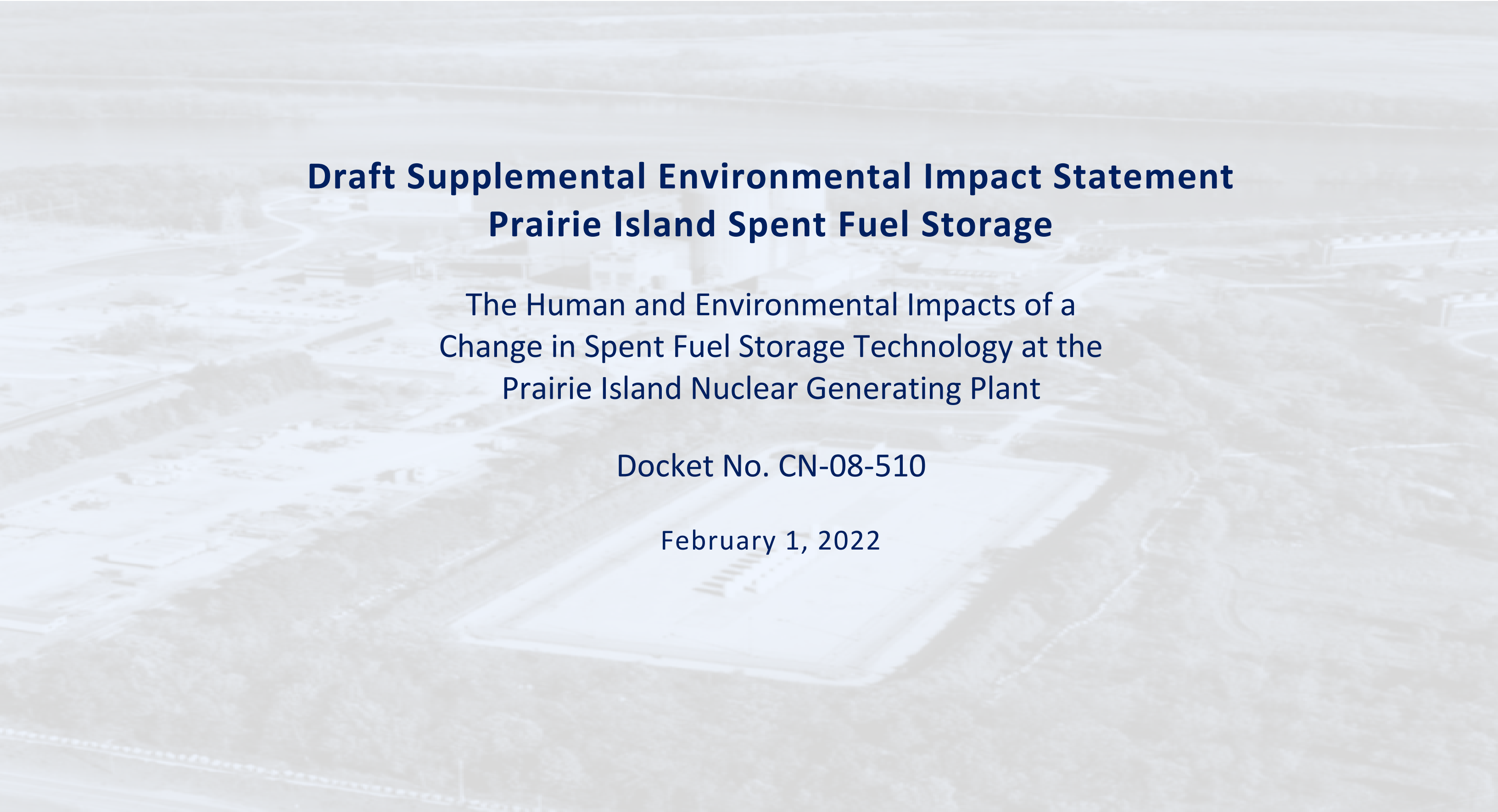

Draft Supplemental Environmental Impact Statement
Prairie Island Spent Fuel Storage

The Human and Environmental Impacts of a
Change in Spent Fuel Storage Technology at the
Prairie Island Nuclear Generating Plant

Docket No. CN-08-510

February 1, 2022

Supplement to the 2009 Prairie Island EIS
Extended Power Uprate Project
Docket No. E002/CN-08-509
Docket No. E002/GS-08-690

Request for Additional Dry Cask Storage
Docket No. E002/CN-08-510

mn COMMERCE DEPARTMENT

Project Contacts

Responsible Governmental Unit
Department of Commerce
85 Seventh Place East, Suite 280
Saint Paul, MN 55101-2198

Commerce Representative
Ray Kirsch
(651) 539-1841
raymond.kirsch@state.mn.us

Project Proposer
Xcel Energy
414 Nicollet Mall
Minneapolis, MN 55401

Xcel Energy Representative
Bria Shea
(612) 330-6064
bria.e.shea@xcelenergy.com

Abstract

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

In 2009, the Minnesota Public Utilities Commission (Commission) granted Xcel Energy a certificate of need (CN) authorizing the company to store enough spent fuel in the ISFSI to facilitate operation of the PINGP through the end of its current licenses – 2033 for Unit 1 and 2034 for Unit 2. To aid the Commission's decision-making, and as the responsible governmental unit, the Minnesota Department of Commerce (Department) prepared an environmental impact statement for the proposed project (2009 Prairie Island EIS).

Xcel Energy is now requesting that the Commission amend its 2009 CN decision. Xcel Energy is proposing to use a different spent fuel storage technology in the PINGP ISFSI. Xcel Energy proposes to use any fuel storage cask approved by the Nuclear Regulatory Commission (NRC) at the ISFSI, rather than being limited to the TN-40HT casks approved by the Commission in 2009.

After reviewing Xcel Energy's request, the Department concluded that the request represented substantial new information that affects the potential environmental effects at the PINGP ISFSI such that the 2009 Prairie Island EIS must be supplemented. After conducting a public scoping process, the Department has prepared this draft, supplemental environmental impact statement (draft SEIS).

This draft SEIS addresses the issues and mitigation measures identified in the Department's scoping decision of December 7, 2021. It evaluates the potential human and environmental impacts of the Xcel Energy's proposed change in spent fuel storage technology and possible mitigation measures for these impacts.

This draft SEIS was issued on February 1, 2022. It has been issued in draft form so that it may be improved by public comment. Comments on the draft SEIS will be accepted through March 3, 2022. Comments should be sent by email, facsimile, or U.S. mail to:

Ray Kirsch, Environmental Review Manager
Minnesota Department of Commerce
85 7th Place East, Suite 280
St. Paul, MN 55101-2198
Email: raymond.kirsch@state.mn.us
Fax: 651-539-0109
On-line: http://mn.gov/commerce/energyfacilities

Following the comment period, the draft SEIS will be revised to incorporate comments and a final SEIS will be issued. The final SEIS will be used by the Commission in determining whether to amend its 2009 CN decision.

The 2009 Prairie Island EIS and other materials related to this project are available on (1) the Department's website: http://mn.gov/commerce/energyfacilities, select *Power Plants* and then *Prairie Island Nuclear Plant Spent Fuel Storage*, and (2) the Commission's website: http://mn.gov/puc, select *eDockets* and enter the year (08) and docket number (510) and select *Search*.

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

List of Preparers

Ray Kirsch
Energy Environmental Review and Analysis
Minnesota Department of Commerce

Acronyms and Abbreviations

BRC	Blue Ribbon Commission
CFR	U.S. Code of Federal Regulations
CISF	Consolidate Interim Storage Facility
CN	Certificate of Need
Commission	Minnesota Public Utilities Commission
CTV	Cask Transportation Vehicle
Department	Minnesota Department of Commerce
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EERA	Department of Commerce Energy Environmental Review and Analysis
EIS	Environmental Impact Statement
ISFSI	Independent Spent Fuel Storage Installation
MnDOT	Minnesota Department of Transportation
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
PIIC	Prairie Island Indian Community
PINGP	Prairie Island Nuclear Generating Plant
RGU	Responsible Governmental Unit
SEIS	Supplemental Environmental Impact Statement
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 Prairie Island nuclear generating plant (PINGP) in Red Wing, Minnesota. Spent nuclear fuel from the plant is stored on site in an independent spent fuel storage installation (ISFSI).

In 2009, the Minnesota Public Utilities Commission (Commission) granted Xcel Energy a certificate of need (CN) authorizing the company to store enough spent fuel in the ISFSI to facilitate operation of the PINGP through the end of its current licenses – 2033 for Unit 1 and 2034 for Unit 2. To aid the Commission's decision-making, and as the responsible governmental unit, the Minnesota Department of Commerce (Department) prepared an environmental impact statement for the proposed project (2009 Prairie Island EIS).

Xcel Energy is now requesting that the Commission amend its 2009 CN decision. Xcel Energy is proposing to use a different spent fuel storage technology in the PINGP ISFSI. Xcel Energy proposes to use any fuel storage cask approved by the Nuclear Regulatory Commission (NRC) at the ISFSI, rather than being limited to the TN-40HT casks approved by the Commission in 2009. Xcel Energy would select from NRC-approved cask designs based on considerations including price and compatibility with future offsite storage facilities.

Project Need

Xcel Energy indicates that its proposed change in spent fuel storage technology would likely result in lower customer costs. The spent nuclear fuel industry has moved away from all-in-one cask designs such as the TN-40HT cask and toward canister-based storage systems. Xcel indicates that a canister-based storage system would likely lead to lower spent fuel storage costs and thus lower customer costs.

Additionally, Xcel Energy indicates that a change in technology could potentially facilitate earlier shipments of spent nuclear fuel from Prairie Island to offsite storage facilities. The NRC is currently reviewing applications for private, interim storage facilities in Texas and New Mexico. These facilities are based on canister-based storage systems; they do not currently provide for the storage of TN-40 or TN-40HT casks. Spent fuel canisters could be transported and stored once the facilities are licensed and operating.

Human and Environmental Impacts

The Department has prepared this supplementary EIS (SEIS) to analyze the potential human and environmental impacts of Xcel Energy's proposed change in spent fuel storage technology in the PINGP ISFSI. The SEIS builds upon the analysis in the 2009 Prairie Island EIS.

This SEIS finds that the non-radiological impacts of a change in spent fuel storage technology in the PINGP ISFSI are anticipated to be minimal. A change from casks to a canister-based system would not adversely impact water resources, flora, or fauna; further, a change would not impact the human environment, e.g., noise, lighting, aesthetics.

The SEIS also finds that the radiological impacts of a change in spent fuel storage technology are anticipated to be minimal. The radiation dose to the public with different spent fuel storage technology in the PINGP ISFSI is anticipated to be minimal and indistinguishable from background radiation. Further, a change in spent fuel storage technology in the PINGP 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 within NRC standards.

The SEIS does note that if Xcel Energy selects a canister-based system for use in the PINGP ISFSI, health impacts to workers would likely be incrementally greater due to relatively higher radiation dose levels associated with canister systems. This incremental increase in dose levels would be within NRC standards and health impacts to workers would remain minimal.

Environmental Justice

The Prairie Island Indian Community (PIIC) is the closest community to the PINGP and a community for whom there are environmental justice concerns. The SEIS finds that a change in storage technology at the PINGP ISFSI would not change environment justice concerns for the PIIC. Concerns would neither increase with the change, nor would they be allayed by a change. Concerns could only be addressed by closure of the PINGP and the removal of spent fuel from the PINGP ISFSI.

Transportation of Spent Fuel to Interim Storage Facilities

The SEIS notes that analysis, testing, and experience with shipping spent fuel indicate that the impacts of transporting spent nuclear fuel in the United States are anticipated to be minimal. A 2019 table-top transportation exercise at the PINGP highlighted the need for proactive communication among transportation stakeholders including tribes and states.

Long-Term Storage of Spent Nuclear Fuel

The SEIS confirms a key finding of the 2009 Prairie Island EIS – that institutional control is essential for proper maintenance and monitoring of spent fuel in ISFSIs. Without institutional control, individuals living near degraded ISFSIs would suffer severe health impacts.

The SEIS notes that consolidated interim storage facilities (CISF) proposed in Texas and New Mexico are being reviewed by the NRC. These facilities could, at some time in the future, accept spent nuclear fuel from U.S. nuclear plants, including the PINGP. When or whether these facilities will accept spent nuclear fuel is uncertain.

Contents

Appendices

Figures

Tables

1 Introduction

This supplemental environmental impact statement (SEIS) has been prepared by the Minnesota Department of Commerce (Department) for Xcel Energy's proposed change in spent fuel storage technology at the Prairie Island nuclear generating plant (PINGP). This SEIS evaluates the potential human and environmental impacts of the project and possible mitigation measures. This document supplements the 2009 Prairie Island environmental impact statement (EIS), which was prepared, in part, to analyze a proposed increase in storage of spent nuclear fuel at the PINGP.

This SEIS is not a decision-making document, but rather a guide for decision makers. The SEIS 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 PINGP is a 1,100 megawatt (MW), two-unit, electric generating plant in Red Wing, Minnesota. Unit 1 has been in operation since 1973; Unit 2 since 1974. Spent nuclear fuel from the plant is stored on-site in an independent spent fuel storage installation (ISFSI).

On May 16, 2008, Xcel Energy applied to the Minnesota Public Utilities Commission (Commission) for a certificate of need (CN) to expand the Prairie Island ISFSI by 35 casks. This 35-cask expansion would enable the ISFSI to accommodate a total of 64 spent fuel storage casks. The 64 casks would: (1) facilitate the storage of 2,560 spent fuel assemblies and (2) allow operation of the PINGP through the end of its federal operating licenses – 2033 for Unit 1 and 2034 for Unit 2.

Department staff prepared an EIS that analyzed the proposed ISFSI expansion (2009 Prairie Island EIS).[2] At that time, Xcel Energy proposed that the additional storage casks be Transnuclear TN-40HT casks. On December 18, 2009, the Commission issued a CN authorizing Xcel Energy to expand the Prairie Island ISFSI by 35 casks, to accommodate a total of 64 casks.[3]

1.2 Proposed Project

Xcel Energy proposes to use a different spent fuel storage technology in the Prairie Island ISFSI.[4] Xcel Energy proposes to use any fuel storage cask approved by the Nuclear Regulatory Commission (NRC) for the ISFSI, rather than being limited to the TN-40HT casks approved by the Commission in 2009. Xcel Energy indicates that they would select from NRC-approved cask designs based on considerations including price and compatibility with future offsite storage facilities. Xcel Energy notes that the design selected could be similar to the welded, canister system used in the Monticello nuclear generating plant ISFSI.

Xcel Energy indicates that it is not seeking to store more spent fuel that was approved by the Commission in 2009.[5] Xcel Energy indicates that it still seeks to store the 2,560 spent-fuel assemblies anticipated by the Commission's 2009 CN. Xcel Energy's request is that it not be limited to storing these assemblies in 64 TN-40HT casks, but rather storing them in any NRC-approved spent fuel storage casks. Xcel Energy notes that depending on the cask design selected for the ISFSI and its fuel assembly capacity, the total number of casks needed for 2,560 fuel assemblies could increase, i.e., could be greater than 64 casks.

1.3 Project Need

Xcel Energy indicates that its proposed change in spent fuel storage technology would likely result in lower customer costs.[6] Xcel Energy notes that the spent nuclear fuel industry has moved away from all-in-one cask designs such as the TN-40 and TN-40HT and toward canister-based storage systems.[7] Thus, efficiencies and cost savings have accrued to canister-based systems. This has made cask systems relatively more expensive and less supported by technological advances.[8] Xcel indicates that a canister-based storage system would likely lead to lower spent fuel storage costs and thus lower customer costs.

Additionally, Xcel Energy indicates that a change in technology could potentially facilitate earlier shipments of spent nuclear fuel from the PINGP ISFSI to offsite storage facilities.[9] The NRC is currently reviewing applications for private, interim storage facilities in Texas and New Mexico.[10] These facilities would consolidate and store spent nuclear fuel from power reactors throughout the United States. The applications for these facilities are predicated on canister-based storage systems; they do not currently provide for the storage of TN-40 or TN-40HT casks.[11] The facilities' licenses would require amendment in order to store TN-40 and TN-40HT casks. Any amendment, if pursued by the storage facilities, would take additional time and would likely push the associated casks to the back of the line, so to speak, for transport and storage. In contrast, spent fuel canisters could be transported and stored once the facilities are licensed and operating.

1.4 State of Minnesota Review Process

Xcel Energy's proposed change in spent fuel storage technology requires approval from the Commission – an amendment of the Commission's 2009 CN for the Prairie Island ISFSI.[12] Additionally, and prior to the Commission's decision on a CN amendment, the project requires that the 2009 Prairie Island EIS be supplemented.[13] The Department has prepared this SEIS for the project. The SEIS 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 SEIS. The Commission will consider the final SEIS and the entire record in making a decision on a CN amendment for Xcel Energy's proposed change in spent fuel storage technology.

1.5 Organization of SEIS

This SEIS addresses the issues identified in the Department's scoping decision of December 7, 2021 (Appendix A), and is organized as follows:

Chapter 1.0	Introduction	Provides an overview of the proposed project, the state of Minnesota's review process, and this SEIS.
Chapter 2.0	Regulatory Framework	Describes the regulatory framework associated with the project, including federal oversight, the Commission's oversight, and environmental review.
Chapter 3.0	Spent Fuel Storage Technology	Describes the proposed project, including NRC-certified casks and canisters, spent fuel handling and monitoring, and the PINGP ISFSI.
Chapter 4.0	Potential Impacts – Non-Radiological	Describes potential non-radiological impacts to human and natural resources and possible mitigation measures.
Chapter 5.0	Potential Impacts – Radiological	Describes potential radiological impacts to human and natural resources and possible mitigation measures.
Chapter 6.0	Transportation of Spent Nuclear Fuel	Describes the regulatory framework for the transportation of spent fuel, the safety of fuel transport, and a 2019 table-top transportation exercise.
Chapter 7.0	Long-Term Storage of Spent Nuclear Fuel	Describes changes in the spent fuel storage landscape since 2009 in the United States.

1.6 Sources of Information

The primary sources of information for this SEIS are:

- Xcel Energy's request for a change in spent fuel storage technology.
- New and additional information from Xcel Energy regarding its request.
- The 2009 Prairie Island EIS, available at: https://mn.gov/eera/web/project/315/

All information sources are indicated in chapter endnotes. Several sources were suggested or provided by the Prairie Island Indian Community.

Notes

[1] Minnesota Statute 116D.02.

[2] 2009 Prairie Island Final EIS, Xcel Energy Prairie Island Nuclear Generating Plant, Extended Power Uprate Project (CN-08-509, GS-08-690) and Request for Additional Dry Cask Storage (CN-08-510), https://mn.gov/eera/web/file-list/14504.

[3] Order Accepting Environmental Impact Statement, and Granting Certificates of Need and Site Permit with Conditions, December 18, 2009, Docket Nos. CN-08-509, CN-08-510, GS-08-690, eDockets Number 200912-45206-02.

[4] Xcel Energy Request for Change in Spent-Fuel Storage Technology, Prairie Island Fuel Storage, Docket No. E002/CN-08-510, April 30, 2021, eDockets Number 20214-173680-01 [hereinafter Xcel Energy Request for Technology Change].

