



Xe-100 PRA Technical Adequacy Approach

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October 2022



Summary

- Purpose:
 - Describe the approach and the methodology used for determining the appropriate site characteristics, PRA scope, level of detail, and degree of plant representation for a technically adequate PRA supporting the Xe-100 licensing basis.
 - Initiate an NRC review of X-energy's approach and methodologies for achieving PRA technical adequacy
 - Seek NRC feedback on the proposed approach to evaluating environmental risks associated with severe accidents to support development of Xe-100 Environmental Reports
- Outline
 - Overview of regulatory requirements and regulation implementation guidelines
 - Xe-100 PRA technical adequacy approach
 - Proposed approach to assessing environmental risks of severe accidents
 - NRC review objectives



Applicable Regulatory Requirements

- Requirements related to PRA
 - only those plants with a CP or ML pending as of February 16, 1982, were required under paragraph 50.34(f), “Additional TMI [Three Mile Island]-related requirements,” to perform a PRA. Consequently, there is no longer any requirement to perform a PRA prior to submittal of an application for a CP or OL under Part 50.
 - 10 CFR 50.34(a)(1) - Contents of applications; technical information
 - 10 CFR 50.34 (f) (1) (i) PRA to improve reliability of Core and Containment Heat Removal Systems
 - 10 CFR 50.71 (h) Maintenance of Records – PRA
 - 10 CFR 52.47(a) - Contents of applications; technical information
- Requirements related to assessing the environmental risks of severe accidents
 - 10 CFR 51.45, Environmental Report
 - (b)(1) – “The environmental report shall contain a description of the proposed action... The impact of the proposed action on the environment. Impacts shall be discussed in proportion to their significance.”
 - (c) - “The environmental report must include an analysis that considers and balances the environmental effects of the proposed action, the environmental impacts of alternatives to the proposed action, and alternatives available for reducing or avoiding adverse environmental effects.”
 - 10 CFR 50, Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants
- WP identifies which parts of these applicable regulations are relevant for each stage of the licensing process



Applicable Regulation Implementation Guidelines

- Trial Use RG 1.247 Acceptability of PRA Results for NLWR Risk-Informed Activities
- RG 1.233 TI-RIPB Methodology to Inform the Licensing Basis
- NRC Input on NEI 21-07
- SECY-19-0084: New Reactor Licensing Rulemaking
- SECY-15-0002: Updating New Reactor Licensing Policies, Rules and Guidance
- Regulatory Guide 4.2 Preparation of Environmental Reports for Nuclear Power Stations
- 10 CFR 50, Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants



Xe-100 PRA Technical Adequacy Approach: Reg Guide 1.247 *(Trial Use)*



- White paper outlines X-energy's intended approach for demonstrating PRA technical adequacy through compliance with RG 1.247.
- The Xe-100 PRA will be developed in accordance with the requirements of the ASME/ANS NLWR PRA Standard.

NRC general framework for achieving PRA acceptability



Xe-100 PRA Technical Adequacy Approach: C.1 and C.2

- Regulatory Guidance C.1, An Acceptable PRA
- Regulatory Guidance C.2, National Consensus Standards and Industry Programs for PRA

“If the ASME/ANS NLWR PRA standard is used, as endorsed by the NRC in Appendix A to this RG, Regulatory Positions C.1 through C.2 are considered to be met.”

- RG 1.247 Staff Position C.3.2, “Development and Use of an Acceptable Probabilistic Risk Assessment”

- X-energy is using the ASME/ANS NLWR PRA Standard as endorsed in Appendix A
- Identified deviations from the RG are described in the white paper



Xe-100 PRA Technical Adequacy Approach: C.3.1 Probabilistic Risk Assessment Scope, Level of Detail, and Degree of Plant Representation

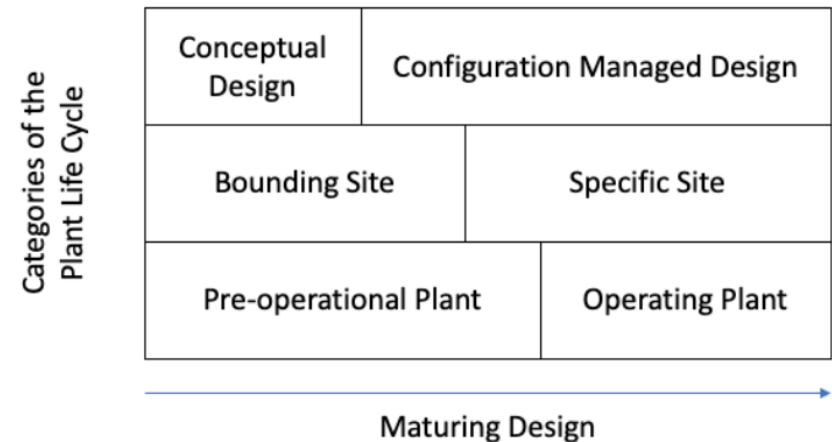
“The scope of a PRA used to support an application ... should be complete and comprehensive through consideration of the following:

- **All radiological sources** at the plant (e.g., reactor cores, spent fuel, fuel reprocessing facilities for molten salt reactors) should be addressed, including accident scenarios that lead to a radioactive release from multiple radiological sources.
- **All internal and external hazards** should be addressed. For licensing activities, a PRA for the seismic hazard group must always be developed; other hazards should also be included if they cannot be screened out with appropriate justification. Appendix B to this RG lists hazards to consider when developing the PRA.
- **All POSs** (e.g., at-power and low-power and shutdown (LPSP) types of POSs) should be addressed.”



