent fuel, which can be up to 14 feet long, and they can weigh up to 150 tons—as much as 50 midsize cars. Plants may need a special crane that can handle heavy loads to be able to lift a loaded cask full of water out of the pool for drying. After the casks are dried, robotic equipment is used to seal them closed to keep doses to workers as low as possible.

Two basic designs are in wide use today. Welded, canister-based systems feature an inner steel canister that contains the fuel surrounded by 3 feet or more of steel and concrete. The canisters may be oriented either vertically or horizontally. In bolted cask systems, there is no inner canister. Bolted casks have thick steel shells, sometimes with several inches of radiation shielding inside.

Plants use special transporters to move the loaded cask outdoors to where it will be stored. At that point, the radioactivity from the cask must be less than 25 millirem per year at the site boundary. That means the highest dose allowed to someone standing at the fence for a full year is about the dose someone would receive going around the world in an airplane. The actual dose at the site boundary is typically much lower.

Dry cask storage has proven to be a safe technology over the 30 years it has been used. Since the first casks were loaded in 1986, dry storage has released no radiation that affected the public or contaminated the environment. As of January 2017, more than 2,400 casks have been loaded and are safely storing 100,000 spent fuel assemblies. Tests on spent fuel and cask components after years in dry storage confirm that the systems continue to provide safe storage.



Loading spent fuel cask under water.
(Courtesy: Holtec International)

Workers prepare to load an AREVA-TN NUHOMS canister into a concrete storage module at the Calvert Cliffs Nuclear Power Plant in Lusby, MD. (Courtesy: Exelon)

The U.S. Nuclear Regulatory Commission (NRC) analyzed the risks from loading and storing spent fuel in dry casks. Two separate studies found the potential health risks are very, very small. To ensure continued safe dry storage of spent fuel, the NRC is further studying how the fuel and storage systems perform over time. The NRC is also staying on top of related research planned by the Department of Energy and the nuclear industry.

What We Regulate and Why

The NRC oversees the design, manufacturing, and use of dry casks. This oversight ensures licensees and designers are following safety and security requirements, meeting the terms of their licenses, and implementing quality assurance programs.

The NRC's regulations appear in Chapter 10 of the Code of Federal Regulations*, also known as 10 CFR.*

Cask designers must show that their systems meet the NRC's regulatory requirements. The NRC staff reviews cask applications in detail. The agency will only approve a system that meets NRC requirements and can perform safely. NRC inspectors visit cask designer offices, fabricators and spent fuel storage facilities to ensure they are meeting all our regulations. Cask design applications, the NRC's documentation of reviews, and NRC inspection reports are available to the public on the agency website at www.nrc.gov.

There are strict security requirements in place to protect the stored fuel. Security has multiple layers, including the ability to detect, assess, and respond to an intrusion. Our general security requirements for dry cask storage are in 10 CFR Part 73 (https://www.nrc.gov/reading-rm/doc-collections/cfr/part073/). The specific requirements in NRC orders and the licensee's security plans are not available to the public, as they could give an adversary the ability to defeat the security measures and compromise the safety systems. There have been no known or suspected attempts to sabotage cask storage facilities.

The NRC's requirements for dry cask storage can be found in 10 CFR Part 72 (https://www.nrc.gov/reading-rm/doc-collections/cfr/part072/), which requires all structures, systems, and components important to safety to meet quality standards for design, fabrication, and testing. Part 72 and related NRC guidance on casks and storage facilities also detail specific engineering requirements.

The NRC has dozens of experts in different scientific and engineering disciplines whose job is to review cask applications (which can be hundreds of pages long) and the detailed technical designs they contain. The agency will only approve a storage cask design if these experts are satisfied that all the specific safety requirements in each discipline have been met.

Cask transporter moves loaded spent fuel storage cask to storage pad.

The following sections discuss technical evaluations the NRC conducts during technical reviews of dry cask storage.

Materials

NUHOMS horizontal spent fuel storage system under construction at the Calvert Cliffs Nuclear Power Plant in Lusby, MD.

Materials—the stuff of which everything is made. In every case—the metal in a car door, the plastic used in airplane windows, or the steel used in elevator cables—the selection of appropriate materials is critical to safety.

Systems that transport and store spent nuclear fuel and other radioactive substances are made of a variety of materials. All of them are reviewed to confirm that those systems can protect the public and environment from the effects of radiation. The NRC does not dictate what materials are used. Rather, the NRC evaluates the choice of materials proposed by applicants. What makes a material "appropriate" to transport and store radioactive substances depends on a number of factors.

First, materials must be adequate for the job. In other words, the mechanical and physical properties of the materials have to meet certain requirements. For example, the steel chosen for a storage cask has to withstand possible impacts such as from tornadoes or earthquakes.

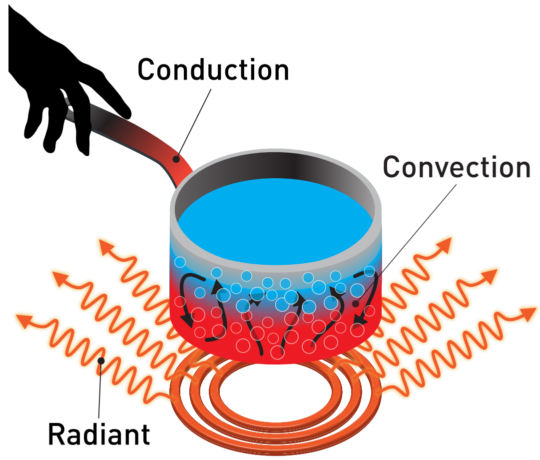
Next, when making a complex metal system, parts often are welded together—that is, partially melted—in a way that ensures that the joints themselves are adequate. The welder actually creates a new material at the joint with its own unique properties. That is why the NRC looks at how this is done, including the selection of weld filler metals, how heat is controlled to ensure good welds, and the use of examinations and testing to verify that no defects are present.

Finally, the NRC considers how materials degrade over time. Reviewers must take into account a material's chemical properties, how it was manufactured, and how it reacts with its environment. Just as iron rusts and elastic materials become brittle over time, all materials can degrade. This degradation and its impact must be well understood. Materials must be selected based on their present condition and their projected condition throughout their lifetimes.

Loaded vertical HI-STORM 100 casks are storing spent fuel at the Diablo Canyon Power Plant in Avila Beach, CA.

Best practices for appropriately selecting materials and the processes used to join them often can be found in consensus codes and standards. These guidelines are typically developed over many years of operational experience, and through industrywide and government technical discussions and agreement. The NRC also relies on both historical operating experience and the latest materials performance and testing data.

Managing Heat



Three different methods transfer heat.

Keeping the spent fuel from getting too hot is one way to ensure casks will be safe. The NRC requires the cask and fuel to remain within a certain temperature range. These requirements protect the cladding (the metal tube that holds the fuel pellets). As the fuel cools, heat is transferred from inside the cask to the outside. NRC experts examine how that heat will move through the cask and into the environment.