[5] Id.

[6] Id.

[7] Id.

[8] Id.

[9] Id.

[10] Id.

[11] Id.

[12] See., e.g., Minnesota Rule 7849.0400. There is not a Minnesota statute or rule which directly addresses modification of a certificate of need for the storage of spent nuclear fuel at an ISFSI. See analysis and comments by the Department, Division of Energy Resources, May 28, 2021, eDockets Number 20215-174604-01.

[13] Minnesota Rule 4410.3000. The Department, as the RGU for the EIS, has determined that Xcel Energy's proposed project represents substantial new information that significantly affects the potential environmental effects at the Prairie Island ISFSI. See analysis and comments by the Department, Energy Environmental Review and Analysis, May 27, 2021, eDockets Number 20215-174578-01. See also, Commission Order, October 21, 2021, eDockets Number 202110-178440-01 (taking no action on Xcel Energy's request until the 2009 Prairie Island EIS has been supplemented).

2 Regulatory Framework

Xcel Energy's proposed change in spent fuel storage technology requires review by state and federal regulators. At the state level, the project requires approval from the Commission – an amendment of the CN issued by the Commission in 2009. At the federal level, Xcel Energy must notify the NRC of its intention to use a different NRC-certified cask in the Prairie Island ISFSI and must document that use of the cask is consistent with NRC conditions on its use.

2.1 State Regulation

Storage of spent nuclear fuel at Prairie Island is regulated by the Commission, whose decisions must be affirmed by the Minnesota Legislature.[1] In 2003, the Minnesota Legislature authorized storage of spent nuclear fuel sufficient to allow the PINGP to operate until the end of its then NRC operating licenses – 2013 for Unit 1 and 2014 for Unit 2.[2] The cask proposed by Xcel Energy to the store the spent nuclear fuel was a steel cask with a bolted lid that could hold 40 fuel assemblies designed by the Transnuclear Corporation (TN-40 cask).

In 2008, Xcel Energy applied to the NRC for a 20-year extension of the PINGP operating licenses.[3] The NRC granted these extensions in 2011, authorizing operation of Unit 1 through 2033 and Unit 2 through 2034.

To accommodate the additional spent fuel generated by operation of the PINGP through 2033/34, Xcel Energy applied to the Commission for a CN to expand the Prairie Island ISFSI by 35 casks – such that the ISFSI could hold a total of 64 casks or 2,560 spent fuel assemblies.[4] Department staff prepared an EIS that analyzed the proposed ISFSI expansion (2009 Prairie Island EIS). In 2009, the Commission issued a CN authorizing Xcel Energy to expand the PINGP ISFSI by 35 casks, for a total of up to 64 casks.[5] This total would facilitate operation of the PINGP through 2033/34. At that time, Xcel Energy proposed that the 35 additional casks be Transnuclear TN-40HT casks.[6]

On April 30, 2021, Xcel Energy requested that the Commission authorize a change in the spent fuel storage technology at Prairie Island.[7] Xcel Energy requested that it be authorized to use any spent fuel storage technology that has been approved by the NRC, rather than being limited solely to the TN-40HT cask. Additionally, as the cask ultimately selected for use in the ISFSI may not hold 40 fuel assemblies (as the TN-40HT cask does), Xcel Energy requested that it not be limited to 64 casks in the ISFSI, but rather the number of casks necessary to store 2,560 fuel assemblies.[8]

Certificate of Need

The Commission is guided by Minnesota statutes and rules in determining whether to issue or amend a CN for a specific project. For the storage of spent nuclear fuel, the Commission must apply Minnesota Rules, Chapter 7855. This chapter provides criteria that the

Commission must use in determining whether to issue a CN.[9] However, this chapter does not explicitly provide guidance on whether or how the Commission may amend an existing CN for spent nuclear fuel.

Minnesota Rule 7849.0400 provides procedures the Commission must use when considering a change to the size, type, or timing of a non-nuclear generating plant or a high-voltage transmission line for which a CN has been issued. The Commission could look to this rule, which addresses other types of energy facilities, for guidance in how to address Xcel Energy's request. The rule requires notice to the Commission of the proposed change to the CN, a comment period, and then a decision by the Commission on the proposed change.[10] The rule also requires the Commission to order a hearing if it determines that the proposed change to the CN, if known at the time of the initial CN decision, could reasonably have resulted in a different CN decision.[11]

The Commission could place conditions on any amendment of its 2009 CN decision for the PINGP ISFSI.

Environmental Review

The Department is the responsible governmental unit (RGU) for conducting environmental review of ISFSI expansions.[12] In 2009, the Department prepared the EIS for Xcel Energy's expansion of the PINGP ISFSI to 64 casks (2009 Prairie Island EIS). The EIS analyzed expansion of the ISFSI using TN-40HT casks.

Xcel Energy's current request proposes: (1) using any NRC-certified cask in lieu of the TN-40HT cask, and (2) amending the 64-cask ISFSI limit to be a limit based on the total number of fuel assemblies (2,560) that need to be stored in order to allow the PINGP to operate through its current licenses (2033/34).

An EIS for a project must be supplemented if the RGU determines that any of the following situations exist:

A. Whenever after a final EIS has been determined adequate, but before the project becomes exempt under part 4410.4600, subpart 2, item B or D, the RGU determines that either:

    (1) substantial changes have been made in the proposed project that affect the potential significant adverse environmental effects of the project; or

    (2) there is substantial new information or new circumstances that significantly affect the potential environmental effects from the proposed project that have not been considered in the final EIS or that significantly affect the availability of prudent and feasible alternatives with lesser environmental effects;

B. Whenever an EIS has been prepared for an ongoing governmental action and the RGU determines that the conditions of item A, subitem (1) or (2), are met with respect to the action; or

C. Whenever an EIS has been prepared for one or more phases of a phased action or one or more components of a connected action and a later phase or another component is proposed for approval or implementation that was not evaluated in the initial EIS.[13]

Department staff has concluded that Xcel Energy's request for a change in spent fuel storage technology represents substantial new information that significantly affects the potential environmental effects at the Prairie Island ISFSI such that the 2009 Prairie Island EIS must be supplemented. Accordingly, staff has prepared this SEIS in accordance with Minnesota Rule 4410.3000.

The SEIS 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 SEIS. The Commission will consider the final SEIS and the entire record in making a decision on Xcel Energy's request.

Supplemental EIS Scoping

Scoping is the first step in the development of an SEIS. Department staff gathered input on the scope of this SEIS through public meetings and an associated comment period. Staff also gathered input through a meeting with the Prairie Island Indian Community (PIIC).

Department staff held a public meeting regarding Xcel Energy's proposed change in spent fuel storage technology on October 5, 2021, in Red Wing, Minnesota. Approximately 15 persons attended this meeting; six persons provided public comments. Comments addressed a range of topics including the type of technology that Xcel Energy might select for the project, licensing requirements, transportation of casks, and changes in spent nuclear fuel regulation since the 2009 Prairie Island EIS.

The following evening, October 6, 2021, EERA staff held a virtual public meeting. Approximately 10 persons attended this meeting; two persons provided public comments. Comments addressed coordination with the PIIC regarding Xcel Energy's proposal and the potential relicensing of the PINGP.

Following the public scoping meetings, written comments were received from the PIIC, the city of Red Wing, and three citizens. Comments addressed several topics including the transportation of spent nuclear fuel, the need for more information regarding the types of technology that could be used by Xcel Energy, and licensing requirements.

In coordination with the PIIC, Department staff held a community meeting with PIIC members on November 10, 2021. Approximately 10 persons attended this meeting in person with a similar number joining on-line; five community members provided comments. Comments addressed the sealing of casks, cask transportation, potential impacts due to earthquakes and low temperatures, and the integrity of spent fuel rods. The Department issued a scoping decision for the SEIS on December 7, 2021 (Appendix A). This SEIS has been prepared in accordance with the scoping decision.

Casks That Facilitate Transportation of Spent Fuel

In addition to the requirements for a CN and environmental review, the Minnesota Legislature has directed the Commission to ensure that spent nuclear fuel in the PINGP ISFSI 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.[14]

As is discussed further, below, the NRC regulates casks for storage and for transportation independently. The TN-40 cask used in the PINGP ISFSI is certified for storage and transportation.[15] The TN-40HT cask is currently certified solely for storage. Xcel Energy applied to the NRC for a transportation license for the TN-40HT cask on November 30, 2021.[16]

Additionally, Xcel Energy has noted that any new spent fuel technology selected for use in the PINGP ISFSI will be certified for storage and transportation.[17] Thus, if the NRC issues a transportation license for the TN-40HT cask, all of the casks that are and will be used in the ISFSI would satisfy Minnesota Statute 116C.776.

2.2 Federal Regulation

The NRC regulates the storage of spent nuclear fuel in ISFSIs by means of two licensing processes – a site-specific license and a general license.[18] The NRC also regulates the casks and canisters (generically, casks) that can be used to store spent nuclear fuel,[19] and those casks that can be used to transport spent nuclear fuel.[20]

Prairie Island ISFSI

The Prairie Island ISFSI has a site-specific license for the use of TN-40 casks.[21] The ISFSI was initially licensed by the NRC in 1993.[22] The license has subsequently been renewed and currently expires in 2053.[23] The TN-40 cask was designed specifically for Prairie Island and is used at no other ISFSIs in the United States.[24] The PINGP ISFSI license contains technical requirements and operating conditions for the ISFSI and specifies the spent fuel that is authorized to be stored at the site. At the time Xcel Energy applied for, and was granted, a site-specific license for the PINGP ISFSI, the NRC had not yet implemented its general license process.[25]

The NRC's general license for an ISFSI allows the operator of a nuclear power plant to store spent fuel in any of several NRC-certified casks at the plant site.[26] This general license process is now used by most ISFSIs in the United States.[27] Xcel Energy notes that a general license is available for all nuclear power plant ISFSIs, even those that previously received a site-specific license.[28]

A power plant operator using the general license process is required to evaluate their ISFSI site to demonstrate that the site is adequate for storing spent fuel in dry casks. This evaluation must show that the cask certificate of compliance conditions and technical specifications can be met.[29] The operator must also review their security program, emergency plan, quality assurance program, training program, and radiation protection program, and make any necessary changes to incorporate the cask into the plant ISFSI.[30]

Storage of Spent Fuel

The NRC certifies casks for the storage of spent nuclear fuel.[31] An NRC-certified cask is a cask that has been certified to safely store spent nuclear fuel. Safe storage depends on several factors including structural and thermal integrity, radiation shielding, material confinement, and performance in accident conditions (Appendix B).[32] An NRC-certified cask is issued a certificate of compliance. In addition to identifying the cask as NRC-certified for the storage of spent fuel, the certificate defines the conditions under which the cask is properly used.[33]

Xcel Energy proposes to use an NRC-certified cask for the storage of spent nuclear fuel in the PINGP ISFSI. As it would use an NRC-certified cask, Xcel Energy proposes to proceed under the NRC's general license process (discussed above).[34] Using this process, Xcel Energy will need to file documentation with the NRC demonstrating that the cask selected can be properly used in the PINGP ISFSI, i.e., that its use in the ISFSI will be consistent with the conditions in the cask's certificate of compliance.[35]

Transportation of Spent Fuel

The NRC certifies casks for the transportation of spent nuclear fuel.[36] NRC regulations establish design parameters and packaging requirements for spent fuel.[37] Casks are packaged for shipment by truck or rail; packages include shielding and impact limiters.[38] Transportation packages must meet design criteria related to structural integrity, shielding, and criticality, among others.[39] Transportation packages must demonstrate their ability to function after several accident scenarios, e.g., dropping onto a hard surface, crushing, exposure to fire.[40]

Xcel Energy has indicated that any new spent fuel technology selected for use in the PINGP ISFSI will be certified for storage and transportation.

2.3 Other Permits and Approvals

A building permit from the city of Red Wing may be required for the project depending on the need for any ground-disturbing activities, e.g., paving, storage module construction.[41]

2.4 Issues Outside the Scope of this SEIS

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

- Potential Impacts and mitigation measures that are addressed in the 2009 Prairie Island EIS.
- Potential impacts associated with operation of the PINGP.
- The appropriateness of NRC regulations for spent nuclear fuel storage technology.
- Potential impacts associated with the nuclear fuel cycle.
- The appropriateness of NRC regulations and standards for radiation exposure. The SEIS may reference certain standards promulgated by the NRC; however, the SEIS will not address the adequacy of these standards.

Notes

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

[2] Minnesota Statute 116C.83, Subd. 1.

[3] Prairie Island Nuclear Generating Plant, Units 1 and 2 - License Renewal Application, https://www.nrc.gov/reactors/operating/licensing/renewal/applications/prairie-island.html#appls.

[4] 64 casks X 40 spent fuel assemblies per cask = 2,560 spent fuel assemblies.

[5] Order Accepting Environmental Impact Statement, and Granting Certificates of Need and Site Permit with Conditions, December 18, 2009, Docket Nos. CN-08-509, CN-08-510, GS-08-690, eDockets Number 200912-45206-02

[6] The TN-40HT cask is similar to the TN-40 cask in that it holds 40 spent fuel assemblies. The TN-40HT cask can store spent fuel with relatively greater enrichment and fuel burnup. To do this, the TN-40HT cask has a fuel assembly basket design that improves heat transfer. See 2009 Prairie Island EIS, Chapter 2, Section 2.1.

[7] Xcel Energy Request for Technology Change.

[8] Id.

[9] Minnesota Rule 7855.0120.

[10] Minnesota Rule 7849.0400, Subpart H.

[11] Id.

[12] Minnesota Statutes section 116C.83, Subd. 6(b)

[13] Minnesota Rule 4410.3000, subp. 3.

[14] Minnesota Statute 116C.776.

[15] Transportation Package Information, https://www.nrc.gov/materials/transportation/package.html/. The NRC certificate of compliance for the TN-40 cask is 71-9313.

[16] Xcel Energy Additional Information.

[17] Xcel Energy Request for Technology Change.

[18] Xcel Energy Additional Information.

[19] Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater than Class C Waste, Title 10 Code of Federal Regulations Part 72, https://www.nrc.gov/reading-rm/doc-collections/cfr/part072/index.html [hereinafter 10 CFR 72].

[20] Packaging and Transportation of Radioactive Material, Title 10 Code of Federal Regulations Part 71, https://www.nrc.gov/reading-rm/doc-collections/cfr/part071/index.html [hereinafter 10 CFR 71]; Standard Review Plan for

Transportation Packages for Spent Fuel and Radioactive Material: Final Report (NUREG-2216), https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr2216/index.html [hereinafter NUREG 2216].

[21] Xcel Energy Request for Technology Change; Xcel Energy Additional Information.

[22] Xcel Energy Additional Information.

[23] Id.

[24] Id

[25] Id.

[26] Xcel Energy Additional Information; 10 CFR 72, Subpart K

[27] Xcel Energy Additional Information.

[28] Xcel Energy Additional Information. Examples provided by Xcel Energy include the Surry and North Anna nuclear power plants and ISFSIs in the state of Virginia.

[29] 10 CFR 72, Subpart K.

[30] Id.

[31] 10 CFR 72; Standard Review Plan for Dry Cask Storage Systems (NUREG-1536), https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1536/index.html [hereinafter NUREG-1536].

[32] Certification Process for Spent Fuel Storage Casks, https://www.nrc.gov/waste/spent-fuel-storage/sf-storage-licensing/cert-process-casks.html#new.

[33] Xcel Energy Additional Information. See, e.g., the certificate of compliance for the canister-based storage system used at the Monticello nuclear generating plant: Certificate of Compliance No. 1004, Renewed Amendment No. 17, for the Standardized NUHOMS System, https://www.nrc.gov/docs/ML2110/ML21109A325.html.

[34] Xcel Energy Request for Technology Change.

[35] General License Considerations, https://www.nrc.gov/waste/spent-fuel-storage/sf-storage-licensing/license-considerations.html

[36] 10 CFR 71; NUREG-2216.

[37] Id.

[38] Going the Distance?: The Safe Transport of Spent Nuclear Fuel and High-Level Radioactive Waste in the United States, https://www.nap.edu/catalog/11538/going-the-distance-the-safe-transport-of-spent-nuclear-fuel [hereinafter Going the Distance].

[39] 10 CFR 71.

[40] 10 CR 71; Going the Distance.

[41] Xcel Energy Additional Information.

3 Spent Fuel Storage Technology

Xcel Energy proposes to use a different spent fuel storage technology in the Prairie Island ISFSI. Xcel Energy proposes to use an NRC-certified fuel storage cask for the ISFSI, rather than being limited to the TN-40HT casks approved by the Commission in 2009. This chapter describes the ISFSI and TN-40HT casks. Additionally, it describes other NRC-certified casks that could be used in the ISFSI.

3.1 Prairie Island ISFSI

The PINGP is located on the west bank of the Mississippi River in Goodhue County within the city limits of Red Wing, Minnesota. The Prairie Island ISFSI is located approximately 300 yards west of the plant (Figure 1). The ISFSI is approximately 720 feet long and 340 feet wide, roughly 5.5 acres in size.[1] Two fences surround the facility with a monitored, clear zone between the fences. A 17 foot high earthen berm surrounds the ISFSI. Within the ISFSI, casks are stored on reinforced concrete pads that are three feet thick.

Figure 1. Prairie Island Nuclear Generating Plant and ISFSI

A steel frame equipment storage building approximately 30 feet high is located on the ISFSI site. The primary purpose of this building is to store the cask transport vehicle. A smaller block building within the ISFSI houses security equipment while one outside the ISFSI houses cask pressure monitoring equipment. The site is monitored with cameras and other security devices.

3.2 Spent Fuel Storage Systems

Spent nuclear fuel is highly radioactive and must be properly handled and stored. All spent nuclear fuel storage casks must be approved by the NRC and meet NRC design criteria. Among other criteria, spent fuel storage casks must: (1) confine 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).[2]

NRC-certified casks 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 or canister-based system). These systems are discussed further here.

TN-40 Casks

The TN-40 and TN-40HT casks are all-in-one metal casks that provide both containment and shielding.[3] The cask walls are thick – 9.5 inches for TN-40 casks.[4] The thickness ensures that the spent fuel is contained and that persons are appropriately shielded from radioactivity. Individual TN-40 casks are approximately eight feet in diameter, 16 feet tall, and weigh approximately 240,000 lbs. when loaded (Figure 2).[5]

Figure 2. TN-40 Casks on ISFSI Pad

Because all-in-one metal casks have thick cask walls, they are bolted shut. That is, the lid for the cask is bolted into place rather than welded. For the TN-40 cask, the cask lid is 10 inches thick and is attached with 48 bolts.[6] The cask lids have two seals (O-rings) which are pressurized and monitored to ensure the cask is properly sealed at all times.[7]

Canister Systems

Canister systems for spent fuel storage are two-part systems – a metal canister to contain the spent fuel and a concrete overpack that provide radiation shielding. Because the metal canister is designed primarily for containment and not shielding, the canister walls are much thinner than an all-in-one metal cask (less than one inch).[8] Because they are thinner, canister lids can be welded in place rather than bolted. Two lids are welded in place for a secure, redundant seal.[9]

Sealed canisters can be placed in a vertical or horizontal concrete overpack. Vertical storage systems use a thick-walled concrete cylinder to provide radiation shielding (Figure 3). A gap between the canister and concrete overpack is provided to allow airflow for heat removal. Openings in the concrete cylinder at the top and bottom allow air convection to aid cooling. The canisters, in their overpacks, look very similar to all-in-one metal casks.