Xe-100 PRA Technical Adequacy Approach: C.3.1 Probabilistic Risk Assessment Scope, Level of Detail, and Degree of Plant Representation

- ASME/ANS NLWR PRA Standard Figure 1-4, “Major Phases of a New Reactor Development for Which Applicability of Various Supporting Requirements May Change in this Standard”
- PRA technical adequacy is determined by assessing the PRA against the technical requirements of the NLWR PRA Standard
- Applicability of supporting requirements and ability to meet higher Capability Category changes over time
- PRA conformance to supporting requirements will increase with the maturing design





Xe-100 PRA Technical Adequacy Approach: C.3.1 Probabilistic Risk Assessment Scope, Level of Detail, and Degree of Plant Representation

For the CPA, the Xe-100 PRA will:

- identify all radiological sources at the plant.
 - For radiological sources that lack the design detail necessary to address them according to the requirements of the NLWR PRA Standard, X-energy will use supplementary analysis and supplementary requirements as described in Section 3 of the NLWR PRA Standard.
 - Only sources of radionuclides within the helium pressure boundary are expected to have the necessary design detail to meet the technical requirements of the NLWR PRA Standard.
- address all internal and external hazards in Appendix B of RG 1.247. The PRA will characterize the hazards that are applicable to the specific site and inform selection of Design Basis Hazard Levels.
- address the supporting requirements of the NLWR PRA Standard POS element at CC I. PRA for at-power events and sources of radionuclides within the helium pressure boundary will aim to meet the requirements of the NLWR PRA Standard.
 - Low-power modes will be addressed qualitatively with justification
- provide the frequencies and consequences of AOOs, DBEs, and BDBEs and implement a fully integrated statement of risk using the NLWR PRA Standard



Xe-100 PRA Technical Adequacy Approach: C.3.1 Probabilistic Risk Assessment Scope, Level of Detail, and Degree of Plant Representation

For the OLA, the Xe-100 PRA will:

- consider all radiological sources at the plant. PRA modeling of radiological sources will be justified using the applicable screening criteria in the ASME/ANS NLWR PRA Standard.
- address all internal and external hazards identified in Appendix B of RG 1.247. White Paper Section 2.3.2 provides more information on how the Xe-100 PRA will address hazards.
- consider all POSs (e.g., at-power and low-power and shutdown (LPSD) types of POSs). PRA modeling of POSs will be justified using the applicable screening criteria in the ASME/ANS NLWR PRA Standard.
- provide the frequencies and consequences of AOOs, DBEs, and BDBEs and implement a fully integrated statement of risk using the NLWR PRA Standard



Xe-100 PRA Technical Adequacy Approach: C.3.1 Probabilistic Risk Assessment Scope, Level of Detail, and Degree of Plant Representation

For the standard design, the Xe-100 PRA will:

- consider all radiological sources at the plant. PRA modeling of radiological sources will be justified using the applicable screening criteria in the ASME/ANS NLWR PRA Standard.
- **Identify and address RG 1.247 Appendix B hazards relevant to the sites selected for the Design Control Document (DCD). Seismic risk analysis and external hazards events analysis will be performed for a bounding site selected to cover a range of sites, mechanistic source terms, and off-site radiological doses.**
- consider all POSs (e.g., at-power and low-power and shutdown (LPSD) types of POSs). PRA modeling of POSs will be justified using the applicable screening criteria in the ASME/ANS NLWR PRA Standard.
- provide the frequencies and consequences of AOOs, DBEs, and BDBEs and implement a fully integrated statement of risk using the NLWR PRA Standard



Xe-100 PRA Technical Adequacy Approach: C.3.2, Development and Use of an Acceptable Probabilistic Risk Assessment

- The Xe-100 PRA will be developed in accordance with the requirements of the ASME/ANS NLWR PRA Standard.
- Xe-100 PRA quality will be commensurate with the maturity of the design and the intended license applications

Application	Approach for Demonstrating PRA Technical Adequacy
Construction Permit	Instead of a peer review, demonstrate PRA technical adequacy using the PRA self-assessment process following the guidance of NEI 20-09, which is described in: -Section 3.2, “Performance of the Self-Assessment by the Host User,” -Section 6.2, “Use of Self-Assessment in Assignment of CCs,” -and Sections A.3.1 and A.3.2, “Information Availability and Preparation via the Self-Assessment
Operating License and Design Certification	The Xe-100 PRA will be peer reviewed against the requirements of the ASME/ANS NLWR PRA Standard using the NEI 20-09 approach.