The method used to remove heat has to be reliable and provable. It must also be passive—that is, without the need for electrical power or mechanical device. Casks use conduction, convection, and radiation to transfer the heat to the outside.

Conduction transfers heat from a burner through a pot to the handle. The process of heat rising (and cold falling) is known as convection. The heat coming from a hot stove is known as radiant heat.

These methods work the same way in a storage cask. Where the structure containing the fuel touches the fuel assemblies, it conducts heat toward the outside of the cask. Most casks have vents that allow outside air to flow naturally into the cask and around the canister to cool it (convection). And most casks would feel warm to the touch from radiant heat, much like a home radiator.

The NRC also confirms that the pressure inside a cask is below the design limit so it will not impact the structure or operations. Technical experts review applications for cask designs carefully to verify that the fuel cladding and cask component temperatures and the internal pressure will remain below specified limits.

Each storage cask is designed to withstand the effects from a certain amount of heat. This amount is called the heat load. The NRC reviews whether the designer correctly considered how the heat load will affect cask component and fuel temperatures, and how this heat load was calculated. Cask designs must show that heat from spent fuel can be effectively transferred to the outside of the cask.

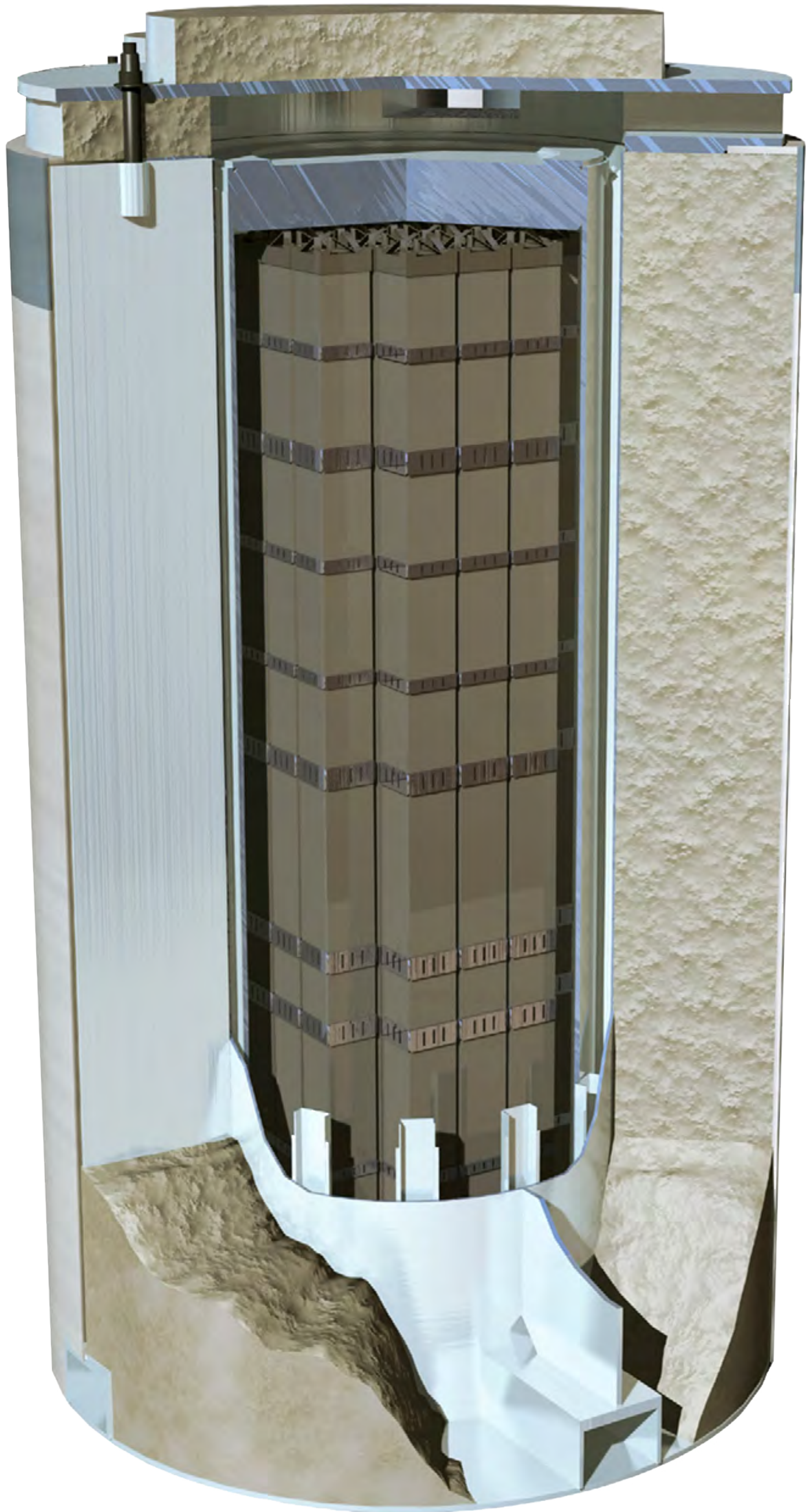
The NRC's review also verifies that the cask designer looked at all the environmental conditions that can be expected to affect cask components and fuel temperatures. These conditions may include windspeed and direction, temperature extremes, and a site's elevation. To make sure the right values are considered, the NRC verifies that they match the historical records for a site or region.

NRC reviewers consider all of the methods used to prove that the storage system can handle the specified heat loads. They verify computer codes, making sure they are the latest versions and have been endorsed by experts. They look at the values used in the codes, such as for material properties, and confirm calculations for temperature and pressure. The NRC might run its own analysis using a different computer code to see if those results match the application.

Making Sure Casks Will Hold Up

In its application, the cask designer must provide an evaluation that shows the system will be strong and stable enough to perform its safety functions even after experiencing a load, such as if the cask were dropped. NRC reviewers examine the structural design and analysis of the system under all credible loads for normal conditions—that is, planned operations and environmental conditions that can be expected to occur often during storage. They also look at accidents, natural events, and conditions that can be expected to occur from time to time, but not regularly.

The NRC review looks at whether the cask designer evaluated the proper loading conditions. It will also ensure the designer evaluated the system's response to those loads accurately and completely. Reviewers must verify whether the resulting stresses in the material meet the acceptance criteria in the appropriate code. The NRC's review also looks at several different realistic combinations of loads. These cases are analyzed to determine the stresses placed on the material used to construct the cask system. To be conservative, the NRC and the designers overestimate loads and underestimate material strength. Doing this enhances the NRC's assurance that the design is adequate.



Cutaway of spent fuel storage cask shows spent fuel assemblies surrounded by steel and thick concrete shielding.

Confinement

The cask design must prevent the release of radioactive material. This role is performed by the confinement boundary, which usually includes a metal canister with a lid that has at least two closures. Some casks have two separate lids that are each welded closed. Others are bolted and have two separate seals. Having both closures provides an extra layer of protection to ensure the radioactive materials remain confined.