Figure 3. Vertical Canisters in Concrete Overpack

Horizontal storage systems place sealed canisters in a rectangular concrete module (Figure 4). Similar to vertical systems, air ducts are provided to allow air convection to remove heat.

Figure 4. Horizontal Canisters in Concrete Module

NRC-Certified Casks and Canisters

There are several manufacturers and models of NRC-certified spent fuel casks and canisters (Table 1).[10] Canister systems are more widely used than casks. The two largest manufactures of canister systems are Holtec International, with 1,657 canisters currently in use, and Orano, with 1,205 canisters currently in use.[11] By comparison, there are currently 203 TN casks in use in the United States (TN-32, TN-40, and TN-68 models).[12] Xcel Energy notes that while other ISFSIs use casks like the TN-40, no other ISFSI in the United States is still loading fuel into metal, bolted casks.[13]

As discussed in Chapter 2.1, Xcel Energy indicates that it would solicit proposals for canister systems that are licensed for storage and for transportation. Xcel Energy notes that it would also request a proposal for TN-40HT casks, so that a comparison can be made between the current TN-40HT casks and a new canister system.[14]

Table 1. NRC-Certified Casks and Canisters[15]

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

3.3 Handling and Storing Spent Fuel

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 cask or canister for transport to the ISFSI pad. The process for loading and transporting spent fuel is similar for casks and canisters.

TN-40 Casks

Loading of an all-in-one metal cask (e.g., TN-40 cask) begins with lowering the cask into the spent fuel pool.[16] Fuel assemblies (40 assemblies per cask) are loaded into the cask and the lid for the cask is installed underwater. The cask is lifted from the pool, drained, and decontaminated (Figure 5). The cask is vacuum dried, backfilled with helium, and a helium leak test of the cask seals is performed.

The decontaminated cask is placed into a specialized cask transport vehicle (CTV). A final protective weather cover is attached, and the cask is moved via the CTV to the ISFSI pad (Figure 6) (Appendix C).

Figure 5. TN-40 Cask Removed from Spent Fuel Pool

Figure 6. TN-40 Cask Placed on ISFSI Pad

Canister Systems

Loading of a spent fuel canister begins with lowering the canister into the spent fuel pool. It's not possible to lower a concrete overpack into the pool as well; thus, a temporary metal overpack (transfer cask) is used to maneuver the canister and provide radiation shielding (Figure 7).[17] Once the fuel assemblies are loaded, the 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.[18] Like the TN-40 cask, the canister is filled with helium. After filling, the second lid is welded on.

Figure 7. Canister and Temporary Metal Overpack Being Decontaminated

For vertical storage systems, the canister is transferred from its temporary metal overpack to a concrete overpack. The entire package – canister plus concrete overpack – is moved to the ISFSI pad using a specialized crawler (Figure 8).

For horizontal storage systems, the canister is moved to the ISFSI while still in the temporary metal overpack. The canister is aligned with an opening in the concrete storage module (Figure 9). The canister is them pushed, using a hydraulic ram, into the storage module and a shielding door is bolted into place (Appendix C).

Figure 8. Canister and Vertical Concrete Overpack on ISFSI Pad

Figure 9. Canister Being Placed in Horizontal Concrete Storage Module

3.4 Monitoring and Maintenance of Spent Fuel

All spent fuel casks and canisters 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.

TN-40 casks require monitoring of the pressure maintained between the two O-ring seals on the cask lid.[19] This monitoring ensures that the seals are working properly and that the spent fuel remains contained. Canisters have welded lids and do not require this type of monitoring. Welds on canister lids are examined prior to placing canisters in a concrete overpack or storage module.[20] This examination is considered sufficient to ensure the long term integrity of the closure.[21]

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.

3.5 Transporting Spent Fuel

As discussed in Chapter 2.2, the NRC certifies casks and canisters for the transportation of spent nuclear fuel. The NRC approves transportation packages that must meet design criteria related to structural integrity, shielding, and criticality, among others.

Xcel Energy has noted that any new spent fuel technology selected for use in the PINGP ISFSI will be certified for storage and transportation. The TN-40 cask currently used in the PINGP ISFSI is certified for storage and transportation. Xcel Energy applied to the NRC for a transportation license for the TN-40HT cask on November 30, 2021. Thus, if the NRC certifies the TN-40HT cask for transportation, all of the casks and canisters that are and will be used in the PINGP ISFSI would be approved by the NRC for transport to offsite storage facilities.

No removal of spent fuel from existing casks for repackaging into transportation-ready casks or canisters would be required for the transport of spent fuel from the PINGP ISFSI. Xcel Energy is not proposing any repackaging or other handling of spent fuel from existing TN-40 and TN-40HT casks in the PINGP ISFSI.[22]

3.6 Project Costs

Xcel Energy estimates that a change to a canister system at Prairie Island would be 40 to 50 percent cheaper than continued use of the TN-40 cask system.[23] Xcel Energy notes that these savings are driven by three factors – (1) the relative difference in fabrication costs, (2) the increased number of fuel assembles that can now be stored in a canister, and (3) the increased use of canisters systems in the spent fuel industry.[24]

TN-40 casks have thick walls for containment and radiation shielding. Each cask weighs approximately 100 tons.[25] Fabricating and handling such a cask requires a specialized facility, and there are relatively few of these facilities. In contrast, a typical canister system uses a steel containment shell less than one-inch thick. Fabrication of a relatively thin-walled canister requires less infrastructure at a fabricator and results in lower costs. Additionally, there are more facilities that are capable of manufacturing canisters, leading to greater price competition.

Xcel Energy indicates that when the TN-40 cask was first selected for Prairie Island, canister systems were limited in fuel-assembly capacity – canisters at the time could only store 24 Prairie Island fuel assemblies.[26] Thus, the TN-40 cask was relatively less expensive due to the smaller number of casks needed for a set amount of spent fuel. Subsequently, canister systems have enlarged their capacity and are now capable of storing between 32 and 37 Prairie Island fuel assemblies.[27]

Finally, Xcel Energy notes that canister systems have now been adopted by the nuclear industry as the standard method of storing spent fuel.[28] Prairie Island is the only remaining site in the United States using the TN-40 cask design, and no other sites are currently ordering or loading a bolted cask design similar to the TN-40.[29] Continued use of the TN-40 cask would make Prairie Island an outlier with respect to fabrication expense, loading operations, and technology advances. Advances in canister system handling (e.g., welding, testing) can be shared among ISFSI operators using canister systems, and these advances are not available or applicable to the TN-40 cask design.

In 2008, Xcel Energy estimated that the cost for 35 TN-40HT casks would be $143.3 million.[30] Thus, about $4.1 million per cask. Xcel Energy indicates that it will not know the cost of different spent fuel storage technology for the PINGP ISFSI (if different technology is approved by the Commission) until it completes a competitive bidding process for the technology.

3.7 Summary of Spent Fuel Storage Technology

Casks and canisters use similar loading, handling, and storage processes. Casks and canisters must meet the same NRC requirements; there are not different requirements for one type of storage technology or the other.

The primary difference between casks and canisters is that casks use an all-in-one, containment plus shielding approach, whereas canisters separate the two functions and require a separate overpack for shielding (and handling) (Table 2). This difference also leads to differences in sealing and in costs.

Table 2. Characteristics of Spent Fuel Casks and Canisters

Characteristic	Cask (e.g., TN-40)	Canister System
Fuel Confinement	Steel	Steel
Loading of Fuel	In spent fuel pool; dried; backfilled with helium	In spent fuel pool; dried; backfilled with helium
Seal	Bolted, with O-ring seal	Welded, with two lids
Shielding	Steel	Concrete overpack for storage; metal overpack (transfer cask) for handling
Cost	Relatively more expensive; approximately $4.1 million per cask	Relatively less expensive; estimated to be 40 to 50 percent less expensive than TN-40 casks

Notes

[1] 2009 Prairie Island EIS, Chapter 2, Section 3.0.

[2] 2009 Prairie Island EIS, Chapter 2, Section 3.2. Storage casks are designed to ensure that: (1) fuel critically is prevented, (2) cask integrity is maintained, and (3) fuel is not damaged so as to preclude its removal from the cask. These design criteria must be met for normal operations and for off-normal events including natural phenomena (e.g., tornadoes, floods) and man-made accidents (e.g., missiles).

[3] Id. The TN-40HT cask is an enhanced version of the TN-40 cask. Both the TN-40 and the TN-40HT hold 40 fuel assemblies. The TN-40HT allows for storage of relatively more highly enriched fuel and fuel with greater burnup.

[4] Xcel Energy Additional Information.

[5] 2009 Prairie Island EIS, Chapter 2, Section 3.2.

[6] Id.

[7] Id.

[8] Xcel Energy Additional Information.

[9] Id.

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

[11] Xcel Energy Additional Information.

[12] Id.

[13] Id.

[14] Id.

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

[16] 2009 Prairie Island EIS, Chapter 2, Section 3.2.

[17] Xcel Energy Additional Information.

[18] Id.

[19] Id.

[20] Id.

[21] Standard Review Plan for Spent Fuel Dry Storage Systems and Facilities - Final Report (NUREG-2215), Chapter 9, https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr2215/index.html.

[22] Xcel Energy Additional Information.

[23] Xcel Energy Request for Technology Change.

[24] Id.

[25] Id.

[26] Id.

[27] Id.

[28] Id.

[29] Id.

[30] 2009 Prairie Island EIS, Chapter 2, Section 3.2.

4 Potential Non-Radiological Impacts

Xcel Energy's proposed change in spent fuel storage technology could impact human or environmental resources at Prairie Island. The handling and storing of spent fuel, as a physical activity, could create non-radiological impacts.

The 2009 Prairie Island EIS concluded that the non-radiological impacts of the expansion of the Prairie Island ISFSI were not significant.[1] This SEIS concludes the same – the non-radiological impacts of a change in spent fuel storage technology at Prairie Island are anticipated to be minimal.

4.1 Environmental Setting

The PINGP is located on the west bank of the Mississippi River on the southeastern portion of Prairie Island, an outwash terrace above the river. The plant site is located at an elevation of 690 feet above mean sea level (MSL), about 15 feet above the normal pool elevation of the river.[2] The Mississippi River at this location is known as Sturgeon Lake, a backwater area located approximately one mile upstream from U.S. Army Corps of Engineers (USACE) Lock and Dam 3.

The PINGP site is comprised of approximately 578 acres of land.[3] Access to the site is controlled and there is an enforced exclusion zone. On Prairie Island, access to the exclusion zone is restricted by a perimeter fence with "No Trespassing" signs. East of the plant the exclusion zone boundary extends to the main channel of the Mississippi River. The Prairie Island ISFSI is located within the PINGP site, approximately 300 yards west of the main plant (Figure 1).

The Prairie Island Indian Reservation is located directly north of the PINGP. The Prairie Island Indian Community (PIIC) is a federally recognized Indian tribe with about 1,080 enrolled members.[4] The PIIC owns and operates the Treasure Island Resort and Casino.

There are approximately 450 full-time residents within two miles of the PINGP.[5] Though the PINGP is within the city limits of the city of Red Wing, the great majority of the city's population (about 16,300 persons) is located approximately six miles southeast of the PINGP.

4.2 Potential Impacts to the Natural Environment

Of the 578 acres that comprise the PINGP site, approximately 338 acres have been undisturbed by the construction of the PINGP and its ISFSI.[6] This acreage is covered with non-native herbaceous species (e.g., brome grass), shrubs, and trees. Common trees include elms, cottonwoods, ashes, box elders, and burr oaks. Wetland plant communities are found around, adjacent to, and within the PINGP site.

Wetland communities and nearby upland habitats support a diversity of fauna, including fish, mollusks, turtles, frogs, birds, waterfowl, muskrats, and raccoons.[7] The habitats are also part of the larger Mississippi River flyway ecosystem that supports migration of birds and waterfowl between the Americas.

Non-radiological impacts to the natural environment from Xcel Energy's proposed change in spent fuel storage technology are anticipated to be minimal. All handling of spent fuel will occur within the PINGP and its ISFSI. This handling is not anticipated to impact flora, fauna, or water resources in the area. A change from casks to canisters with concrete overpacks may provide niches for birds or small animals to explore – i.e., the spaces between a canister and overpack that facilitate air flow. However, as discussed above, these spaces are kept clear by plant personnel such that any animal exploration would be temporary.

4.3 Potential Impacts to the Human Environment

There are relatively few persons that live near the PINGP. The PIIC is the largest nearby community, situated just north of the PINGP. The city of Red Wing is approximately six miles southeast of the PINGP.

Non-radiological impacts to the human environment from Xcel Energy's proposed change in spent fuel storage technology are anticipated to be minimal. The use of a different storage technology would not produce significant new noise or traffic impacts. Lighting at the PINGP and ISFSI would remain the same. Though this lighting may impact activities that benefit from a dark sky, e.g., stargazing, a change in spent fuel storage technology would not change current lighting.

The aesthetics of canisters with vertical concrete overpacks are very similar to those of the TN-40 casks (compare Figures 2 and 3). Use of a horizontal overpack, i.e., a rectangular concrete module, would change the aesthetics of the PINGP ISFSI. However, because of the earthen berm surrounding the ISFSI and because access to the PINGP is controlled, any aesthetic changes due to a rectangular concrete module would be difficult for nearby residents to perceive.

Horizontal concrete modules can be pre-fabricated or constructed on-site. Either method would require construction activities within the ISFSI. These activities could involve, among others, building concrete forms, placing rebar, and pouring concrete. These activities would introduce additional traffic to the site, e.g., construction workers, materials, supplies. They would also introduce additional noise sources, e.g., trucks, construction equipment. Potential impacts to nearby residents due to additional traffic and additional noise are anticipated to be minimal. The 2009 Prairie Island EIS concluded that traffic and noise impacts related to expanding the Prairie Island ISFSI would not be significant.[8] That conclusion holds for the construction of any horizontal concrete storage modules at the ISFSI.

The largest community of persons that could experience non-radiological impacts through operations at the PINGP are the plant's workers. The PINGP 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. The use of new spent fuel storage technology is not anticipated to increase risks or introduce new risks to plant personnel that are not managed by these safety programs.

Tax Revenues

The city of Red Wing receives property tax revenues from the PINGP. Revenues are based on the valuation of the PINGP, including the ISFSI.

Xcel Energy indicates that though different spent fuel technology, e.g., a canister system, would be relatively less expensive, the use of this technology would have minimal impact on the valuation of the PINGP.[9] There are 55 TN-40 and TN-40HT casks currently in the PINGP ISFSI.[10] A canister system would be used solely for the fuel assemblies associated with the last nine casks. Thus, the incremental change to the valuation of the PINGP would be minimal, and any impacts to tax revenues are anticipated to be minimal.

Notes

[1] 2009 Prairie Island EIS, Chapter 2, Section 4.

[2] Id.

[3] Id.

[4] Prairie Island Indian Community.

[5] 2009 Prairie Island EIS, Chapter 2 Section 5.2.

[6] 2009 Prairie Island EIS, Chapter 2, Section 4.

[7] Id.

[8] Id.

[9] Xcel Energy Additional Information.

[10] Id.

5 Potential Radiological Impacts

Xcel Energy's proposed change in spent fuel storage technology could impact the health of persons near the PINGP and its ISFISI 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.

The 2009 Prairie Island EIS concluded that the radiological impacts of the expansion of the PINGP ISFSI were not significant.[1] This SEIS concludes the same – the radiological impacts of a change in spent fuel storage technology at Prairie Island are anticipated to be minimal.

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.[2] Approximately half of this dose comes from natural sources, e.g., gases produced by radioactive decay (Table 3). 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 3. Background Radiation Sources[3]

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.[4] 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.[5] 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.[6] 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 at Prairie Island

Radiation monitoring programs are conducted for the PINGP and its ISFSI by Xcel Energy, the Minnesota Department of Health (MDH) and the Wisconsin Department of Health Services (WDHS).[7]

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. Xcel Energy must operate the PINGP such that the dose to individual members of the public from operations does not exceed 100 mrem per year.[8]

Xcel Energy ensures that radiation doses are within NRC regulations through sampling and monitoring around Prairie Island. Xcel Energy samples air and water near and around the PINGP and samples milk from local farms.[9] It uses thermoluminescent dosimeters (TLDs) to monitor radiation on the plant site and within the ISFSI.[10]

MDH samples air, surface water, well water, and milk near and around the PINGP.[11] Ambient radiation dose levels are monitored using TLDs. MDH also monitors the PINGP ISFSI with two pressurized ion chambers (PICs). The PICs constantly measure and report the levels of ambient radiation around the ISFSI. WDHS conducts air, water, soil, and other sampling in Wisconsin, just east of the PINGP.[12] WDHS also uses TLDs to monitor background radiation.

5.3 Potential Radiological Impacts to Residents

Radiation doses to the general public from PINGP ISFSI operations result from skyshine radiation.[13] Skyshine radiation is gamma and neutron radiation that travels upward from the spent fuel casks and is reflected off the atmosphere back to the ground. Shielding on the casks themselves reduces the direct radiation dose, as does the earthen berm surrounding the ISFSI.

The 2009 Prairie Island EIS estimated that the annual dose from skyshine radiation to the residence closest to the PINGP ISFSI would be approximately 0.4 mrem per year.[14] In 2015, the NRC estimated that the annual dose to the nearest residence would be approximately 2.2 mrem per year.[15] Both of these dose estimates are within NRC standards and indistinguishable from background radiation.[16]

All NRC-approved spent fuel storage casks and canisters must meet the same NRC requirements for radiation dose rates to workers and the general public.[17] Thus, if a different spent fuel storage technology were used at Prairie Island – e.g., canisters in a concrete overpack rather than TN-40 casks – the radiation dose to the public would remain essentially the same. The radiation dose to the nearest residence would remain in the range of 0.4 to 2.2 mrem per year.[18]

Expanding from the nearest residence to the local populace (approximately 450 residents), the 2009 Prairie Island EIS concluded that health risks to the general public resulting from long-term exposure to skyshine radiation from the PINGP ISFSI were not significant.[19] The EIS estimated an additional 0.013 incidences of cancer in the local population over 70 years due to skyshine radiation.[20] If a different spent fuel storage technology were used in the PINGP ISFSI, radiation doses and health risks would remain essentially the same.[21] Radiation doses would be indistinguishable from background radiation and health risks would not be significant.

Accident Conditions

The 2009 Prairie Island EIS discussed the potential radiological impacts of off-normal and accident conditions at the Prairie Island ISFSI.[22] These conditions included, among others, earthquakes, tornadoes, floods, fire, and terrorism. No release of radioactive materials was anticipated during any of these conditions.[23] The EIS also analyzed hypothetical release scenarios, and under these scenarios impacts to the general public were not significant and within NRC standards.[24]

All NRC-certified spent fuel storage casks and canisters must meet the same NRC requirements for performance during accident conditions.[25] Thus, a change in spent fuel storage technology in the PINGP ISFSI would not change the performance of the ISFSI during accident conditions. Potential radiological impacts to the general public under these conditions would remain not significant and within NRC standards.