Xe-100 PRA Technical Adequacy Approach: C.4, PRA Documentation in Support of a Regulatory Decision

- Regulatory Guidance C.4.1, Archival Probabilistic Risk Assessment Documentation
 - Overall, X-energy will meet this guidance by developing PRA documentation in accordance with the documentation SRs of the ASME/ANS NLWR PRA Standard technical elements
 - The documentation will describe the process used to determine the acceptability of the PRA, including a description of how the staff position in RG 1.247 is met.
- Regulatory Guidance C.4.2, Submittal of Probabilistic Risk Assessment Documentation
 - The Xe-100 submittal documentation includes LTRs, white papers, and formal license applications developed in accordance with NEI 21-07. Collectively, these documents aim to implement the staff guidance in RG 1.247.



Proposed Xe-100 Approach for Meeting Severe Accident Regulations

U.S. NUCLEAR REGULATORY COMMISSION REGULATORY GUIDE 4.2, REVISION 3



Issue Date: September 2018
Technical Lead: J. Davis

PREPARATION OF ENVIRONMENTAL REPORTS FOR NUCLEAR POWER STATIONS

A. INTRODUCTION

Purpose

This regulatory guide (RG) provides guidance to applicants for the format and content of environmental reports (ERs) that are submitted as part of an application for a permit, license, or other authorization to site, construct, and/or operate a new nuclear power plant.

Applicability

This RG applies to applications for a permit, license, or other approval for a nuclear power plant subject to Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, "Domestic Licensing of Production and Utilization Facilities" (Ref. 1), 10 CFR Part 52 "Licenses, Certifications, and Approvals for Nuclear Power Plants" (Ref. 2), and the associated review under 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions" (Ref. 3).

Applicable Regulations

- The National Environmental Policy Act of 1969, as amended (NEPA; 42 United States Code (U.S.C.) 4321 et seq.) (Ref. 4) requires that Federal agencies prepare detailed environmental impact statements (EISs) on proposed major Federal actions significantly affecting the quality of the human environment. A principal objective of NEPA is to require a Federal agency to consider, in its decision-making process, the environmental impacts of each proposed major Federal action and alternative actions, including alternative sites. Additional direction is provided in Executive Order 11514 "Protection and Enhancement of Environmental Quality" (Ref. 5), as amended by Executive Order 11991 "Environmental Impact Statements" (Ref. 6), and in the Council on Environmental Quality's regulations at 40 CFR Chapter V – Council on Environmental Quality - Parts 1500–1508 (Ref. 7). Regarding the CEQ regulations, as stated in 10 CFR 51.10, the NRC takes account of those regulations voluntarily, subject to certain conditions.

Written suggestions regarding this guide or development of new guides may be submitted through the NRC's public Web site in the NRC Library at <https://nrcweb.nrc.gov/reading-rm/doc-collections/reg-guides/>, under Document Collections, in Regulatory Guides, at <https://nrcweb.nrc.gov/reading-rm/doc-collections/reg-guides/consent.html>.

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- X-energy seeks NRC feedback on a proposed approach to meet the intent of the RG 4.2 guidance related to severe accidents contained in Section 5.11.2, "Severe Accidents," and Section 5.11.3, "Severe Accident Mitigation Alternatives"
- RG 4.2, Section C.2.5, "Chapter 5: Operational Impacts at the Proposed Site" states:
 - "If the SMR is also a non-LWR, there may be significant differences in the analysis of accidents. An applicant for such a design should consult with the NRC staff in accordance with 10 CFR 51.40 to discuss the information and analysis that should be provided in the ER to support the evaluation of the impacts of accidents."
- Section 4 of the white paper presents X-energy's proposed approach for evaluating the impacts of Licensing Basis Events



NRC Review Objectives

- X-energy is requesting the NRC to review and comment on the contents of this white paper, most notably the following:
 - The approach and the methodology used for determining the appropriate site characteristics, PRA scope, level of detail, and quality for a technically adequate PRA supporting the Xe-100 licensing basis.
 - Initiate an NRC review of X-energy's approach and methodologies for achieving PRA technical adequacy
 - The proposed approach to evaluating environmental risks associated with severe accidents to support development of Xe-100 Environmental Reports



Acronyms

Acronym	Description
AOO	Anticipated Operational Occurrence
ASME/ANS	American Society of Mechanical Engineers / American Nuclear Society
BDBE	Beyond Design Basis Event
CFR	Code of Federal Regulations
CPA	Construction Permit Application
DBE	Design Basis Event
DCD	Design Control Document
ER	Environmental Report
LPSD	Low Power Shutdown
LTR	Licensing Topical Report
NEI	Nuclear Energy Institute
NLWR	Non-Light Water Reactor
NRC	Nuclear Regulatory Commission
OLA	Operating License Application
POS	Plant Operating State
PRA	Probabilistic Risk Assessment
RG	Regulatory Guide
SMR	Small Modular Reactor
SR	Supporting Requirements