Loaded spent fuel storage casks are in place on storage pad at the Haddam Neck Plant in Meriden, CT. (Courtesy: Connecticut Yankee)

The design must also keep the fuel assemblies in a protected, or "inert," environment. This is important to keep the fuel cladding from degrading. Once the water is removed from inside the cask, it is filled with a gas such as helium that will not react with fuel cladding.

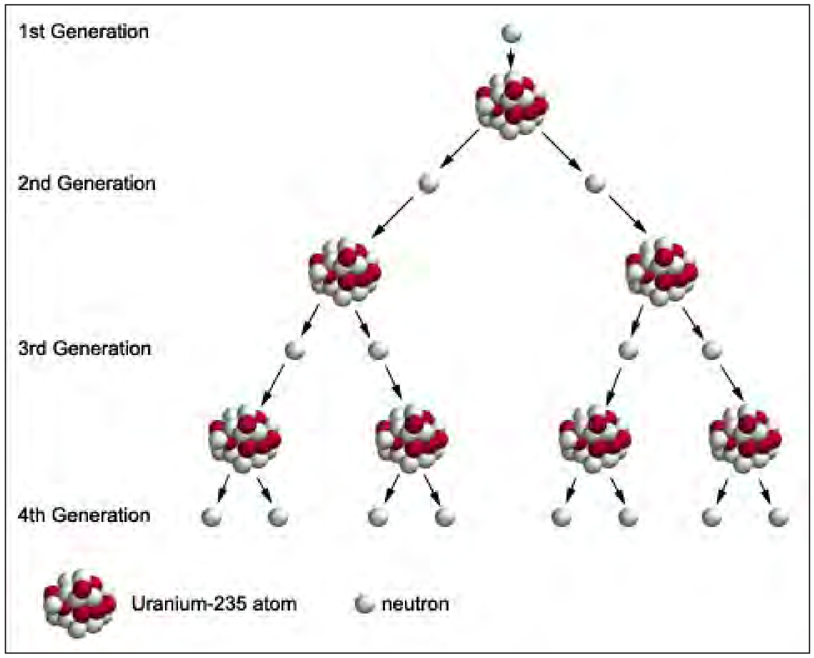
Cask users must monitor the confinement boundary. The monitoring requirements depend on whether a cask is bolted or welded. Bolted confinement boundaries with O-ring seals need to have alarms to alert the user if a seal starts to leak. In that case, the seal would need to be repaired or replaced to ensure the cask continues to have redundant confinement. Our experts review the proposed monitoring programs to make sure they are adequate. Welded closures do not need to be monitored in the same way. This is because the welds are examined closely after they are made to ensure they do not leak.

The NRC's review of a cask's confinement boundary looks at the "source term." This is the inventory of radioactive material inside the cask. While the redundant closures and other requirements ensure the material will remain safely confined, the NRC requires cask designers to look at the dose rates in case some material were to come out. They also need to analyze how those dose rates compare to the NRC's regulatory limits.

Loaded spent fuel storage cask on transporter is moved from the fuel handling building at the Surry Power Station in Surry, VA.

Finally, cask designers must provide an analysis of how the confinement boundary works. Casks must be designed and tested to meet criteria approved by the American National Standards Institute, or ANSI. The ANSI standard for leak tests on radioactive materials packages was put together by a committee of experts and went through a lengthy review and approval process before it was adopted.

Criticality Safety



Neutrons cause uranium-235 atoms to split in a nuclear chain reaction.

The nuclear chain reaction used to create heat in a reactor is known as fission. In this process, uranium atoms in the fuel break apart, or disintegrate, into smaller atoms. These atoms cause other atoms to split, and so on. Another word for this process is criticality.

The potential for criticality is an important thing to consider about reactor fuel throughout its life. Fuel is most likely to go critical when it is fresh. The longer the fuel is in the reactor, the less likely it is to go critical. This is why it is removed from the reactor after several years—it loses energy and will no longer easily support a self-sustaining chain reaction. Once fuel is removed from the reactor, the NRC requires licensees to ensure it will never again be critical. This state is referred to as "subcriticality."

Subcriticality is required whether the fuel is stored in a pool or a dry cask. It is required for both normal operating conditions and any accident that could occur at any time.

Many methods help to control criticality. The way spent fuel assemblies are positioned is an important one. How close they are to each other and the burnup of (or amount of energy extracted from) nearby assemblies all have an impact. This method of control is referred to as fuel geometry.

Certain chemicals, such as boron, can also slow down a chain reaction by absorbing neutrons released during fission, and keeping them from striking other uranium atoms.

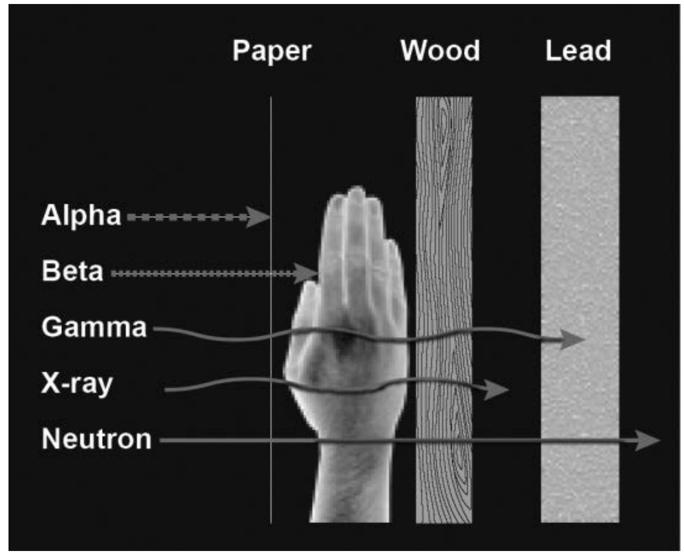
Casks have strong baskets to maintain fuel geometry. They also have solid neutron absorbers, typically made of aluminum and boron, between fuel assemblies. A cask application must include an analysis of all the elements that contribute to criticality safety during both normal and accident conditions.

NRC technical experts review this analysis to verify several things:

- The factors that could affect criticality have been identified.
- The models address each of these factors in a realistic way.
- Any assumptions used in the models are conservative—they result in more challenging conditions than would actually be expected.

Radiation Shielding

The fission process turns uranium into a number of other elements, many of which are radioactive. These elements continue to produce large amounts of radiation even when the fuel is no longer supporting a chain reaction. Shielding is necessary to block this radiation and protect workers and the public.



Different types of radiation have different properties.

The four major types of radiation differ in mass, energy, and how deeply they penetrate people and objects. Alpha radiation—particles consisting of two protons and two neutrons—are the heaviest type. Beta particles—free electrons—have a small mass and a negative charge. Neither alpha nor beta particles will move outside the fuel itself.