Climate Change

Greenhouse gas emissions resulting from human activities are making Minnesota's climate warmer and wetter.[26] In addition, the frequency of extreme storms – storms with extreme rainfall and high winds – is increasing.[27] These changes in the climate could adversely impact the resilience of spent fuel casks and canisters under accident conditions.

The NRC has taken climate change into account in its regulation and review of spent fuel storage systems.[28] The primary risks that are exacerbated by climate change are high winds and flooding.[29] The NRC indicates that current regulations are appropriate for a warmer, wetter, and more energetic climate.[30] 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.

In the NRC's 2015 environmental review of the PINGP ISFSI for a license renewal, the NRC discussed potential radiological impacts due to postulated accidents.[31] The review did not explicitly address climate change, but did address extreme winds and flooding. The review concluded that these scenarios would not compromise cask integrity or lead to a release of radioactive materials.[32] As all NRC-certified casks and canisters must afford the same protection against potential accidents, the NRC's conclusion is applicable to any new spent fuel storage technology used in the PINGP ISFSI.

Emergency Response Plan

As a nuclear power plant licensee, Xcel Energy is required to have an emergency response plan for the PINGP. The city of Red Wing provides emergency services to the PINGP and its ISFSI including responding to any fire, a breach of containment resulting in radioactive release, and the treatment of any injuries resulting from emergency services.[33] The 2009 Prairie Island EIS noted that if emergency services could not be maintained into the future, the risk of radiological impacts resulting from an accident at the PINGP would increase and could be significant.[34]

In 2009, the Commission conditioned its granting of a CN for expansion of the PINGP ISFSI on a requirement that Xcel Energy provide a compliance filing on its emergency response plan.[35] In 2013, the city of Red Wing and Xcel Energy entered into a letter of agreement for emergency response services at the PINGP.[36]

As discussed in Chapter 2.2, if Xcel Energy were to use different spent fuel storage technology in the PINGP ISFSI, Xcel Energy would need to review its emergency response plan. If this review determined that the effectiveness of the emergency response plan was adversely affected by the new technology, Xcel Energy would need to make appropriate changes to the plan and obtain necessary approvals.[37] It is likely that such changes would need to be coordinated with the city of Red Wing and other local emergency responders.

5.4 Potential Radiological Impacts to Workers

Workers at Prairie Island, particularly workers who load spent fuel and handle spent fuel storage casks, are exposed to greater radiation risks than the general public.[38] 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.[39]

The 2009 Prairie Island EIS noted that radiation exposures for workers from all operations at the PINGP average approximately 111 person-rem annually.[40] The EIS also noted that worker radiation doses are managed to keep them below NRC regulatory limits.[41] The EIS concluded that health impacts to workers due to radiation exposures would be not be significant.[42]

If Xcel Energy selects different spent fuel technology for the PINGP ISFSI, this technology could have an impact on radiation doses for workers. Data from Xcel Energy indicates that radiation doses to workers for spent fuel handling could increase or decrease (Table 4).[43] Data collected by Xcel Energy for the PINGP and its Monticello nuclear generating plant indicates that radiation doses will increase for workers during fuel loading if the PINGP ISFSI uses a canister system with a horizontal overpack (Table 4). Data collected by Holtec, a canister system vendor, indicates that radiation doses may decrease for workers if the PINGP ISFSI uses a canister system with a vertical overpack (Table 4).

Table 4. Worker Radiation Exposure for Different Spent Fuel Technologies

Type of Cask / Canister	Average Cumulative Worker Exposure During Fuel Loading (mrem)
TN-40 Cask[1]	343
Canister – Horizontal Overpack[2]	608
Canister – Vertical Overpack[3]	220

[1] PINGP ISFSI cask loading data.
[2] Monticello cask loading data, NUHOMS canister system.
[3] Average from three plant sites, provided by vendor (Holtec).

As discussed in Chapter 3, there are differences in how casks and canisters are loaded and handled. These differences suggest that radiation doses to workers will likely be higher for canister systems as compared with casks.[44] For example,

- Canister lids are welded into place outside of the spent fuel pool, while cask lids are put into place while the cask is still in the spent fuel pool. Additionally, welds must be inspected to ensure proper sealing of the canister.
- Canisters must use an overpack (concrete or metal) each time the canister is handled. Placing the canister in the overpack requires handling by workers. Casks do not require an overpack.

Thus, if Xcel Energy selects a canister system for use in the PINGP ISFSI, health impacts to workers would likely be incrementally greater due to relatively higher radiation dose levels associated with canister systems. The extent of this increment is uncertain. The 2009 Prairie Island EIS and the data in Table 4 indicate that any incremental increase in dose levels would be within NRC standards and that health impacts to workers would not be significant.

Accident Conditions

As discussed in Chapter 2.2, all NRC-certified spent fuel storage casks and canisters must meet the same NRC requirements for performance during accident conditions. Additionally, a potential change in spent fuel storage technology at the PINGP would not change the spent fuel itself. Thus, the radiation risks associated with the spent fuel, should an accident occur, would be independent of the technology used to store the fuel.

The 2009 Prairie Island EIS discussed potential radiological impacts to workers and emergency responders during a hypothetical cask confinement failure.[45] The EIS noted uncertainties in estimating potential impacts. The EIS discussion assumed that 100 workers/emergency responders would receive the maximum occupational radiation dose (5,000 mrem).[46] This dose would result in an estimated 0.5 additional cancer incidences among this group of 100 persons.[47] If a different spent fuel storage technology were used in the PINGP ISFSI, radiation doses and health risks would remain about the same.

5.5 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. 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 2009 Prairie Island EIS identified the PIIC as an environmental justice community that would bear a disproportionate share of negative consequences from operation of the PINGP.[48] The PIIC is the closest community to the PINGP. As such, members of the community receive slightly higher radiation doses (skyshine radiation) than communities at a greater distance. These doses create a small incremental risk that the PIIC bears differentially from other communities.[49]

Additionally, the PIIC is the closest community to the PINGP should an accident which released radiation occur at the PINGP or its ISFSI. The likelihood of such an accident is small. Nonetheless, there is a low-level of continuing uncertainty regarding an accident.[50] This uncertainty is borne by many Minnesota and Wisconsin communities, but is most directly felt by those communities closest to the PINGP; these communities would most likely be impacted should an accident occur.[51] The PIIC is such a community.

The 2009 Prairie Island EIS noted that the uncertainty related to a potential accident at the PINGP and the continued storage of spent fuel could result in socio-psychological impacts to the PIIC. The PIIC affirmed the impacts of the PINGP in 2015:

> The presence of the PINGP and ISFSI has had a negative effect on the PIIC, its people and lands … many tribal members do not want to raise their families so close to such a facility. Prairie Island is the ancestral homeland of the Mdewakankton Dakota, a land of traditional and cultural significance, and portions of Prairie Island are held in Trust by the United States government and designated as a reservation for the common benefit of all tribal members. This land was to allow the PIIC to continue to maintain its traditions and culture in perpetuity. Prairie Island itself is integral to tribal traditions and culture. Because of the ISFSI and the spent nuclear fuel, the Tribal Council has been looking for land elsewhere, away from the PINGP and ISFSI, to meet the housing and other needs of tribal members. If tribal members cannot live on Prairie Island or refuse to reside on Prairie Island, the tribe's culture may not survive.[52]

The 2009 Prairie Island EIS concluded that the only apparent means to mitigate environmental justice concerns for the PIIC would be to discontinue operations at the PINGP.[53] The EIS noted that discontinuing operations would not eliminate environmental justice concerns related to the continued operation of the PINGP ISFSI.[54] These concerns could only be addressed by removal of the spent fuel from the ISFSI.

As discussed above, Xcel Energy's proposed change in spent fuel storage technology would not significantly change skyshine radiation levels associated with the ISFSI. Thus, radiation doses to PIIC members would not change. The slighter higher incremental risk associated with these doses and borne by PIIC members would not change.

Additionally, Xcel Energy's proposed change in storage technology would not significantly change the likelihood of an accident at the PINGP or its ISFSI. The level of uncertainty regarding an accident, as experienced by PIIC members, would not change.

In sum, if a change in storage technology occurred at the PINGP ISFSI, environmental justice concerns would remain generally the same for the PIIC. Concerns would neither increase with the change, nor would they be allayed by a change.

Notes

[1] 2009 Prairie Island EIS, Chapter 1, Section 4.13 and Chapter 2, Section 5.

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

[3] Id.

[4] 2009 Prairie Island EIS, Chapter 1, Section 4.13.

[5] 2009 Prairie Island EIS, Chapter 1, Section 4.13; Beir VII: Health Risks from Exposure to Low Levels of Ionizing Radiation, https://www.nap.edu/resource/11340/beir_vii_final.pdf.

[6] Id.

[7] 2009 Prairie Island EIS, Chapter 1, Section 4.13.

[8] Id.

[9] Id.

[10] Id.

[11] Id.

[12] Id.

[13] 2009 Prairie Island EIS, Chapter 2, Section 5.2.

[14] Id. The closest residence is approximately 0.45 miles northwest of the Prairie Island ISFSI.

[15] Final Environmental Assessment for the Proposed Renewal of U.S. Nuclear Regulatory Commission License SNM-2506 for Prairie Island Independent Spent Fuel Storage Installation, June 2015, https://www.nrc.gov/docs/ML2027/ML20275A342.pdf (see Section 4.11.2) [hereinafter 2015 Federal EA for PINGP ISFSI].

[16] 10 CFR 72.104 (25 mrem per year limit for ISFSI) and 10 CFR 20.1301 (100 mrem per year limit for entire plant).

[17] Xcel Energy Additional Information; 10 CFR 72.

[18] Initial calculations by Xcel Energy for a PINGP ISFSI with a mix of TN-40 casks (55 casks) and canisters in a horizontal overpack (9 canisters) indicate that the radiation dose to the nearest residence would be approximately 0.4 mrem per year (Xcel Energy Additional Information).

[19] 2009 Prairie Island EIS, Chapter 2, Section 5.2.

[20] Id.

[21] All NRC-approved spent fuel storage technology must meet the same radiation shielding requirements. See 10 CFR 72; NUREG 1536

[22] 2009 Prairie Island EIS, Chapter 2, Section 5.3.

[23] Id.

[24] Id.

[25] Xcel Energy Additional Information; 10 CF 72.

[26] Climate Trends, Minnesota Department of Natural Resources, https://www.dnr.state.mn.us/climate/climate_change_info/climate-trends.html.

[27] Id.

[28] 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].

[29] Id.

[30] Id.

[31] 2015 Federal EA for PINGP ISFSI (see Chapter 4.11.3).

[32] Id.

[33] 2009 Prairie Island EIS, Chapter 5.3; 2015 Federal EA for PINGP ISFSI, Chapter 4.3.

[34] 2009 Prairie Island EIS, Chapter 5.3.

[35] Order Accepting Environmental Impact Statement, and Granting Certificates of Need and Site Permit with Conditions, December 18, 2009, Docket Nos. CN-08-509, CN-08-510, GS-08-690, eDockets Number 200912-45206-02.

[36] 2015 Federal EA for PINGP ISFSI, Appendix B, Comment 3-24.

[37] 10 CFR 72, Subpart K (72.212); https://www.nrc.gov/reading-rm/doc-collections/cfr/part072/index.html.

[38] 2009 Prairie Island EIS, Chapter 2, Section 5.2.

[39] 2009 Prairie Island EIS, Chapter 2, Section 5.4 (noting 10 CFR 20 radiation dose limits); 2009 Prairie Island EIS, Chapter 3, Response to Comment 15-18.

[40] 2009 Prairie Island EIS, Chapter 2, Section 5.2.

[41] Id.

[42] Id.

[43] Xcel Energy Additional Information.

[44] Certificate of Need Application for Dry Cask Storage at the Monticello Nuclear Generating Plant Independent Spent Fuel Storage Installation, Xcel Energy, Chapter 9, https://apps.commerce.state.mn.us/eera/web/file-list/14561.

[45] 2009 Prairie Island EIS, Chapter 2, Section 5.3; 2009 Prairie Island EIS, Chapter 3, Response to Comment 15-20.

[46] 2009 Prairie Island EIS, Chapter 3, Response to Comment 15-20.

[47] Id.

[48] 2009 Prairie Island EIS, Chapter 2, Section 5.4. See also, Understanding Environmental Justice in Minnesota, Minnesota Pollution Control Agency, https://mpca.maps.arcgis.com/apps/MapSeries/index.html?appid=f5bf57c8dac24404b7f8ef1717f57d00. See also, 2015 Federal EA for PINGP ISFSI, Chapter 4.13.

[49] Id.

[50] 2009 Prairie Island EIS, Chapter 2, Section 5.4.

[51] Id.

[52] 2015 Federal EA for PINGP ISFSI, Chapter 4.1.

[53] 2009 Prairie Island EIS, Chapter 2, Section 5.4.

[54] Id.

6 Transportation of Spent Nuclear Fuel

The transportation of spent nuclear fuel takes places primarily under the aegis of three federal agencies – the U.S. Department of Transportation (DOT), the NRC, and the U.S. Department of Energy (DOE). Analysis, testing, and experience with shipping spent fuel indicate that the impacts of transporting spent nuclear fuel are anticipated to be minimal.

6.1 Regulatory Framework

DOT, NRC, and DOE are the federal agencies that have primary responsibility for the safe shipment of spent nuclear fuel (Appendix D).[1] To ensure clarity of responsibilities, the DOT and NRC have entered into a memorandum of understanding regarding transportation of spent fuel.[2] DOT regulates shipments of all hazardous materials, including spent nuclear fuel.[3] DOT regulations are frequently enforced by states; thus, states have a role to play in ensuring the safe shipment of hazardous materials.[4] NRC certifies casks and canisters for transporting spent nuclear fuel (see Chapter 2.2). NRC regulations establish design parameters and packaging requirements for spent fuel. The NRC also approves the routes that shippers would use to transport spent fuel.[5]

DOE has the responsibility for shipping spent nuclear fuel to a federal, geologic repository (or other federal interim storage site).[6] Shipments to a federal repository must be in NRC certified casks or canisters and in NRC-approved transportation packages.[7] To plan for shipments of spent nuclear fuel, DOE has established a national transportation stakeholders forum (NTSF). The NTSF is the primary mechanism by which the DOE communicates with states, tribes, and other federal agencies about the transportation of spent nuclear fuel.[8] The State of Minnesota and the PIIC participate in the NTSF.[9]

6.2 Spent Fuel Transportation Safety

Analysis, testing, and experience with shipping spent fuel indicate that the impacts of transporting spent nuclear fuel are anticipated to be minimal. In 2006, the National Research Council issued a report on the transportation of spent nuclear fuel in the United States.[10] The report concluded, in part, that there were:

> No fundamental technical barriers to the safe transport of spent nuclear fuel and high-level radioactive waste in the United States. Transport by highway … and by rail … is, from a technical viewpoint, a low-radiological-risk activity with manageable safety, health, and environmental consequences when conducted with strict adherence to existing regulations.[11]

The report did find that there are social and institutional challenges to shipping spent nuclear fuel. Further, the report noted that there is a risk of malevolent actions (e.g., terrorism) that could impact safe transport. The report examined analysis and testing results from a variety of sources. It also looked at national and international experience with shipping spent nuclear fuel. With respect to this experience, the report noted:

> There have been no recorded instances of which the committee is aware of any releases of radioactive material exceeding regulatory limits from any transport package in Western Europe, Japan, or the United States. There are, however, well-documented instances of exposures to radioactivity from inadequate decontamination of the external surfaces of transport packages after they are loaded with spent fuel. However, these releases have been small, and the committee is not aware of any documented instances in which exposures to workers or the public exceeded regulatory limits.[12]

A 2016 report prepared for DOE reached similar conclusions regarding experience with transporting spent nuclear fuel:

> In general, there have been few transportation accidents worldwide in the history of transporting [spent nuclear fuel, SNF] and none have had significant radiological consequences … Instances of radioactive contamination on … casks and the vehicles that carry them have occurred more frequently than transportation accidents.[13]

Thus, to date, experience with transporting spent nuclear fuel worldwide indicates that the primary risk is radiation exposure due to contamination remaining on the *outside* of a cask or canister that has been loaded for transportation. This is not to say that contamination on the outside of a transportation package is the primary concern with respect to transporting spent fuel. The primary concern remains the possibility of an accident that releases radioactive materials that are *inside* a transportation package.

The NRC is tasked with developing standards and regulations for spent fuel transportation packages. These regulations are based on analysis conducted by the NRC. The NRC's most recent risk analysis for spent fuel transportation (NUREG-2125) concluded, in part, that:

- Radiation doses to the public and workers from routine transportation of spent nuclear fuel are less that background radiation levels.
- If there was an accident during shipment, by rail or truck, of spent nuclear fuel, there is a less than a one-in-one billion chance that radioactive materials would be released.[14]

Though the analysis indicates that spent fuel transportation accidents are projected to be rare, it does estimate potential radiation dose levels for such accidents. The analysis finds that an accident which released radioactive material from a transportation package would result in a dose to the public of 218 person-rem.[15] This dose would result in an additional 0.22 incidences of cancer among persons near the accident. The analysis indicates that the greater public health risk is an accident resulting in a fire that compromises the lead shielding in a transportation package.[16] This type of accident could result in a dose of 6,900 person-rem.[17] This dose would result in an additional 6.9 incidences of cancer among persons near the accident. The analysis notes that not all transportation packages utilize lead shielding (e.g., packages could use steel shielding) and that the likelihood of a fire damaging lead shielding is minimal.[18]

In sum, the NRC's risk analysis finds that the potential radiological impacts of spent fuel transportation are small.[19]

6.3 2019 Table-Top Transportation Exercise at Prairie Island

The United States has been transporting irradiated nuclear fuel since the Manhattan Project.[20] It's estimated that between 1964 and 2004 there were 2,848 shipments of spent nuclear fuel by truck and 540 by rail.[21] Among these shipments, Xcel Energy transported 1,058 fuel assemblies in 29 shipments from its Monticello nuclear plant to the General Electric company in Morris, Illinois.[22]

Though this transportation experience is extensive, it is relatively small compared with future spent fuel transport anticipated by a geologic repository or several MRS facilities.[23] It's estimated that transport of spent nuclear fuel from ISFSIs in the United States to a geologic repository would represent 20 times the amount of spent fuel shipped in the United States since 1964.[24] In order to prepare for this increase, transportation stakeholders have turned to table-top exercises, among other planning tools.

In 2019, the Nuclear Energy Institute, in partnership with Xcel Energy, hosted a table-top exercise at the PINGP focused on the actions that would be necessary to transport spent nuclear fuel from a generic ISFSI located in the Upper Midwest to a generic consolidated interim storage facility (CISF) in the Southwest.[25] Objectives of the exercise included: (1) identification and discussion of the steps necessary to safely transport the spent fuel, and (2) fostering relationships and communications among stakeholders.