But spent fuel also emits neutron radiation (particles from the nucleus that have no charge) and gamma radiation (a type of electromagnetic ray that carries a lot of energy). Both neutron and gamma radiation are highly penetrating and require shielding.

Shielding for the two main types of dry storage casks is configured in slightly different ways. For welded, canister-based systems, the thick steel-reinforced concrete vault that surrounds an inner canister provides shielding for both neutron and gamma radiation. Shielding in bolted cask systems comes from their thick steel shells that may have several inches of lead gamma shielding inside. These systems have a neutron shield on the outside consisting of low-density plastic material, typically mixed with boron to absorb neutrons.

The NRC's reviews ensure that dry cask designs meet regulatory limits on radiation doses at the site boundary, under both normal and accident conditions, and that dose rates in general are kept as low as possible. Every applicant must provide a radiation shielding analysis. This analysis uses a computer model to simulate how radiation penetrates through the fuel and into thick shielding materials under normal operating and accident conditions. Reviewers ensure the analysis has identified all the important radiation-shielding parameters and models them conservatively, in a way that maximizes radiation sources and external dose rates.

At right, a dry storage cask recently loaded with spent fuel is lifted from a horizontal transporter to be placed on a specially designed storage pad. (Courtesy: Sandia National Laboratories)

Inspections

Inspectors examine dry storage casks containing spent nuclear fuel.

As part of its oversight function, the NRC inspects the companies that design and fabricate dry storage casks and the facilities that use them. Inspectors from NRC headquarters and the four regional offices conduct these inspections and issue their findings in publicly available reports.

Cask designers are responsible for ensuring that the fabricated cask components comply with the design as approved by the NRC. To do this, they are required to have a quality assurance program that meets the 18 criteria described in NRC dry storage regulations. The NRC reviews and approves these programs.

The designers must make sure their quality assurance programs are properly implemented during both design and fabrication. The NRC conducts periodic safety inspections to independently assess and verify that the designers are doing so. Some inspections look at design activities carried out at corporate offices. At fabrication facilities, both in the United States and overseas, NRC inspectors look at controls for fabrication, the process for verifying that the fabricated components comply with the approved design, and how the designer ensures that the fabricator meets its quality assurance program.

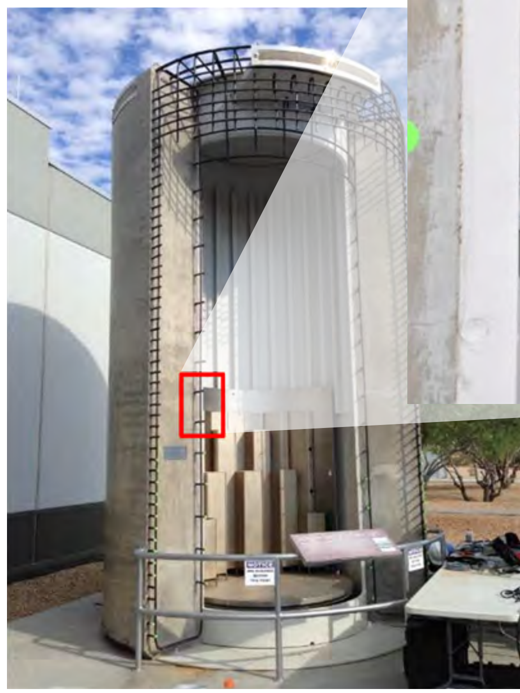
Each licensee is responsible for ensuring that its storage facility meets NRC regulations during construction and operation. NRC inspectors verify that the licensees are properly implementing the regulations. These inspections cover the design and construction of the concrete pad or modules that support the storage casks, preoperational testing (also referred to as dry runs), cask loading, and routine monitoring of operating dry storage facilities.

Transportable spent fuel storage casks sit on a storage pad.
(Courtesy: Holtec International)

Managing Aging

Cutting-edge robotic technology is making it easier to inspect inside spent fuel dry cask storage systems. As these casks remain in use for longer time frames, the ability to inspect canister surfaces and welds will become an important aspect of the NRC's confidence in their safety.

The techniques for inspecting canister surfaces and welds have been used for decades. These techniques are collectively known as nondestructive examination (NDE) and include a variety of methods, such as visual, ultrasonic, eddy current, and guided wave examinations.




Cutaway mockup of NAC International MAGNASTOR cask system at Palo Verde Nuclear Generating Station in Wintersburg, AZ. (Courtesy: EPRI/APS)

Robots are being developed to apply these NDE techniques inside casks. These robots need to fit into small spaces and withstand the heat and radiation inside the cask. The state-of-the-art robot technology is evolving quickly.

The Electric Power Research Institute and cask manufacturers have successfully demonstrated robotic inspection techniques to NRC staff several times at different reactor sites. These demonstrations are helping to refine the robots' designs.

In one demonstration, a robot inside a spent fuel storage cask maneuvered a camera with a fiber optic probe, which meets the industry code for visual examinations. The robot was able to access the entire height of the canister, allowing the camera to capture images of the fabrication and closure welds. The welds showed no signs of degradation. The canister was intact and in good condition.

Prototype robotic delivery system.
(Courtesy: EPRI/RTT)

The robot was also able to obtain samples from surfaces of the cask and canister. These samples were analyzed for atmospheric deposits that could cause corrosion.

If degradation is identified, cask users would select their preferred mitigation and repair option. They would have to meet the NRC's safety requirements before implementing it.

Cask inspections are important to ensure continued safe storage of spent nuclear fuel, and robots will continue to be a helpful tool in this important activity.

For more information on spent fuel and dry cask storage, visit the NRC's website:

https://www.nrc.gov/waste/spent-fuel-storage.html

Cover Photos:

Top: Massive storage casks loaded with spent nuclear fuel sit on a concrete pad inside a secure storage facility.

Middle: A transportable spent fuel storage system is moved to a storage pad at the Peach Bottom Atomic Power Station in Delta, PA. (Courtesy: AREVA)

Bottom: A horizontal spent fuel storage system sits behind a secure fence at the Calvert Cliffs Nuclear Power Plant in Lusby, MD.

For Additional Information Contact:

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Email: OPA.resource@NRC.GOV
Internet Home Page: http://www.nrc.gov

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Appendix C
Canister Handling Processes

Process Steps and Photographs Provided by Xcel Energy

Canister Loading Operations – Horizontal Overpack (Orano NUHOMS Example)

Canister Loading

Canister loading includes physically placing the fuel assemblies into the canister, decontamination, draining, drying, and seal-welding, and includes the following sequence of events:

1. Stage the transfer cask and canister inside the truck bay door of the plant.
2. Lift the empty canister by its lifting lugs and place it vertically in the transfer cask.
3. Install the pneumatic seal between the cask and the canister and fill the canister with water.
4. Engage the lifting yoke with the cask upper trunnions.
5. Lift the transfer cask and canister up to the fuel pool.
6. Lower cask into the pool.
7. Load the spent fuel assemblies into the canister (Figure C-1).

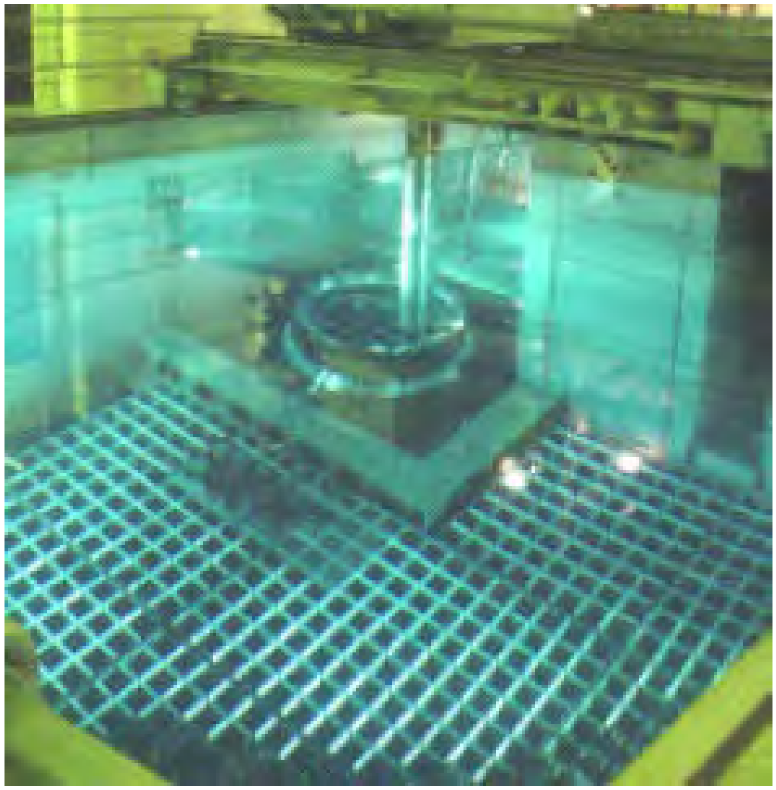


Figure C-1: Loading Fuel into Canister

8. Install the canister shield plug underwater.
9. Lift the transfer cask out of the pool.
10. Drain water as required before the welding operation.
11. Wash down the exposed portions of the transfer cask.
12. Move to cask decontamination area (Figure C-2).

Figure C-2: Lowering Transfer Cask to Decontamination Area

13. Lift the automatic welding machine (AWM) and install it over the inner top cover plate. Lift AWM and inner top cover together and install them over the canister.
14. Perform inner top cover weld.
15. Connect the vacuum drying system to the vent and siphon ports.
16. Remove bulk water from the canister using pressurized air.
17. Perform vacuum drying and helium backfilling.
18. Install and seal weld the vent and siphon port covers.
19. Mount the AWM and outer cover plates on the canister.
20. Weld the canister outer top cover plate.
21. Lift the transfer cask and move it to the loading bay.

Transport to the ISFSI

Canister transfer operations include transferring the loaded transfer cask to the on-site transport trailer, transporting the transfer cask and canister to the ISFSI, and inserting the canister into the storage module. The sequence of events includes:

22. Set the lower trunnions of the transfer cask into the support skid on the trailer.

Figure C-3: Lowering Cask onto Trailer

23. Rotate the transfer cask to a horizontal orientation (Figure C-3).
24. Use the on-site trailer to transfer the cask and canister to the ISFSI.

25. At the ISFSI, back the trailer and align the transfer cask with the storage module (Figure C-4).

Figure C-4: Alignment of Transfer Cask with Storage Module

26. Remove the hydraulic arm access cover, the transfer cask lid, and the storage module door.
27. Use the hydraulic arm to insert the canister into the storage module.
28. Install the storage module door.

Canister Loading Operations – Vertical Overpack (Holtec HI-Storm Example)

Canister Loading

Canister loading includes physically placing the fuel assemblies into the canister, draining, decontamination, closure, and canister transfer into the overpack and includes the following sequence of events:

1. Place the empty canister into the transfer cask.
2. Lift the transfer cask and place it vertically in the cask decontamination area.
3. Fill the transfer cask annulus with demineralized water and install the annulus seal.
4. Engage the lifting yoke with the transfer cask lift lugs.
5. Lift the transfer cask and canister up to the spent fuel pool (Figure C-5).

Figure C-5: Transfer Cask and Canister Movement to the Spent Fuel Pool

6. Lower transfer cask into the pool (Figure C-6).

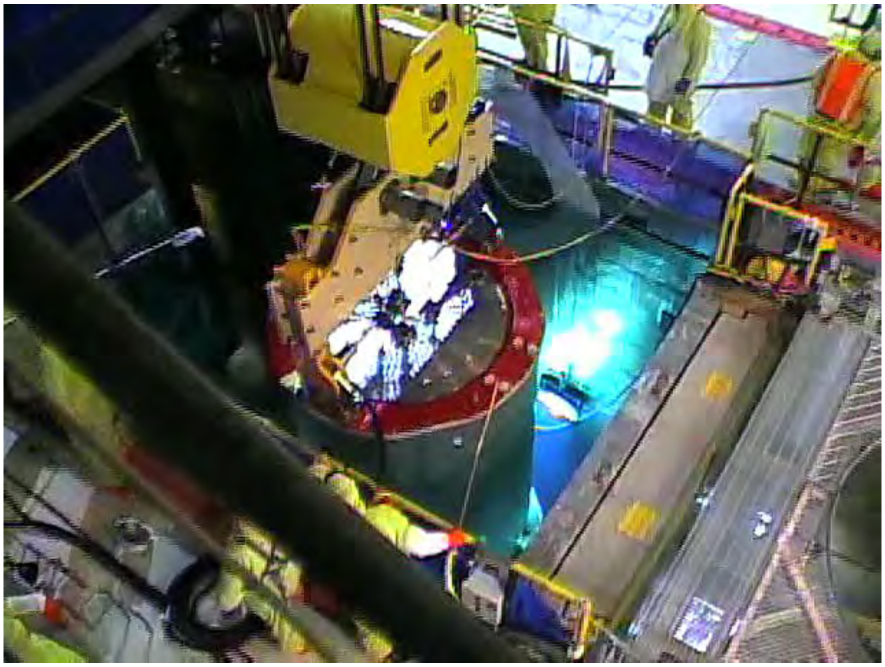


Figure C-6: Transfer Cask and Canister Lowered into Spent Fuel Pool

7. Load the spent fuel assemblies into the canister.
8. Install the canister lid underwater.
9. Engage the lifting yoke and lift the transfer cask and canister out of the pool.
10. Move to cask decontamination area.
11. Perform decontamination.
12. Perform canister closure welding (inner lid).
13. Perform canister draining, drying, and backfill with helium (Figure C-7).