The exercise was based on a private transportation model.[26] In this model, the generic reactor is shutdown, and the plant and ISFSI are sold to a private company that specializes in decommissioning. The NRC licenses associated with the plant and ISFSI are also transferred to this company. Finally, the CISF is owned and operated by the same company (or a subsidiary). Thus, when the spent fuel is shipped, it is shipped privately, i.e., from one location to another within the same corporate structure.[27]

The exercise considered three modes of transportation for the spent fuel – barge, rail, and truck.[28] Representatives of Edlow International, a transportation company that specializes in the transport of spent fuel, participated in the exercise and discussed how they would approach transport of spent fuel from the generic ISFSI. They indicated that it would take 6 to 12 months to determine the fuel being transported and the best mode(s) of transport; 6

to 12 additional months to obtain NRC route approvals; and 7 to 10 days for each transport from ISFSI to CISF.[29]

Key learnings from the exercise included:

- The plant/ISFSI licensee needs to communicate proactively with stakeholders regarding spent fuel shipments. The licensee needs to work with state agencies, e.g., departments of transportation, as these agencies often enforce federal regulations within their states.
- The licensee needs to communicate proactively with tribal nations. The exercise revealed that tribes do not automatically receive notification of spent fuel shipments, but that tribes can opt in for such notifications. After completion of the exercise, the PIIC opted in for such notifications.
- There are multiple, specific steps required to prepare and load transportation packages; likewise, there are multiple steps required to unload a cask or canister and place it in the CISF. These steps require advanced planning, coordination and preparation by all stakeholders.
- Using a private transportation model, it was unclear whether or how federal funding would be available to communities along transportation routes for training emergency personnel.[30]

In sum, the exercise was considered successful in meeting its objectives, albeit one step in a continuing dialogue.

Notes

[1] Going the Distance, Section 1.3.3; PIIC Scoping Comment Letter, October 22, 2021, eDockets Number 202110-179270-02 [hereinafter PIIC Scoping Comment Letter].

[2] Id.

[3] Id.

[4] Going the Distance, Section 1.3.3.

[5] Going the Distance, Section 1.3.3; PIIC Scoping Comment Letter.

[6] Id.

[7] Id.

[8] Id.

[9] PIIC Scoping Comment Letter.

[10] Going the Distance.

[11] Going the Distance, Section S.1.

[12] Going the Distance, Section 3.1.1.

[13] A Historical Review of the Safe Transport of Spent Nuclear Fuel, U.S. Department of Energy, Nuclear Fuels Storage and Transportation Planning Project, August 2016, https://www.energy.gov/ne/articles/historical-review-safe-transport-spent-nuclear-fuel.

[14] Spent Fuel Transportation Risk Assessment, NUREG-2125, January 2014, https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr2125/index.html (Public Summary and Chapter 6).

[15] Id.

[16] Id.

[17] Id.

[18] Id.

[19] Id.

[20] Going the Distance, Chapter 3.1.

[21] Id.

[22] PIIC Scoping Comment Letter.

[23] Going the Distance, Chapter 3.1.

[24] Id.

[25] Xcel Energy Additional Information; PIIC Scoping Comment Letter, Appendix B.

[26] PIIC Scoping Comment Letter, Appendix B.

[27] Id. This private transportation model is being pursued in the United States. Holtec International, the developer of a private CISF (see Chapter 7) has acquired several shutdown nuclear plants, intending to decommission them and to, ultimately, transport the spent fuel to their CISF. See, e.g., https://holtecinternational.com/2019/08/26/holtec-completes-acquisition-of-pilgrim-nuclear-power-station/.

[28] Id. Independent of the exercise, Xcel Energy has indicated that the most likely mode of transport for spent fuel from the PINGP ISFSI is by specialized crawler to rail, and then by rail to an offsite storage facility (Xcel Energy Additional Information).

[29] Id.

[30] Id.

7 Long-Term Storage of Spent Nuclear Fuel

The 2009 Prairie Island EIS analyzed the potential use of the PINGP ISFSI to decommission the PINGP and to store spent nuclear fuel for up to 200 years.[1] The EIS concluded that radiological impacts to the general public and to plant workers would be minimal if the PINGP ISFSI was monitored and maintained over this time period.[2] The EIS noted that monitoring and maintenance depend on institutional control – the social, political, and economic functioning necessary to ensure that monitoring and maintenance occur.[3]

The 2009 Prairie Island EIS used analysis conducted for Yucca Mountain, the proposed federal, geologic repository for spent nuclear fuel, to discuss the implications of a lack of institutional control.[4] The Yucca Mountain EIS concluded that without institutional control spent fuel casks and canisters would eventually degrade leading to a release of radionuclides.[5] Individuals living near degraded ISFSIs would suffer severe health impacts due to direct radiation and internal doses due to ingestion.[6] The Yucca Mountain EIS made clear that institutional control directly influences ISFSI functioning and public health.[7] Regarding institutional control, the 2009 Prairie Island EIS concluded:

> Institutional control assumes not only a solvent and effective entity (e.g., Xcel Energy) responsible for maintaining proper functioning of the ISFSI, but also solvent and effective socio-political institutions that provide a stable societal framework for the ISFSI. For there to be institutional control of the Prairie Island ISFSI, the city of Red Wing, Goodhue County, the State of Minnesota, and the United States of America all have to exist as functioning political entities. There are myriad demands on these entities. In this respect, the Prairie Island ISFSI is just one more demand on the list. However, the ISFSI is unique in that its demands will last much longer than typical socio-political demands and the consequences for failing to meet these demands are predictable and severe.[8]

Based on Chapters 4 and 5 of this SEIS, and assuming institutional control that facilitates monitoring and maintenance of the ISFSI, a different spent fuel storage technology in the PINGP ISFSI is not anticipated to adversely affect public health over of storage period of up to 200 years. Radiological impacts are anticipated to be minimal. A change in storage technology would not affect institutional control, nor would it affect monitoring and maintenance necessary for safe operation of the ISFSI.

All of this said, there have been changes in the spent fuel storage landscape since 2009 that may affect the monitoring and maintenance of spent fuel storage in the United States generally. These changes are discussed further here.

7.1 Generic EIS for Continued Storage of Spent Nuclear Fuel

Though 2010, the NRC expressed confidence (1) that a geologic repository will be available for the storage of spent nuclear fuel, and (2) that spent fuel could be stored in ISFSIs without significant environmental impacts for 60 years beyond the licensed life of a nuclear power plant.[9] This expression was known as the Waste Confidence Rule (WCR).

In 2012, the U.S. Court of Appeals for the District of Columbia overturned the WCR and required the NRC to conduct additional environmental review.[10] Subsequently, the NRC prepared a generic EIS for the continued storage of spent nuclear fuel (NUREG-2157).[11] The generic EIS analyzed three potential lengths of spent fuel storage in an ISFSI: (1) 60 years, (2) 160 years, and (3) indefinite storage.[12] Analysis in the EIS was based on a number of assumptions, including:

- Spent fuel casks and 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.[13]

The NRC amended the WRC to remove any expressions of confidence regarding a federal repository or the length of time that spent nuclear fuel could be safely stored in an ISFSI. Instead, the NRC concluded that "the environmental impacts of continued storage of spent nuclear fuel beyond the licensed life for operation of a reactor are those impacts identified in NUREG–2157."[14] However, the NRC believes that the most likely scenario for spent fuel storage is the availability of a geologic repository within 60 years of a reactor's licensed lifetime.[15] The generic EIS noted that the DOE anticipates the opening of a geologic repository for spent nuclear fuel by 2048.[16]

7.2 Federal Repository and Interim Storage Facilities

The Nuclear Waste Policy Act (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 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]

Interim 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 CISFs (or MRS facilities).

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.[31]

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.[32] The state of New Mexico has filed a lawsuit to block the licensing of the Holtec CISF.[33] Additionally, it is unclear whether private CISFs are compatible with the NWPA. The NWPA permits DOE to construct a 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.[34] 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.[35] 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.[36]

7.3 Funding for Long-Term Storage

The 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 DOE for the removal and disposal of spent fuel.[37] DOE was to begin disposing of spent fuel by January 31, 1998.[38] DOE did not meet this deadline; subsequently, reactor operators filed lawsuits to recover costs for storing spent nuclear fuel.[39]

Xcel Energy has successfully sued DOE for costs associated with the continued storage of the PINGP's spent nuclear fuel.[40] As storage at the PINGP 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.[41] 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.[42]

In 2010, after the Obama administration determined that Yucca Mountain should not be opened, several litigants argued that nuclear waste fund fees should no longer be collected by the federal government.[43] In 2013, the Circuit Court for the District of Columbia ordered DOE to stop collecting the fees; in 2014, DOE stopped collecting nuclear waste fund fees from nuclear reactor operators.[44]

Nuclear Decommissioning Trust Fund

As discussed in the 2009 Prairie Island EIS, a nuclear decommissioning trust fund (NDT) has been established to cover the costs of decommissioning the PINGP and PINGP ISFSI.[45] 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.[46] The NDT is funded through rates charged to Xcel Energy customers.[47] 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).[48] The Commission reviews the NDT every three years; the NRC reviews the NDT every two years.[49]

Xcel Energy submitted its most recent NDT review to the Commission on December 1, 2020.[50] 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.[51]

7.4 Looking Forward

The implications of the changes in the spent fuel storage landscape in the United States since 2009 are uncertain. It is possible that a geologic repository will be open and operating by 2048 as anticipated by the DOE. However, delays to date in opening such a repository argue against this being a firm deadline. The opening of a repository has been and continues to be a politically and socially charged issued.

It is also possible that CISFs or MRS facilities will open in the near future and begin accepting spent fuel. Though the NRC may license such facilities, when or whether these facilities will accept spent fuel is uncertain. It is unclear if these facilities are consistent with the NWPA and with DOE responsibilities. Further it is unclear if these facilities need or can obtain consent from the states hosting them. Legislation addressing the appropriate relationship between interim storage facilities and a repository would reduce these uncertainties.

Notes

[1] 2009 Prairie Island EIS, Chapter 5.4.

[2] Id.

[3] Id.

[4] Id.

[5] Id. Over a timeframe of 10,000 years.

[6] Id.

[7] Id.

[8] Id.

[9] Federal Register, Volume 75, No. 246, 10 CFR 51, Waste Confidence Decision Update, https://www.govinfo.gov/content/pkg/FR-2010-12-23/pdf/2010-31637.pdf

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

[11] NUREG-2157.

[12] NUREG-2157, Executive Summary.

[13] 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."

[14] 10 CFR 51.23, Subpart (a), https://www.nrc.gov/reading-rm/doc-collections/cfr/part051/part051-0023.html .

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

[16] NUREG-2157, Section 1.2.

[17] Civilian Nuclear Waste Disposal.

[18] Id.

[19] Id.

[20] Id.

[21] Id.

[22] Blue Ribbon Commission https://www.energy.gov/sites/prod/files/2013/04/f0/brc_finalreport_jan2012.pdf.

[23] Id.

[24] Civilian Nuclear Waste Disposal.

[25] Xcel Energy Request for Technology Change; 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] Xcel Energy Request for Technology Change; Civilian Nuclear Waste Disposal; Holtec International – HI-STORE CISF, https://www.nrc.gov/waste/spent-fuel-storage/cis/holtec-international.html. Holtec is also a manufacturer of spent fuel storage systems, see Chapter 3.

[29] Civilian Nuclear Waste Disposal.

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

[31] NRC Letter to Holtec International, November 19, 2021, https://adamswebsearch2.nrc.gov/webSearch2/main.jsp?AccessionNumber=ML21322A219 The EIS was scheduled for release in November 2021 and the safety evaluation report in January 2022. The NRC has pushed back these dates in order to incorporate additional information from Holtec.

[32] Civilian Nuclear Waste Disposal.

[33] Id.

[34] Id.

[35] Id.

[36] Id.

[37] Id.

[38] Id.

[39] Id.

[40] 2009 Prairie Island EIS, Chapter 2, Section 3.4 and 5.4.

[41] 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.

[42] See, e.g., Order Approving Decommissioning Study, Decommissioning Accrual, and Taking Other Action, January 7, 2019, Docket No. M-17-828, eDockets Number 20191-148939-01.

[43] Civilian Nuclear Waste Disposal.

[44] Id. The fact that fees are no longer collected does not mean the federal government is unable to pay damages for failing to remove and dispose of spent nuclear fuel. Judgments against the government are paid from the U.S. Treasury's judgment fund (Id. at page 10).

[45] 2009 Prairie Island EIS, Chapter 2, Section 3.4.

[46] Id.

[47] Id.

[48] Id.

[49] Id.

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

[51] Id.

Appendix A
SEIS Scoping Decision

COMMERCE DEPARTMENT

In the Matter of the Petition of Northern States Power Company D/B/A Xcel Energy for a Certificate of Need for Additional Dry Cask Storage at Prairie Island Nuclear Generating Plant

SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT SCOPING DECISION

DOCKET NO. E002/CN-08-510

The above matter has come before the Commissioner of the Department of Commerce (Department) for a decision on the scope of the supplemental environmental impact statement (SEIS) that will be prepared for Xcel Energy's proposed change in spent fuel storage technology at the Prairie Island nuclear generating plant in the city of Red Wing, Minnesota.

Introduction and Background

The Prairie Island nuclear generating plant (PINGP) is a 1,100 megawatt (MW), two-unit, electric generating plant in Red Wing, Minnesota. Unit 1 has been in operation since 1973; Unit 2 since 1974. Spent nuclear fuel from the plant is stored on-site in an independent spent fuel storage installation (ISFSI).

On May 16, 2008, Xcel Energy applied to the Minnesota Public Utilities Commission (Commission) for a certificate of need (CN) to expand the Prairie Island ISFSI by 35 casks, to accommodate a total of 64 spent fuel storage casks. Department of Commerce, Energy Environmental Review and Analysis (EERA) staff prepared an EIS that analyzed the proposed ISFSI expansion (2009 Prairie Island EIS). On December 18, 2009, the Commission issued a CN authorizing Xcel Energy to expand the Prairie Island ISFSI by 35 casks. At that time, Xcel Energy proposed that these casks be Transnuclear TN-40HT casks.

On April 30, 2021, Xcel Energy requested that the Commission authorize a change in the spent fuel storage technology at Prairie Island.[1] Xcel Energy requested that it be authorized to use any spent fuel storage technology approved by the Nuclear Regulatory Commission (NRC), rather than being limited solely to the TN-40HT cask. On May 14, 2021, the Commission issued a notice soliciting comments on Xcel Energy's proposed change in fuel storage technology and on the appropriate processes for considering Xcel Energy's request.[2]

After reviewing Xcel Energy's request, EERA staff concluded that the request represented substantial new information that affects the potential environmental effects at the Prairie Island ISFSI such that the 2009 Prairie Island EIS must be supplemented.[3] EERA staff recommended that the Commission take no action on Xcel Energy's request until EERA staff

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[1] Request for Change in Spent-Fuel Storage Technology, Prairie Island Fuel Storage, April 30, 2021, eDockets Number 20214-173680-01 [hereinafter Xcel Energy Request].

[2] Notice of Comment Period, May 14, 2021, eDockets Number 20215-174178-01.

[3] Minnesota Rule 4410.3000.

could supplement the 2009 Prairie Island EIS in accordance with Minnesota Statutes section 116D.04 and Minnesota Rule 4410.3000.[4] On October 1, 2021, the Commission concurred with EERA staff's recommendation.[5]

Project Description

Xcel Energy proposes to use any NRC-approved fuel storage cask for the ISFSI, rather than being limited to the TN-40HT casks approved by the Commission in 2009. Xcel Energy indicates that they would select from NRC-approved cask designs based on considerations including price and compatibility with future offsite storage facilities. Xcel Energy envisions that the cask designs would be similar to the welded, canister design used at the Monticello nuclear generating plant ISFSI.

Xcel Energy indicates that it is not seeking to store more spent fuel than was approved by the Commission in 2009. Xcel Energy notes that it still seeks to store the 2,560 spent-fuel assemblies anticipated by the Commission's 2009 certificate of need. Xcel Energy's request is that it not be limited to storing these assemblies in 64 TN-40HT casks, but rather storing them in any NRC-approved spent fuel storage casks.

Project Purpose

Xcel Energy indicates that its proposed change in spent fuel storage technology would likely result in lower customer costs. Further, Xcel Energy indicates that a change in technology could potentially facilitate earlier shipments of spent nuclear fuel from Prairie Island to offsite storage facilities.

Regulatory Background

An EIS for a project must be supplemented if the responsible governmental unit determines that any of the following situations exist:

A. Whenever after a final EIS has been determined adequate, but before the project becomes exempt under part 4410.4600, subpart 2, item B or D, the RGU determines that either:

   (1) substantial changes have been made in the proposed project that affect the potential significant adverse environmental effects of the project; or

   (2) there is substantial new information or new circumstances that significantly affect the potential environmental effects from the proposed project that have not been considered in the final EIS or that significantly affect the availability of prudent and feasible alternatives with lesser environmental effects;

[4] EERA Comments and Recommendations, May 27, 2021, eDockets Number 20215-174578-01.
[5] Commission Order, October 1, 2021, eDockets Number 202110-178440-01.

B. Whenever an EIS has been prepared for an ongoing governmental action and the RGU determines that the conditions of item A, subitem (1) or (2), are met with respect to the action; or

C. Whenever an EIS has been prepared for one or more phases of a phased action or one or more components of a connected action and a later phase or another component is proposed for approval or implementation that was not evaluated in the initial EIS.[6]

EERA staff has concluded that Xcel Energy's request represents substantial new information that significantly affects the potential environmental effects at the Prairie Island ISFSI such that the 2009 Prairie Island EIS must be supplemented.[7] EERA staff believes that the request affects potential radiological and non-radiological impacts at the PINGP. Further, staff believes that potential impacts raise environmental justice concerns with respect to the Prairie Island Indian Community (PIIC).

Scoping Process

Scoping is the first step in the development of the SEIS. The scoping process has two primary purposes: (1) to gather public input as to the impacts and mitigation measures to study in the SEIS and (2) to focus the SEIS on those impacts and mitigation measures that will aid in the Commission's decision on Xcel Energy's request for a change in spent fuel storage technology.

EERA staff gathered input on the scope of the SEIS through public meetings and an associated comment period.[8] Staff also gathered input through a community meeting with the PIIC.

This scoping decision identifies the impacts and mitigation measures that will be analyzed in the SEIS.

Public Scoping Meetings

EERA staff held a public meeting regarding Xcel Energy's proposed change in spent fuel storage technology on October 5, 2021, in Red Wing, Minnesota. Approximately 15 persons attended this meeting; six persons provided public comments.[9] Comments addressed a range of topics including the type of technology that Xcel Energy might select for the project, licensing requirements, transportation of casks, and changes in spent nuclear fuel regulation since the 2009 Prairie Island EIS. The following evening, October 6, 2021, EERA staff held a virtual public meeting. Approximately 10 persons attended this meeting; two persons provided public comments.[10] Comments addressed coordination with the PIIC regarding Xcel Energy's proposal and the potential relicensing of the PINGP.

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[6] Minnesota Rule 4410.3000, Subp. 3.
[7] Minnesota Rule 4410.3000, Subp. 3.B.
[8] Minnesota Rule 4410.3000, Subp. 5; Notice of Scoping Meetings for Supplemental Environmental Impact Statement, September 14, 2021, eDockets Number, 20219-177940-01.
[9] Oral Public Meeting Comments on Scope of SEIS, eDockets Number 202110-179270-01.
[10] Id.