Figure C-7: Helium Backfilling

14. Complete canister closure welding (outer lid) (Figure C-8).
15. Install the canister lift cleats.

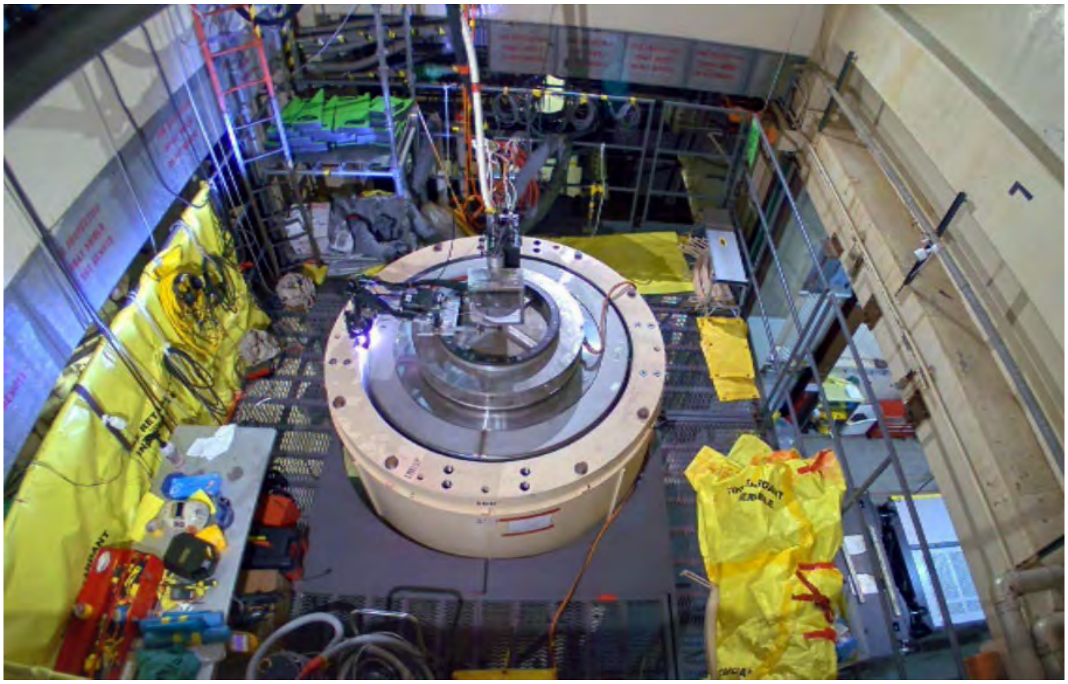


Figure C-8: Final Canister Closure Welding Using Automatic Welding System

Transport to the ISFSI

16. Position the empty concrete overpack on a specialized crawler (Figure C-9).

Figure C-9: Overpack on Crawler

17. Position the empty overpack in the truck bay.
18. Remove the overpack lid.
19. Install the mating device on the overpack (Figure C-10)

Figure C-10: Overpack, Mating Device, and Transfer Cask

20. Raise transfer cask from the decontamination area and place it on the mating device (Figure C-11).

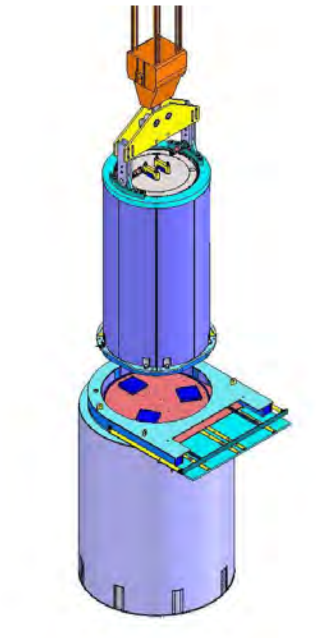


Figure C-11: Placement of Transfer Cask on Overpack with Mating Device

21. Attach the downloader slings between the lift yoke and the canister lift cleats.
22. Raise canister slightly.
23. Remove the transfer cask bottom lid bolts.
24. Open mating device to remove transfer cask bottom lid.
25. Lower the canister into the overpack (Figure C-12).

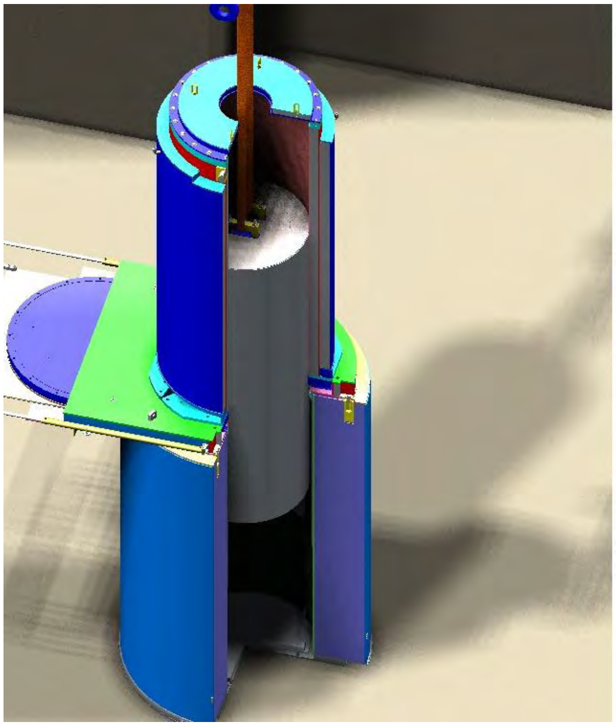


Figure C-12: Lowering of Canister into Overpack

26. Disconnect the downloader slings from the lift yoke.
27. Remove transfer cask from mating device.
28. Disconnect downloader slings and lift cleats from canister (Figure C-13).

Figure C-13: Canister Lowered into Overpack; Lift Cleats and Downloader Slings Removed

29. Remove the mating device.
30. Install the overpack lid.
31. Place the overpack and canister on the ISFSI pad (Figure C-14).

Figure C-14: Overpack and Canister Movement to ISFSI Pad Using Transporter

Appendix D
Life Cycle Greenhouse Gas Emissions from Electricity Generation

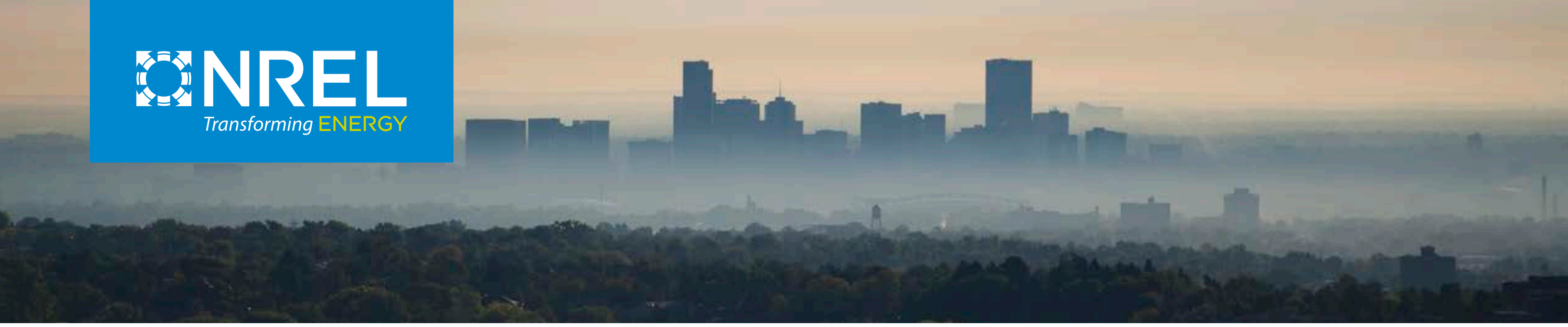


Photo by Dennis Schroeder, NREL 22610

Life Cycle Greenhouse Gas Emissions from Electricity Generation: Update

As clean energy increasingly becomes part of the national dialogue, lenders, utilities, and lawmakers need the most comprehensive and accurate information on greenhouse gas (GHG) emissions from various sources of energy to inform policy, planning, and investment decisions.

Since the National Renewable Energy Laboratory (NREL) published original results from the Life Cycle Assessment Harmonization Project (Heath and Mann 2012), it has updated estimates of electricity generation GHG emissions factors as part of several recent studies. This fact sheet updates an earlier version (NREL 2013).

Systematic Review

NREL considered approximately 3,000 published life cycle assessment studies on utility-scale electricity generation from wind, solar photovoltaics, concentrating solar power, biopower, geothermal, ocean energy, hydropower, nuclear, natural gas, and coal technologies, as well as lithium-ion battery, pumped storage hydropower, and hydrogen storage technologies. A systematic review, comprising three rounds of screening by multiple experts, selected references that met strict criteria for quality, relevance, and transparency. Less than 15% of the original pool of references passed this review process.

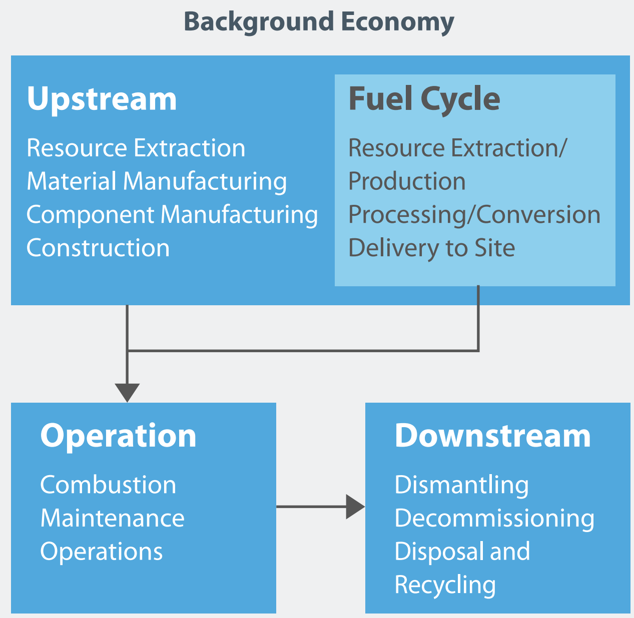
The addition of battery and hydrogen storage technologies introduces a unique set of challenges and assumptions to the compilation of emissions factors. The primary challenges stem from the fact that storage technologies are characterized by two different types of capacity

- Energy Capacity: how much energy a given resource can store, denoted in units of kilowatt hours (kWh)
- Power Capacity: how much energy a given resource can deliver, denoted in units of kilowatts (kW).

Life Cycle Assessment of Energy Systems

Life cycle assessments (LCA) can help quantify environmental burdens from "cradle to grave" and facilitate more-consistent comparisons of energy technologies.

Figure 1. Generalized life cycle stages for energy technologies



Source: Sathaye et al. 2011

Life cycle GHG emissions from renewable electricity generation technologies are generally less than from those from fossil fuel-based technologies, according to evidence assembled from the LCA Harmonization project. Further, the proportion of GHG emissions from each lifecycle stage differs by technology. For fossil-fueled technologies, fuel combustion during operation of the facility emits the vast majority of GHGs. For nuclear and renewable energy technologies, most GHG emissions occur upstream of operation.

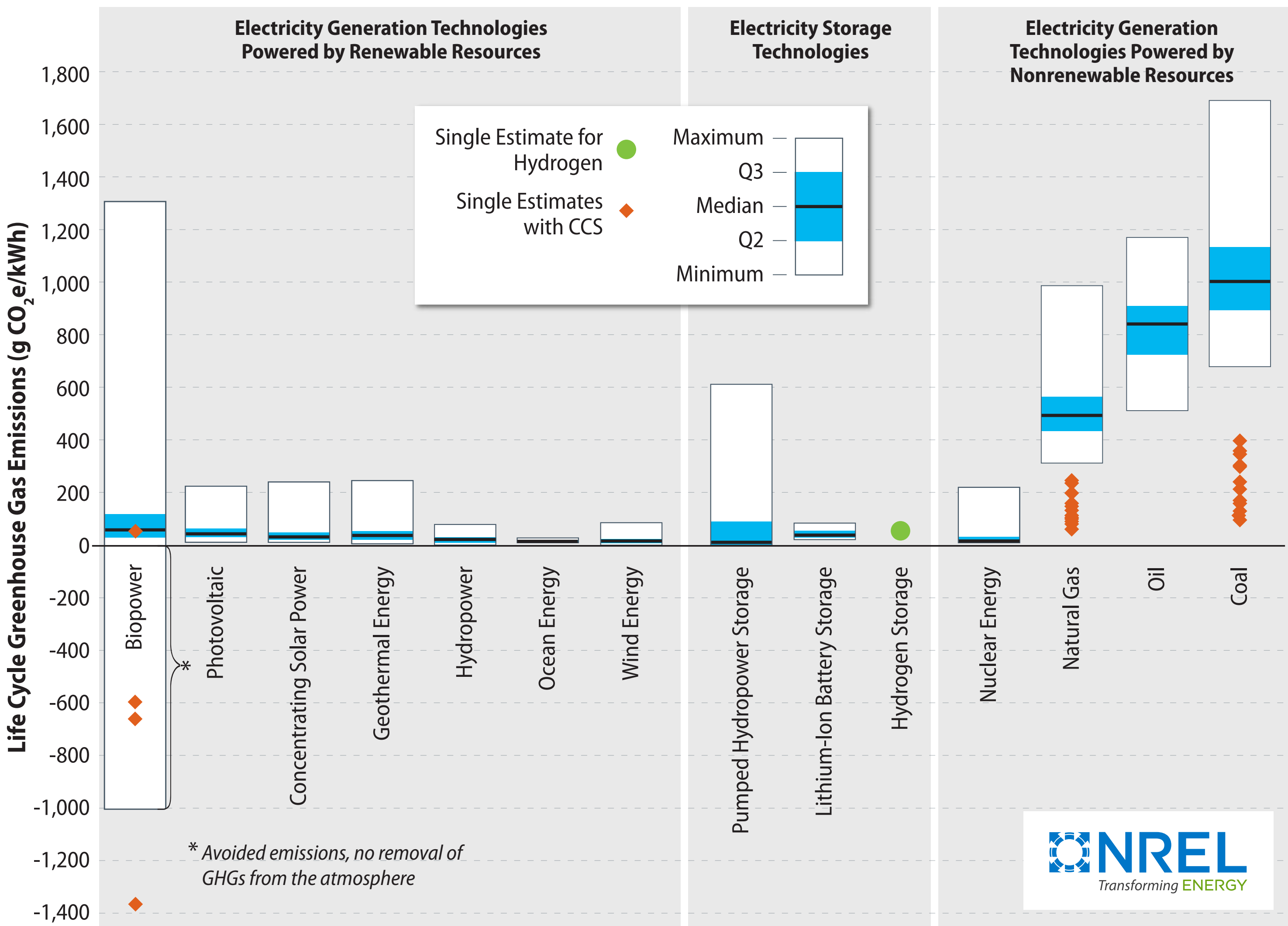
Also, certain storage technologies, especially lithium-ion batteries, can be designed to operate for a variety of grid services, such as time-shifting or frequency regulation. To align the estimates of GHG emissions impacts from the storage technologies with those of other generation technologies, we considered only references that enabled the calculation of emissions per unit of electricity delivered over the lifetime of the storage system. Thus, we have excluded references that report only emissions factors per unit of power capacity.