Written Public Comments

Following the public scoping meetings, written comments were received from the PIIC, the city of Red Wing, and three citizens.[11] The PIIC noted that there is a regulatory framework in place for the transportation of spent nuclear fuel. The PIIC recommended that the SEIS discuss the potential impacts associated with the transportation of spent nuclear fuel. The PIIC also recommended that the SEIS discuss a 2019 table-top spent fuel transportation exercise that was conducted at Prairie Island.

The city of Red Wing requested additional detail on the types of spent fuel storage technology that might be selected by Xcel Energy for the PINGP ISFSI. The city also requested additional information regarding the possible repackaging of any spent nuclear fuel at the PINGP. The city noted that a potential change in casks could impact tax revenues and the city's emergency response plan for the PINGP. The city also raised concerns regarding the planning, inspection, and maintenance necessary for long-term storage of spent nuclear fuel at the PINGP.

Several citizens requested additional information regarding the types of spent fuel storage technology that could be selected by Xcel Energy. Citizens also commented on licensing requirements, environmental justice, climate change, and long-term storage of spent nuclear fuel at the PINGP.

Meeting with Prairie Island Indian Community

In coordination with the PIIC, EERA staff held a community meeting with PIIC members on November 10, 2021. Approximately 10 persons attended this meeting in person with a similar number joining on-line; five community members provided comments.[12] Comments addressed several topics including the sealing of casks, cask transportation, potential impacts due to earthquakes and low temperatures, and the integrity of spent fuel rods.

Following the community meeting, written comments could be submitted to EERA staff through November 22, 2021. No written comments were received.

Having reviewed the matter, consulted with EERA staff, and in accordance with Minnesota Rule 4410.3000, I hereby make the following scoping decision:

[11] Written Public Comments on Scope of SEIS, eDockets Number 202110-179270-02.
[12] Oral Comments on Scope of SEIS, Prairie Island Indian Community Meeting, eDockets Number 202111-180174-01.

MATTERS TO BE ADDRESSED

The issues outlined below will be analyzed in the SEIS for Xcel Energy's proposed change in spent fuel storage technology at the Prairie Island ISFSI. The analysis will be limited to impacts and mitigation measures related to Xcel Energy's proposed change that were not addressed in the 2009 Prairie Island EIS.

I. GENERAL DESCRIPTION OF THE PROJECT

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

II. REGULATORY FRAMEWORK

A. Federal Approvals
   1. Licensing of spent fuel storage technology
   2. Licensing for spent fuel transportation
B. State Approvals
   1. Requirement for casks to facilitate storage and transportation, Minnesota Statutes § 116C.776.
C. Local Approvals

III. ENGINEERING, DESIGN, AND CONSTRUCTION

A. Cask and Canister Systems for Spent Fuel Storage
   1. The types of spent fuel storage technology that could be selected by Xcel Energy for the project.
B. Cask and Canister Handling
C. Cask and Canister Monitoring
D. Readiness of Casks and Canisters for Transportation
E. Prairie Island Independent Spent Fuel Storage Installation

IV. POTENTIAL IMPACTS AND MITIGATIVE MEASURES – NON-RADIOLOGICAL

The SEIS will include a discussion of human and environmental resources potentially impacted by the project. The SEIS will discuss potential non-radiological impacts related to the proposed change in spent fuel storage technology.

A. Environmental Setting
B. Human Environment
   1. Tax revenues
C. Natural Environment

V. POTENTIAL IMPACTS AND MITIGATION MEASURES – RADIOLOGICAL

The SEIS will discuss potential radiological impacts related to the proposed change in spent fuel storage technology.

A. Natural Background Radiation and Radiation Exposure

B. Potential Impacts to the Public
   1. Emergency response plan
   2. Climate change impacts on casks
C. Potential Impacts to Workers
D. Environmental Justice

VI. TRANSPORTATION OF SPENT NUCLEAR FUEL

The SEIS will discuss the regulatory framework for transportation of spent nuclear fuel in the United States. Potential impacts associated with the transportation of spent nuclear fuel will be discussed through reference to existing studies.

A. 2019 Table-Top Transportation Exercise at Prairie Island

VII. LONG-TERM STORAGE OF SPENT NUCLEAR FUEL

A. Changes in Spent Fuel Storage Regulation Since the 2009 Prairie Island EIS
B. Funding for Long-Term Storage of Spent Nuclear Fuel at the PINGP

VIII. DATA AND ANALYSIS

Data and analysis in the SEIS will be commensurate with the importance of potential impacts and the relevance of the information to consideration of the need for mitigation measures.[13] 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 SEIS.

If relevant information cannot be obtained within timelines prescribed by statute and 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 SEIS a statement that such information is incomplete or unavailable and the relevance of the information in evaluating potential impacts.[14]

IX. ALTERNATIVE SITES TO BE EVALUATED

The SEIS will evaluate the storage of spent nuclear fuel at the PINGP ISFSI. No other sites will be evaluated in the SEIS.

X. STUDIES TO BE UNDERTAKEN

No studies will be undertaken in preparation of the SEIS.

[13] Minnesota Rule 4410.2300.
[14] Minnesota Rule 4410.2500.

ISSUES OUTSIDE THE SCOPE OF THE SEIS

The SEIS will not address the following topics:

A. Potential Impacts and mitigation measures that are addressed in the 2009 Prairie Island EIS.
B. Potential impacts associated with operation of the PINGP.
C. The appropriateness of NRC regulations for spent nuclear fuel storage technology.
D. Potential impacts associated with the nuclear fuel cycle.
A. The appropriateness of NRC regulations and standards for radiation exposure. The SEIS may reference certain standards promulgated by the NRC; however, the SEIS will not address the adequacy of these standards.

SCHEDULE

A draft SEIS is anticipated to be completed and available in February 2022. A public meeting and comment period on the draft SEIS will follow. Timely and substantive comments on the draft SEIS will be responded to in a final SEIS. The final SEIS is anticipated to be available in April 2022.

Signed this 7th day of December, 2021

STATE OF MINNESOTA
DEPARTMENT OF COMMERCE

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Katherine Blauvelt, Assistant Commissioner

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

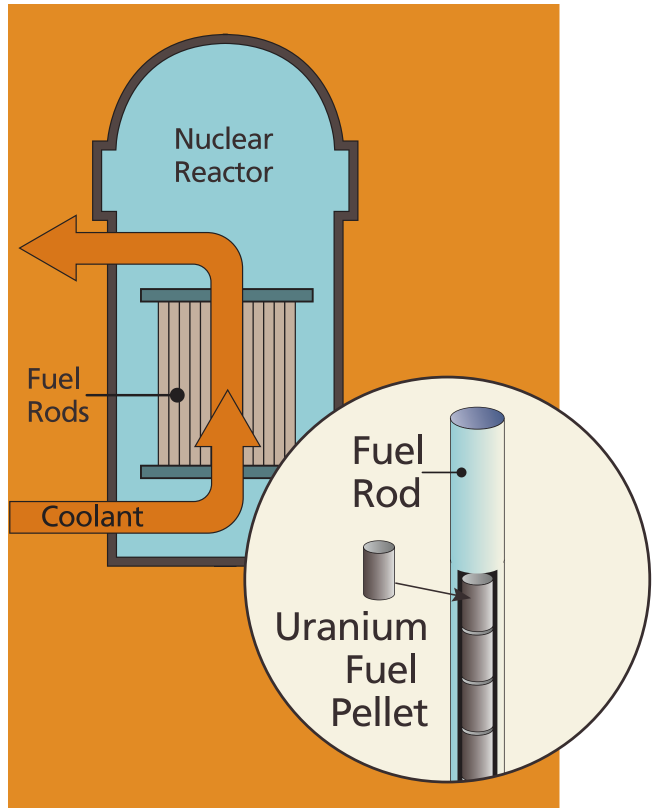
U.S.NRC

United States Nuclear Regulatory Commission

Protecting People and the Environment

Safety of Spent Fuel Storage

What Is Spent Fuel?



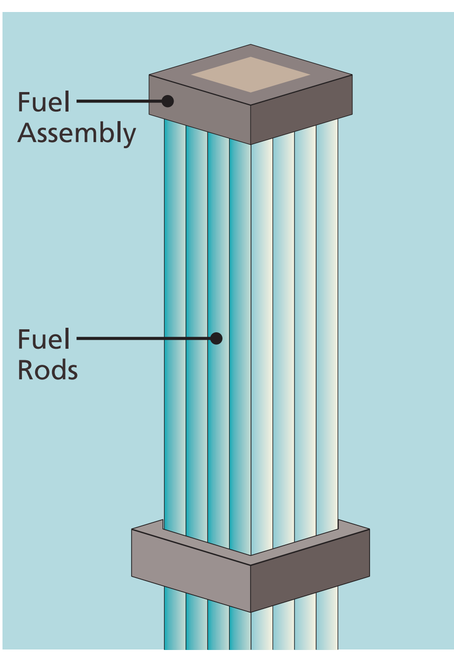
Nuclear reactors use uranium fuel rods bundled into fuel assemblies to generate the heat that turns generators. These generators produce electricity that powers people's homes.

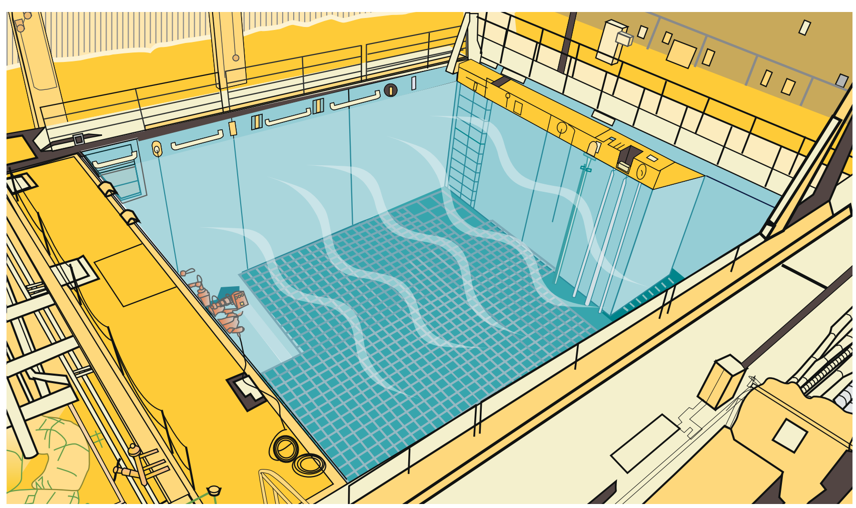
As it burns in the reactor, this fuel becomes very hot and very radioactive. After about 5 years, the fuel is no longer useful and is removed. Reactor operators have to manage the heat and radioactivity that remains in this spent fuel.

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

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)

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:

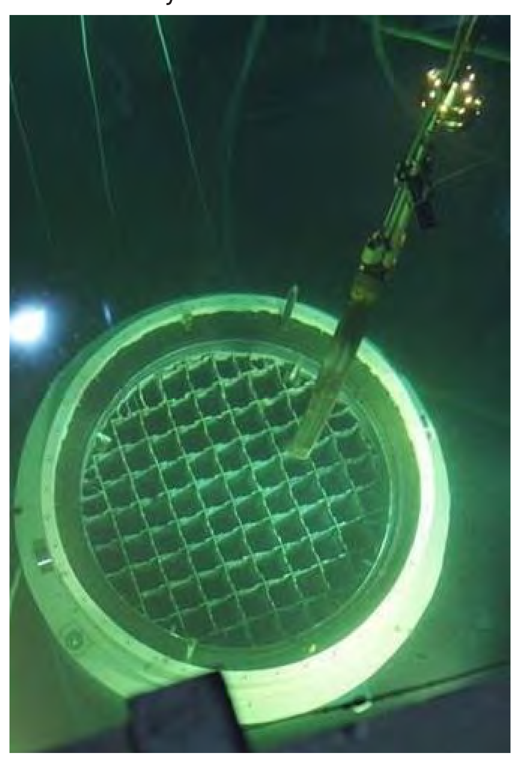
- Maintain confinement of the spent fuel
- Prevent nuclear fission (the chain reaction that allows a reactor to produce heat)
- Provide radiation shielding
- Maintain the ability to retrieve the spent fuel, if necessary
- Resist earthquakes, tornadoes, floods, temperature extremes, and other scenarios.

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)

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.

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)

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.

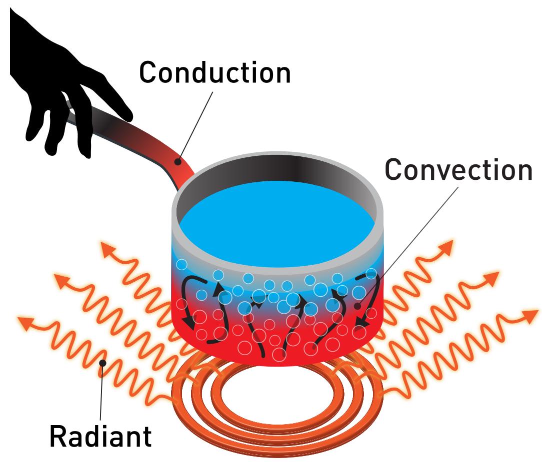
Next, when making a complex metal system, parts often are welded together—that is, partially melted—in a way that ensures that the joints themselves are adequate. The welder actually creates a new material at the joint with its own unique properties. That is why the NRC looks at how this is done, including 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.

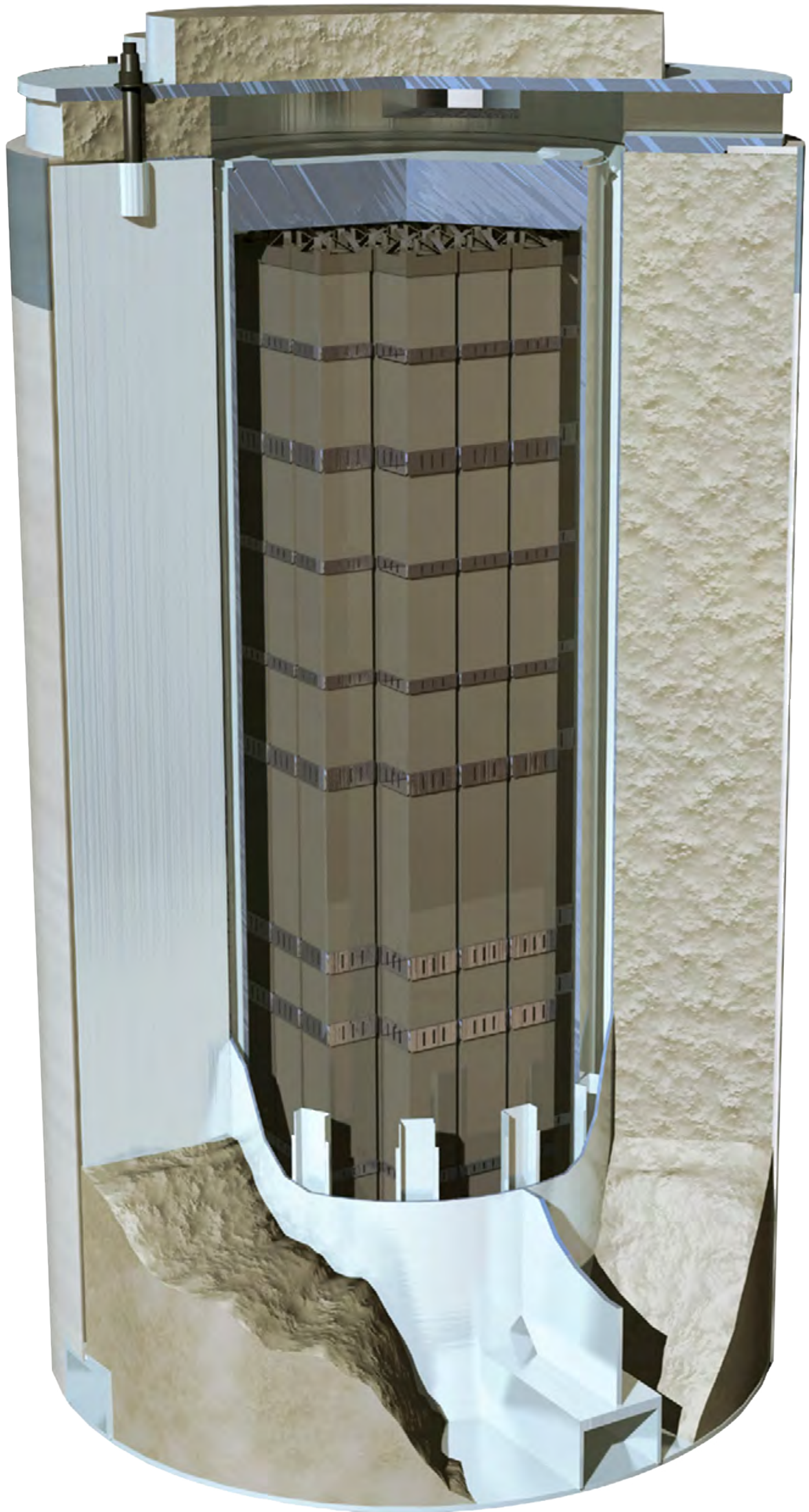
The NRC's review also verifies that the cask designer looked at all the environmental conditions that can be expected to affect cask components and fuel temperatures. These conditions may include windspeed and direction, temperature extremes, and a site's elevation. To make sure the right values are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

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

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.

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.

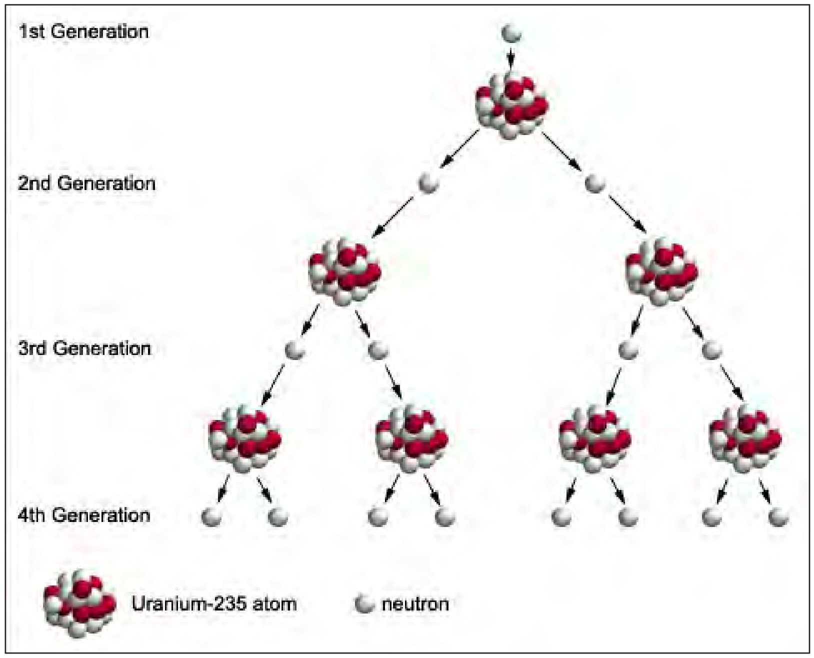
The NRC's review of a cask's confinement boundary looks at the "source term." This is the inventory of radioactive material inside the cask. While the redundant closures and other requirements ensure the material will remain safely confined, the NRC requires cask designers to look at the dose rates in 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

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.