Published estimates of life cycle GHG emissions for biomass, solar (photovoltaics and concentrating solar power), geothermal, hydropower, ocean, wind (land-based and offshore), nuclear, oil, and coal generation technologies as well as storage technologies are compared in **Figure 2.**

These estimates are drawn from three groups of studies:

- Studies conducted as part of NREL's Life Cycle Assessment Harmonization Project ("Life Cycle Assessment Harmonization," NREL, https://www.nrel.gov/analysis/life-cycle-assessment.html)
- U.S. Department of Energy "vision" studies, including Hydropower Vision (DOE 2016), Wind Vision (DOE 2015), Geothermal Vision (Millstein et al. 2019) and On the Path to SunShot (Wiser et al. 2016)
- Grid-scale lithium-ion battery and hydrogen fuel cell stationary storage literature compiled under the Los Angeles 100% Renewable Energy Study (Nicholson et al. 2021)

Figure 2. Life cycle greenhouse gas emission estimates for selected electricity generation and storage technologies, and some technologies integrated with carbon capture and storage (CCS).



	Biopower	Photovoltaic	Concentrating Solar Power	Geothermal Energy	Hydropower	Ocean Energy	Wind Energy	Pumped Hydropower Storage	Lithium-Ion Battery Storage	Hydrogen Storage	Nuclear Energy	Natural Gas	Oil	Coal
Estimates	276 (+4)	46	36	35	149	10	186	16	29	1	99	80 (+13)	24	164 (+11)
References	57 (+2)	17	10	15	22	5	69	4	3	1	27	47 (+11)	10	53 (+9)

Notes for Figure 2: The number of estimates is greater than the number of references because many studies considered multiple scenarios. Numbers reported in parentheses pertain to additional references and estimates that evaluated technologies with CCS.

Table 1 includes the median values for four life cycle phases (one-time upstream (e.g., materials acquisition and plant construction), ongoing combustion (where applicable), ongoing noncombustion (e.g., operation and maintenance), and one-time downstream (e.g., plant decommissioning and disposal/recycling)) as well as a total life cycle emissions factor. These results show that total life cycle GHG emissions from renewables and nuclear energy are much lower and generally less variable than those from fossil fuels. For example, from cradle to grave, coal-fired electricity releases about 20 times more GHGs per kilowatt-hour than solar, wind, or nuclear electricity (based on median estimates for each technology).

Note that because different numbers of references may be used in the calculation of each entry in Table 1, the sum of the median estimates of each life cycle phase for a given generation technology might not equal the median of the total life cycle emissions factors (the sum of the medians need not equal the median of the sums). Indeed, the sum of the individual phase median values may be greater than the median total, as is the case with concentrating solar power.

Table 1. Median Published Life Cycle Emissions Factors for Electricity Generation Technologies, by Life Cycle Phase

	Generation Technology	One-Time Upstream	Ongoing Combustion	Ongoing Non Combustion	One-Time Downstream	Total Life Cycle	Sources
Renewable	Biomass	NR	—	NR	NR	52	EPRI 2013 Renewable Electricity Futures Study 2012
Renewable	Photovoltaic[a]	~28	—	~10	~5	43	Kim et al. 2012 Hsu et al. 2012 NREL 2012
Renewable	Concentrating Solar Power[b]	20	—	10	0.53	28	Burkhardt et al. 2012
Renewable	Geothermal	15	—	6.9	0.12	37	Eberle et al. 2017
Renewable	Hydropower	6.2	—	1.9	0.004	21	DOE 2016
Renewable	Ocean	NR	—	NR	NR	8	IPCC 2011
Renewable	Wind[c]	12	—	0.74	0.34	13	DOE 2015
Storage	Pumped-storage hydropower	3.0	—	1.8	0.07	7.4	DOE 2016
Storage	Lithium-ion battery	32	—	NR	3.4	33	Nicholson et al. 2021
Storage	Hydrogen fuel cell	27	—	2.5	1.9	38	Khan et al. 2005
Nonrenewable	Nuclear[d]	2.0	—	12	0.7	13	Warner and Heath 2012
Nonrenewable	Natural gas	0.8	389	71	0.02	486	O'Donoughue et al. 2013
Nonrenewable	Oil	NR	NR	NR	NR	840	IPCC 2011
Nonrenewable	Coal	<5	1010	10	<5	1001	Whitaker et al. 2012

Notes for Table 1

All values are in grams of carbon dioxide equivalent per kilowatt-hour (g CO_2e/kWh)

[a] Thin film and crystalline silicon

[b] Tower and trough

[c] Land-based and offshore

[d] Light-water reactor (including pressurized water and boiling water) only

NR = Not Reported.

Funding for this fact sheet was provided by the Joint Institute for Strategic Energy Analysis in support of its Energy and Atmospheric Systems Catalyzer, a collaborative effort that explores the multidirectional relationships across climate, air quality, and energy systems.

See Also

General information about life cycle assessments: "Life Cycle Assessment Harmonization," NREL, https://www.nrel.gov/analysis/life-cycle-assessment.html

Data visualization and data downloads: "LCA Harmonization," OpenEI, https://openei.org/apps/LCA/

Additional distributional statistics and subtechnology emissions factors augmenting Table 1: https://data.nrel.gov/submissions/171

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