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

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.

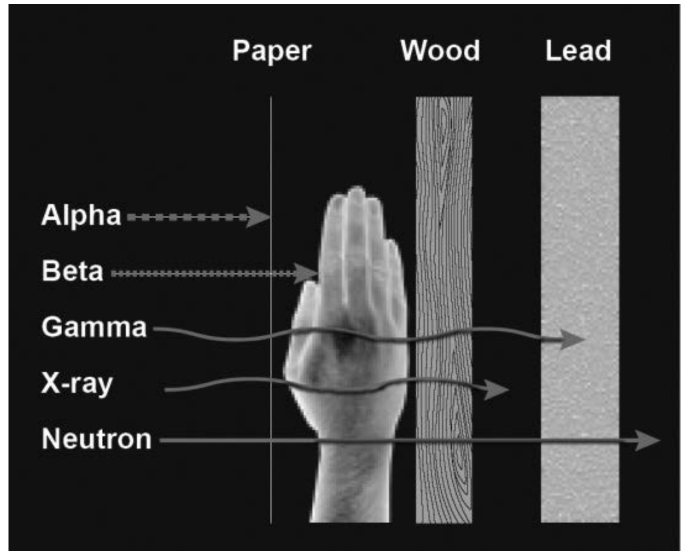
Certain chemicals, such as boron, can also slow down a chain reaction by absorbing neutrons released during fission, and keeping them from striking other uranium atoms.

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



Different types of radiation have different properties.

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.

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

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.


Inspectors examine dry storage casks containing spent nuclear fuel.

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.

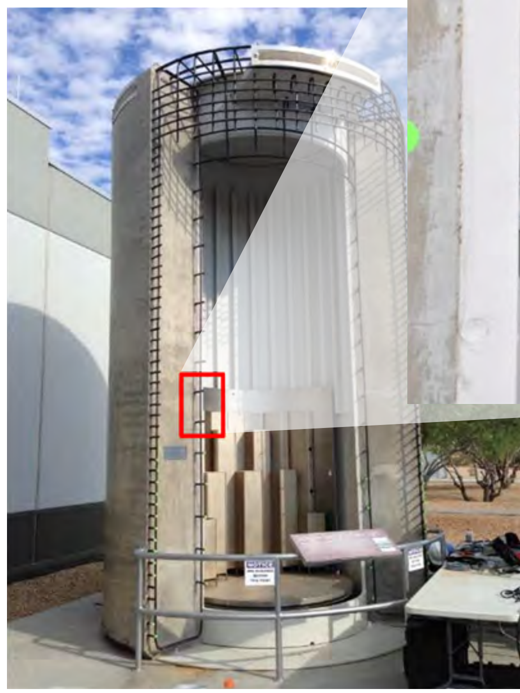
Each licensee is responsible for ensuring that its storage facility meets NRC regulations during construction and operation. NRC inspectors verify that the licensees are properly implementing the regulations. These inspections cover the design and construction of the concrete pad or modules that support 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:

Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
Phone: (301) 415-8200
Email: OPA.resource@NRC.GOV
Internet Home Page: http://www.nrc.gov

U.S. Nuclear Regulatory Commission
NUREG/BR-0528
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Appendix C
Cask and Canister Handling Processes

Process Steps and Photographs Provided by Xcel Energy

TN-40 and TN-40HT Loading Operations

Cask Loading

Cask loading includes physically placing the fuel assemblies into the cask, draining, decontamination, securing the lid, and drying, and includes the following sequence of events:

1. Stage the cask inside the rail bay of the Auxiliary Building (Figure C-1).
2. Lift the empty cask by its lifting lugs and place it vertically in cask decontamination area.

Figure C-1: Rail Bay Staging

3. Remove the lid and perform inspection.
4. Engage the lifting yoke with the cask upper trunnions.
5. Lift the cask up to the spent fuel pool.
6. Lower cask into the pool.
7. Load the spent fuel assemblies into the cask.
8. Install the lid underwater.
9. Engage the lifting yoke and lift the cask out of the pool.

Figure C-2: Cask Wash Down

10. Drain water from the cask.
11. Wash down the exposed portions of the cask (Figure C-2).
12. Move to cask decontamination area. (Figure C-3).

Figure C-3: Cask in Decontamination Area

13. Decontaminate outer surfaces of cask.
14. Torque lid bolts.
15. Install drain port cover.
16. Connect the vacuum drying system to the vent port.
17. Perform vacuum drying.
18. Backfill cask with helium.
19. Install vent port cover.
20. Perform helium leak test of lid seals.

<u>Transport to the ISFSI</u>

Cask transport operations include transferring the loaded cask to the cask transport vehicle (CTV), installing the top neutron shield, transporting the cask to the ISFSI, and connecting the pressure monitoring system. The sequence of events includes:

21. Engage the lifting yoke with cask upper trunnions.
22. Place the cask into the CTV.
23. Install top neutron shield drum.
24. Pressurize the overpressure system.
25. Perform leak test on overpressure system.
26. Install protective weather cover.
27. Use the CTV and tow vehicle to transfer the cask to the ISFSI (Figure C-4).

Figure C-4: Cask Transport Vehicle (CTV)

28. At the ISFSI, position the cask over the desired pad location.
29. Lower the cask onto the ISFSI pad.
30. Rotate the CTV rear wheels to the unloading position (Figure C-5).

Figure C-5: ISFSI Storage Pad

31. Remove the CTV.
32. Connect the seal pressure monitoring instrumentation.

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-6).

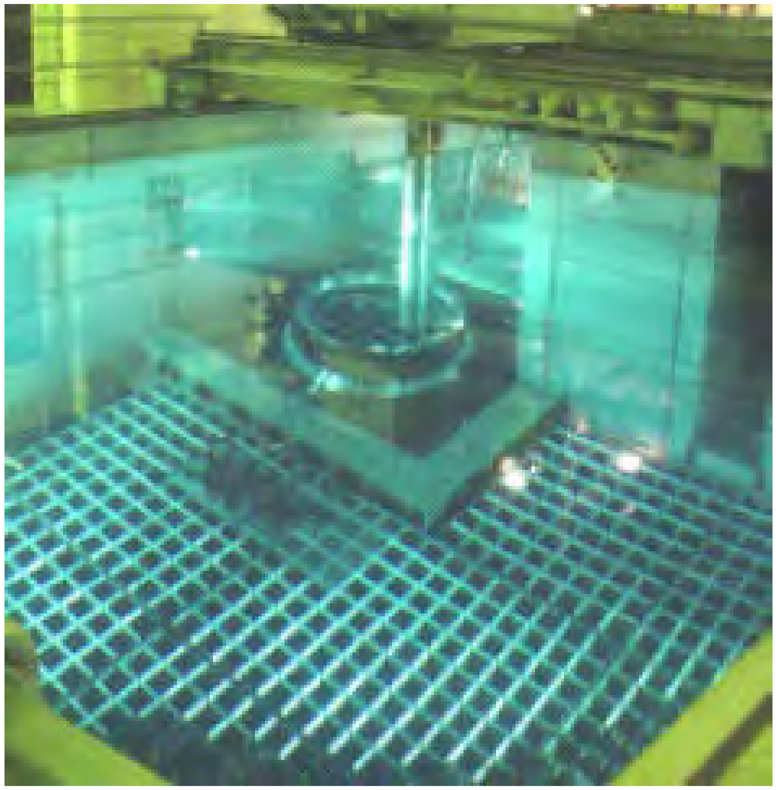


Figure C-6: Loading Fuel into Canister

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-7).

Figure C-7: 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-8: Lowering Cask onto Trailer

23. Rotate the transfer cask to a horizontal orientation (Figure C-8).
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-9).

Figure C-9: 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-10).

Figure C-10: Transfer Cask and Canister Movement to the Spent Fuel Pool

6. Lower transfer cask into the pool (Figure C-11).

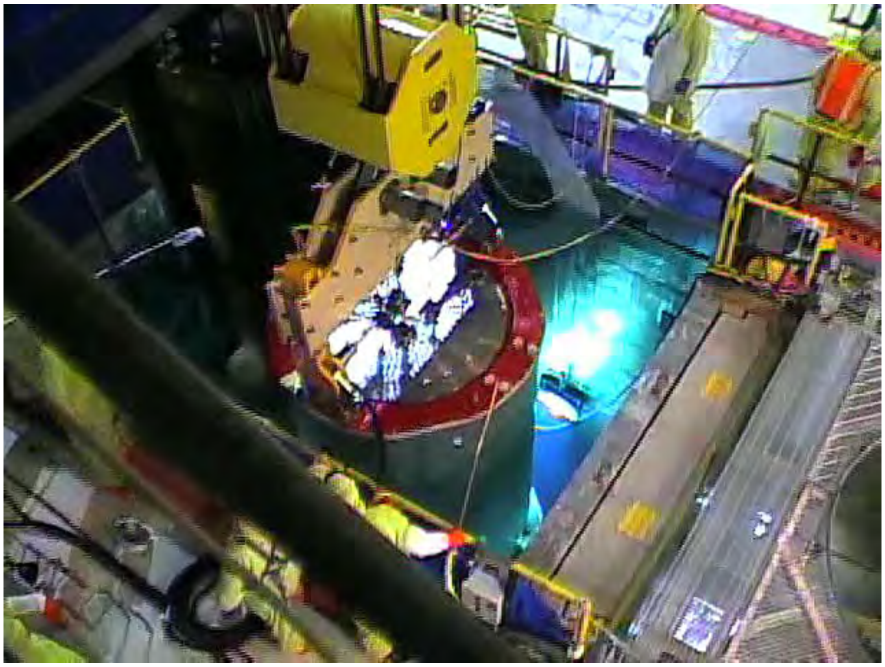


Figure C-11: Transfer Cask and Canister Lowered into Spent Fuel Pool

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-12).

Figure C-12: Helium Backfilling

14. Complete canister closure welding (outer lid) (Figure C-13).
15. Install the canister lift cleats.

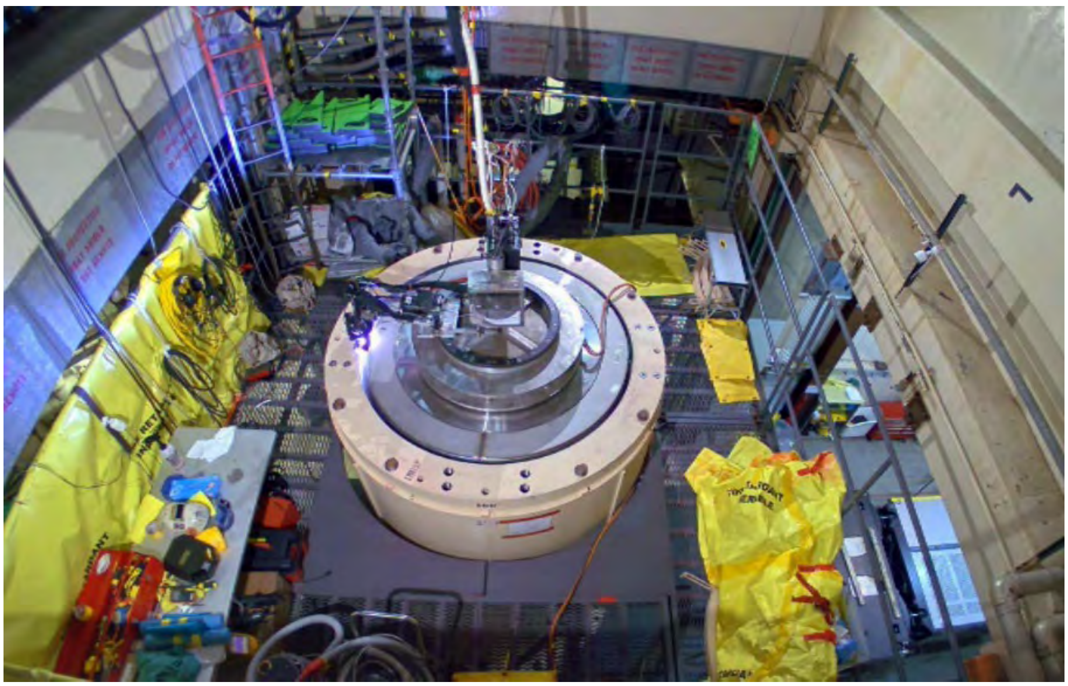


Figure C-13: Final Canister Closure Welding Using Automatic Welding System

Transport to the ISFSI

16. Position the empty concrete overpack on a specialized crawler (Figure C-14).

Figure C-14: 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-15)

Figure C-15: Overpack, Mating Device, and Transfer Cask

20. Raise transfer cask from the decontamination area and place it on the mating device (Figure C-16).

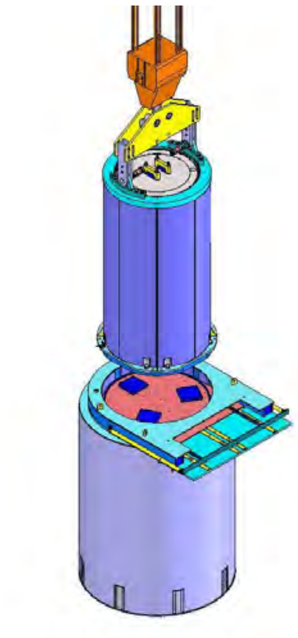


Figure C-16: Placement of Transfer Cask on Overpack with Mating Device

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-17).

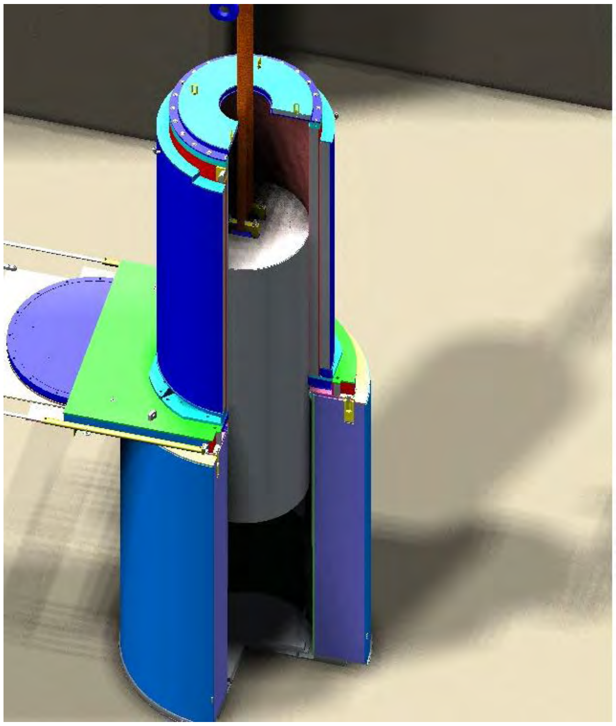


Figure C-17: Lowering of Canister into Overpack

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-18).

Figure C-18: Canister Lowered into Overpack; Lift Cleats and Downloader Slings Removed

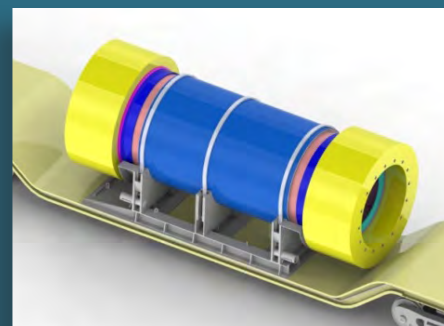
29. Remove the mating device.
30. Install the overpack lid.
31. Place the overpack and canister on the ISFSI pad (Figure C-19).

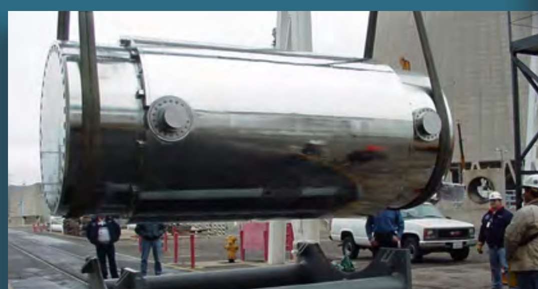
Figure C-19: Overpack and Canister Movement to ISFSI Pad Using Transporter

Appendix D
Safety of Spent Fuel Transportation, NUREG BR-0292

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

Safety of Spent Fuel Transportation





The Agencies: Who Does What?

The U.S. Nuclear Regulatory Commission (NRC) is an independent agency created by Congress. Its mission is to regulate the nation's civilian use of radioactive materials in a way that protects public health and safety and the environment. The NRC regulates commercial nuclear power reactors; research, test, and training reactors; nuclear fuel cycle facilities; and medical, academic, and industrial uses of nuclear materials. The NRC also regulates packaging for the transport, storage, and disposal of nuclear materials and waste, and licenses the export and import of radioactive materials.

The U.S. Department of Transportation (DOT) coordinates with the NRC to set rules for the packaging of nuclear materials. DOT also works with the NRC and affected States to regulate their transport. DOT regulates carriers, sets standards for routes, and is responsible for international agreements on the transport of all hazardous materials.

The U.S. Department of Energy (DOE) is responsible by law for disposal of spent fuel from the nation's nuclear power reactors.

The International Atomic Energy Agency (IAEA) is a forum for scientific and technical cooperation in the nuclear field. Part of the United Nations, the IAEA sets global regulations in many areas of the nuclear industry. IAEA's regulations for materials packaging and transport serve as a model for the United States and other nations.

Cover Photos:

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

(Middle) Spent fuel transport cask arrives at Rancho Seco. *(Courtesy: Areva)*

(Right) Schematic of spent fuel transport cask. *(Courtesy: Holtec International)*

(Bottom) Spent fuel transport cask arrives on site.

Page 1 Photos:

(Left) Empty transportable spent fuel storage system arrives at Prairie Island. *(Courtesy: Areva)*

(Right) Transportable spent fuel storage system is readied for storage. *(Courtesy: Areva)*

(Bottom) Transport package is placed inside conveyance vehicle. *(Courtesy: NAC International)*

The Nuclear Regulatory Commission

The NRC regulates the nuclear fuel cycle from beginning to end. Starting when the uranium is taken from the ground, the NRC oversees its processing and manufacture into fuel to be used in reactors. The NRC also plays a role in ensuring the safe transportation, storage, and permanent geologic disposal of used fuel.

The NRC works to protect public health and safety, the environment, and our national security. To keep the public's confidence, the NRC aims to do its work openly and to be effective, efficient, and realistic.

Proper handling of nuclear materials helps to protect the safety of the public and plant workers. To achieve this aim, the NRC works with the DOT and DOE in the United States, and with the IAEA internationally. Together, these agencies help make sure nuclear materials are packaged and transported safely around the world.

This publication explains the NRC's role in the safe packaging and transport of spent nuclear fuel from commercial nuclear power plants. The NRC oversees the design, manufacture, use, and maintenance of containers for these radioactive shipments. However, the NRC does not control the timing or destination of spent fuel shipments.

The NRC has three main functions:

1. *To set standards and develop regulations*
2. *To issue licenses for nuclear facilities and nuclear materials users*
3. *To inspect facilities to ensure that NRC regulations are being met*

What is Spent Fuel?

> **Radiation**
>
> *About half of the public's average annual radiation exposure comes from natural sources. These sources include radon, the human body, outer space, rocks, and soil. This natural radiation is called background and can vary greatly from place to place. Nearly all of the rest of an average person's exposure comes from medical sources, such as x-rays and diagnostic tests that are used in health care. Radiation that can be traced to radioactive materials transport makes up a tiny fraction of an average person's overall exposure. Such low levels of exposure are very unlikely to have any biological effect, but if they did they would be too small to be detectable. The human body responds to radiation in the same way whether it comes from natural or manmade sources.*

Nuclear reactors make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor for a number of years until it needs to be replaced. The used fuel is then known as spent fuel. It must be stored safely until it can be shipped offsite.

The Nuclear Waste Policy Act sets a policy for safe, permanent disposal of spent fuel and other high-level radioactive wastes. Congress in 1987 selected Yucca Mountain in Nevada as the site to be studied for a repository deep underground. DOE applied to the NRC in 2008 for a permit to construct the repository there. But DOE withdrew its application in 2010. The NRC's role is to assess whether the facility would meet NRC regulatory requirements. Other policy considerations are up to DOE and Congress.

All nuclear power reactors move their spent fuel first into pools for storage on site. As the amount of spent fuel in the pool increases, many reactors are also using dry casks for storage. The NRC reviews and approves the designs for these systems.

The NRC would also review any proposal for central interim storage of spent fuel. Eventually, spent fuel will need to be transported to a central storage or disposal facility from sites around the country. These shipments would likely be made by rail or on public highways.

Because spent fuel is highly radioactive, people may wonder:

- **How does the NRC protect the public from radiation during transport?**
- **What is the likelihood one of these shipments will be involved in an accident?**
- **How well can the shipping containers withstand an accident and prevent the release of nuclear materials?**

The NRC addresses these and other questions as a part of its ongoing efforts to ensure safe transport. As new technology and real-world information become available, the NRC evaluates that information against its regulations. It is important to know that spent fuel has been shipped safely within the United States and abroad for more than 40 years.

The Key to Ensuring Safety: the Spent Fuel Shipping Container

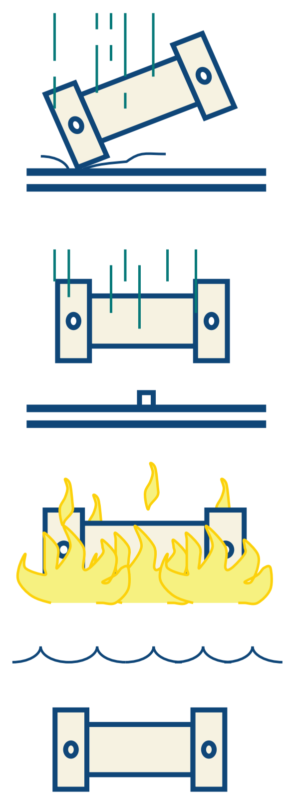
Spent fuel is highly radioactive and must be shielded and contained to be transported safely. Safe shipment requires a large, robust spent fuel container called a cask.

The NRC regulates the design and construction of these casks to ensure the public is protected. Containers used to move spent fuel by rail or highway are designed to withstand severe accidents. In the U.S. and internationally, these designs must pass a series of tests that mimic accident forces. The NRC reviews spent fuel containers very carefully to ensure they meet the design standards and test conditions in the regulations.

These containers must be able to survive four tests involving impact, puncture, fire, and submersion in water. During and after the tests, the casks must contain the nuclear material, limit radiation doses to acceptable levels, and prevent a nuclear chain reaction.

To protect workers and the public, a cask has walls of steel and shielding materials 5 to 15 inches thick and a massive lid. Truck containers weigh about 25 tons when loaded with one to two tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. In an accident, these impact limiters would crush and absorb the impact forces, protecting the package and its contents.

Spent fuel containers are tightly sealed and provide heavy shielding to protect anyone who might be near the cask during transport.



The NRC requires spent fuel shipping casks to survive four tests in sequence:

1. free-drop impact,

2. puncture impact,

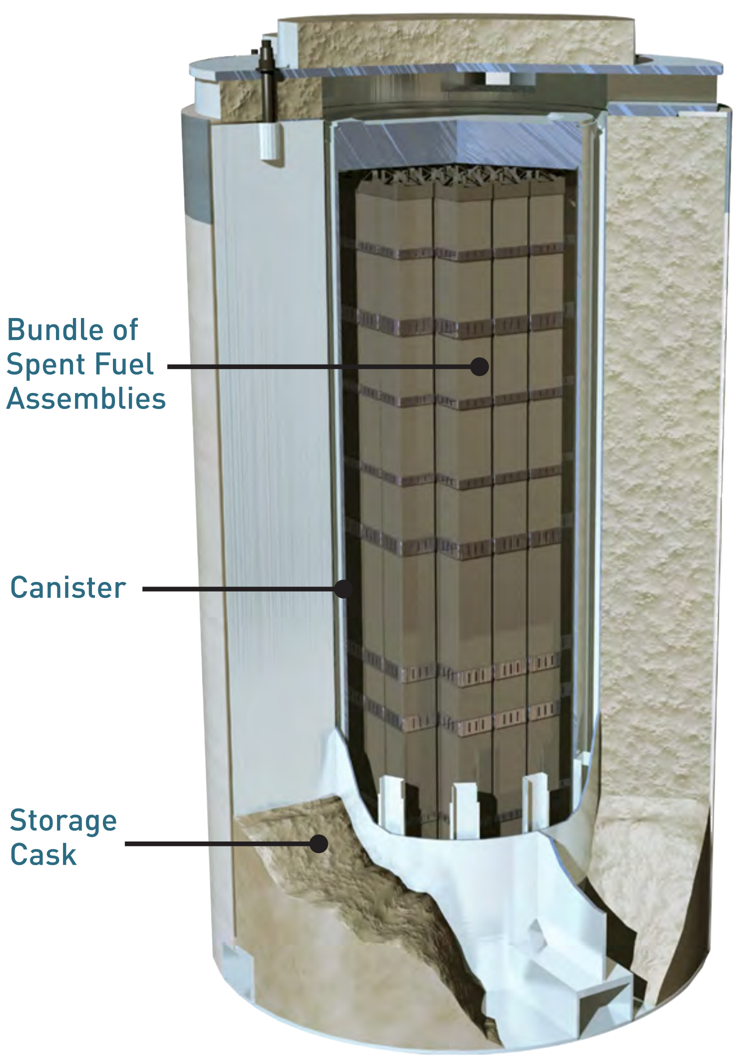
3. fire, and

4. water immersion.

Truck carries NAC LWT transport package.

Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing, physical testing of a scale model, or a combination of these techniques. Most often, they combine analyses and physical testing. They meet with technical review staff from the NRC, explain their design, and provide supporting documents in an application. The NRC evaluates each design, examines the information in depth, and performs its own calculations when needed. NRC reviewers are experts in different areas of science and engineering. They include structural and materials engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC is satisfied that a design meets the requirements, it issues a certificate of compliance. This certificate describes the approved design (including what materials must be used), the authorized contents, and the dimensions of the container. Then the containers can be manufactured and used. Manufacturers and shippers have programs in place to ensure the containers meet design specifications throughout fabrication and transportation. These programs are known as quality assurance. To ensure the casks meet the certificates, NRC staff inspects both the manufacturer and the facilities that will use them.



But just having a certificate does not mean a cask can be used. Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure radiation levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.

A Brief History of Spent Fuel Shipments and Studies

More than 1,300 spent fuel shipments have been completed safely in the United States over the past 35 years. Four were involved in accidents, but none resulted in a release of radioactive material or a fatality due to radiation exposure.

This experience confirms that the safety system is sound. But will this hold true when shipments increase to move spent fuel to a future repository or a storage facility?

The NRC looks at the risks associated with spent fuel transport in a methodical and scientific way. Several NRC-sponsored studies over the years have focused on the risk related to spent fuel transport on highways and railroads. The results provide additional confidence in the current regulations to assure the safety of spent fuel transport.

NAC LWT spent fuel transport package is moved by crane. *(Courtesy: NAC International)*

In a 1977 study[1], the NRC found the risk from transporting spent fuel to be low. The study gave the NRC confidence that existing regulations are adequate to protect the public.

In separate studies in 1987[2] and 2000[3], the NRC looked more closely at how shipping containers would perform in accidents. Each study used more advanced research methods than in the earlier studies. Both of these studies found the risk posed by spent fuel shipments would be even smaller than estimated in 1977. That finding holds true even if the number of spent fuel shipments were to increase greatly.

The latest risk study, published in January 2014, modeled the radiation doses people might receive from spent fuel shipments. This study again confirmed that NRC regulations for spent fuel transport ensure safety of the public and the environment.

The 2014 study[4] looked at how three NRC-certified packages would behave during both normal shipments and transportation accidents. The study modeled a variety of transport routes using population data from the U.S. Census Bureau. It used statistics from actual highway and rail accidents and state-of-the-art computer models. The study considered doses from normal shipments to people living along transportation routes. It also looked at doses to occupants of vehicles sharing the route, vehicle crews and other workers, and anyone present at a stop.

1. *http://pbadupws.nrc.gov/docs/ML1219/ML12192A283.pdf*
2. *http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr4829/*
3. *http://pbadupws.nrc.gov/docs/ML0036/ML003698324.pdf*
4. *http://pbadupws.nrc.gov/docs/ML1403/ML14031A323.pdf*

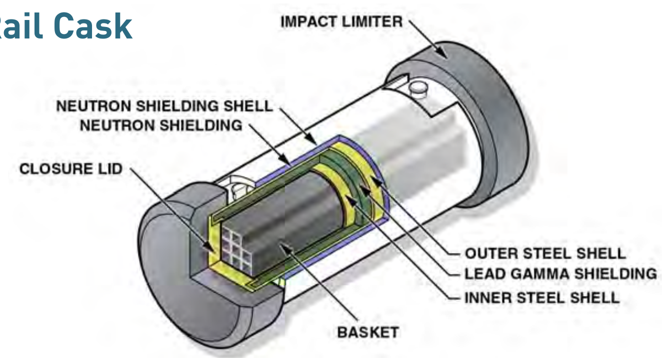

Transportable spent fuel storage cask moves to storage pad.
(Courtesy: Holtec International)

The risk assessment found:

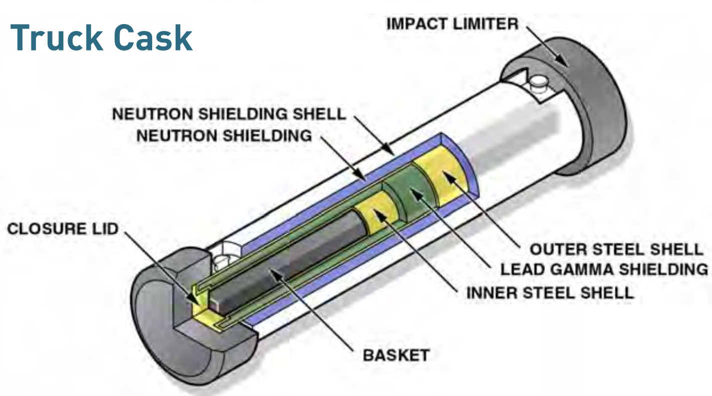
- **Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.**
- **There is less than a 1 in 1 billion chance that radioactive material would be released in an accident.**
- **If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm.**

In addition to these risk studies, the NRC has looked closely at real-world transportation accidents involving fires. The NRC did a series of case studies on the most severe accidents to see how well an NRC-certified spent fuel package would perform. These studies show the current regulations protect the public even in the most severe fires. The case studies include the Howard Street tunnel chemical fire that burned for five days in Baltimore in 2001; the 1982 Caldecott tunnel fire and the 2007 MacArthur Maze fire, both sparked by gasoline tankers outside Oakland, CA.; and a 2007 brush fire in the New Hall Pass tunnel outside Los Angeles.

Rail Cask



Truck Cask



Spent fuel containers are specially designed to protect the public by withstanding accident conditions without releasing their radioactive contents.

Additional NRC studies identified the conditions in an accident that could produce a fire severe enough to engulf a spent fuel transport package.

On the basis of these studies, plus operational experience and its own reviews, the NRC believes spent fuel can continue to be shipped safely. The evidence shows this will be true even if hundreds of shipments are made each year. The NRC is continuing to track spent fuel shipping, including more analyses and testing of spent fuel casks, to ensure that the risks remain low.

Understanding the Risks

Risk is generally understood to be the chance of injury, damage or some kind of loss. The spent fuel shipment record in the United States has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic safety standards.

While shipping spent fuel does involve risk, NRC studies show this risk is low. As a part of its safety effort, the NRC aims to manage the hazards to minimize the risk. To evaluate the risks, the NRC asks the following three questions and then converts the answers into numbers:

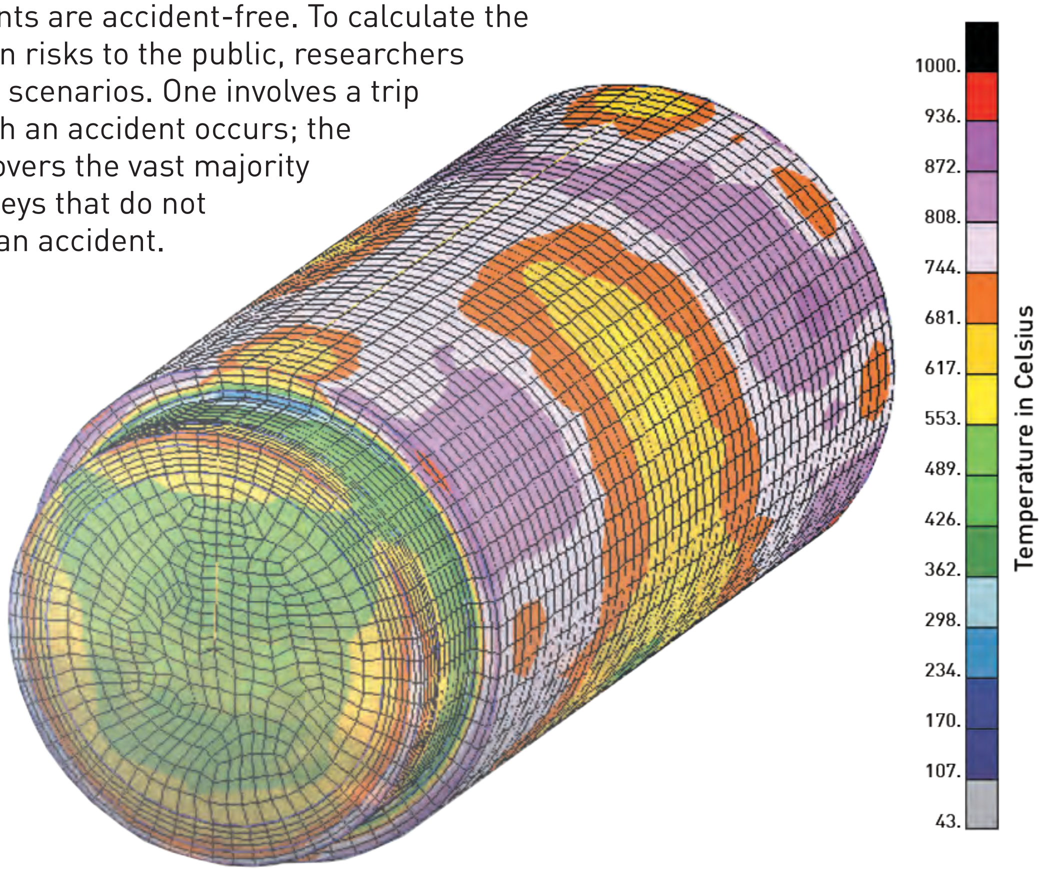
- **What can go wrong?**
- **How likely is it to occur?**
- **If something goes wrong, what are the consequences?**

The overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, researchers use two scenarios. One involves a trip on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects.

Step 1. Experts determine what might happen.

- *They gather historic records.*
- *They also put together data on how many spent fuel shipments are likely each year.*
- *They look at the rate of accidents for rail and highway shipments.*
- *They look at a large number of accidents that are credible.*
- *They also look at the effects of crash impact forces, fires, or punctures on the shipping container. They pick forces that are more severe than those covered by NRC standards.*



Shown is a computer simulation of the response of a cask to a severe fire environment. Analyses like this and tests are used by NRC to assure safe transportation of spent fuel.

Step 2. Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.

- *They gather data on how much spent fuel each container will carry.*
- *They analyze how the spent fuel might respond in a given type of accident.*
- *They calculate the temperature of the container and the spent fuel itself during a long-term fire.*

This information allows engineers to estimate the size of a potential leak and how much nuclear material might escape.

Step 3. Researchers match accident scenarios from Step 1 with the analyses from Step 2. This tells them the likelihood that there would be severe damage to the container or its contents.

Step 4. A special computer program computes a risk estimate. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimate.

The Accident Scenario

NRC studies show the likelihood of a radioactive release is very low. Fewer than 5 in 10,000 accidents involving a spent fuel container may be more severe than the conditions defined in the design standards. We would not expect a radioactive release in 99.99973% of those 5 accidents. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a release.

To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past highway and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

Using this method, the chance that an accident would be serious enough to lead to a release is 1 in 1 billion. If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm.

The Accident-Free Scenario

For most spent fuel shipments, nothing will go wrong and no nuclear material will be released. For these shipments, experts calculate the total radiation dose that all people along the route could receive. They use information on routes and local populations to determine how many people may be affected and the dose they could receive.

The risk to the public from an accident-free journey results from the very low levels of radiation that may come through the cask walls. A person standing along the highway or railroad track might receive a brief exposure that is well below regulatory limits. Exposure will vary depending upon the speed of the vehicle and how far away the person is standing. Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.

The Bottom Line

The NRC believes that shipments of spent fuel in the United States are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

- **The NRC ensures that shipping containers are robust by:**
  - Defining strict requirements for package design and performance
  - Reviewing designs and independently checking a container's ability to meet accident conditions
  - Doing inspections to ensure casks are built, maintained and used properly
- **The NRC also looks at the risks involved in spent fuel shipments. The agency:**
  - Analyzes spent fuel transport records to fully understand potential safety issues
  - Evaluates new transportation issues, such as projections for the number of shipments, changes in population along some routes, and other factors
  - Keeps up with technology as it evolves to refine estimates of current and future risk to the public

There will always be a slight chance that an accident will cause a release of nuclear material. But the NRC has found the likelihood of such an event and the risk to the public to be extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

The NRC also regulates how spent nuclear fuel is protected in transit against sabotage or theft. The agency strengthened these rules after Sept. 11, 2001. The current rules for the physical protection of spent fuel transport include:

- **Coordinating with law enforcement agencies before the shipment**
- **Requiring advance notice to States, Indian tribes, and the NRC**
- **Using a communications center and other means to monitor shipments while in route**
- **Using armed escorts, and**
- **Using devices that allow drivers and escorts to immobilize the vehicle**

For Additional Information Contact:

Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

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