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**X ENERGY, LLC., – FINAL SAFETY EVALUATION OF TOPICAL REPORT 010229,  
REVISION 2, “PLUME EXPOSURE PATHWAY EMERGENCY PLANNING ZONE SIZING  
METHODOLOGY” (EPID L-2024-TOP-0034)**

**SPONSOR AND SUBMITTAL INFORMATION**

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Topical Report (Revision 1)	November 26, 2024	ML24331A305
Completeness Determination	January 28, 2025	ML25024A203
Audit Plan	March 27, 2025	ML25086A253
Topical Report (Revision 2)	November 14, 2025	ML25318A046

**Brief Description of the Topical Report:**

By letter dated November 14, 2025 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML25318A047), X-energy, LLC submitted Topical Report (TR) 010229, Revision 2, “Xe-100 Licensing Topical Report Plume Exposure Pathway Emergency Planning Zone Sizing Methodology” (ML25318A046) to the U.S. Nuclear Regulatory Commission (NRC) staff for review and approval related to Xe-100 plants. Following the November 26, 2024, submission of Revision 1 of the TR (ML24331A305), the NRC staff initiated an audit to identify any information that will require docketing to support the NRC staff’s safety evaluation of the subject TR (ML25086A253).

The TR describes the risk-informed methodology to determine a design- and site-specific plume exposure pathway (PEP) emergency planning zone (EPZ) size to be used by future applicants using the Xe-100 plant design. The methodology follows the approach described in Appendix A, “General Methodology for Establishing Plume Exposure Pathway Emergency Planning Zone Size,” of Regulatory Guide (RG) 1.242, “Performance-Based Emergency Preparedness for Small Modular Reactors, Non-Light-Water Reactors, and Non-Power Production or Utilization Facilities” (ML23226A036) and a generalized risk-informed approach from the dose assessment methodologies that informed EPZ size determinations in NUREG-0396, “Planning Basis for the

Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants” (ML051390356).

For background, X-energy’s overall licensing approach for the Xe-100 reactor design follows the Licensing Modernization Project (LMP) methodology described in Nuclear Energy Institute (NEI) 18-04, Revision 1, “Risk-Informed Performance-Based Technology Inclusive Guidance for Non-Light Water Reactor Licensing Basis Development” (ML19241A472). RG 1.233, “Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light Water Reactors,” Revision 0 (ML20091L698), endorses the LMP methodology described in NEI 18-04.

The proprietary information in this document is marked with double brackets and bold font such as [REDACTED].

## REGULATORY EVALUATION

### Regulatory Basis:

The NRC alternative emergency preparedness (EP) requirements for small modular reactors (SMRs) and other new technologies (ONTs), including non-light-water reactors, are provided in Title 10 of the Code of Federal Regulations (10 CFR) Section 50.160, “Emergency preparedness for small modular reactors, non-light-reactors, and non-power production or utilization facilities,” also referred to as the EP for SMRs and ONTs rule (88 FR 80050). This rule includes a scalable approach to determining the size of the PEP EPZ. For facility applicants electing to comply with 10 CFR 50.160(b)(3), 10 CFR 50.33(g)(2) requires that the application include the analysis used to determine whether PEP EPZ criteria in 10 CFR 50.33(g)(2)(i)(A) and 10 CFR 50.33(g)(2)(i)(B) are met, and if so, the size of the PEP EPZ.

Under 10 CFR 50.33(g)(2)(i), the PEP EPZ is the area within which:

- (A) Public dose, as defined in § 20.1003 [“Definitions”] of this chapter [Chapter I to Title 10] is projected to exceed 10 mSv (1 rem) total effective dose equivalent [TEDE] over 96 hours from the release of radioactive materials from the facility considering accident likelihood and source term, timing of the accident sequence, and meteorology; and
- (B) Pre-determined, prompt protective measures are necessary.

### Guidance:

RG 1.242, Revision 0, “Performance-Based Emergency Preparedness for Small Modular Reactors, Non-Light Water Reactors, and Non-Power Production or Utilization Facilities” (ML23226A036), identifies methods that the NRC staff considers acceptable for use by applicants for SMRs, non-LWRs, and non-production and utilization facilities (NPUFs) to demonstrate compliance with EP requirements of 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities,” specifically, 10 CFR 50.47, “Emergency plans,” 10 CFR 50.160, “Emergency preparedness for small modular reactors, non-light-water reactors, and non-power production or utilization facilities,” and Appendix E, “Emergency Planning and Preparedness for Production and Utilization Facilities,” to 10 CFR Part 50.

NUREG-0396, provides the technical basis for the 10-mile PEP EPZ in 10 CFR 50.33(g)(1) and 50.47(c)(2). As discussed in the preamble to the EP for SMRs and ONTs rule (88 FR 80058), in a 2018 research study, the NRC staff reviewed the dose assessment methodologies that informed the EPZ size determinations in NUREG-0396 and developed a general methodology for determining the PEP EPZ size based on NUREG-0396. The NRC staff used information from that review and a subsequent set of recommended analyses performed by the NRC staff and documented in “Required Analyses for Informing Emergency Planning Zone Size Determinations,” (ML18114A176) dated June 2018, to develop the methodology described in Appendix A, “General methodology for establishing plume exposure pathway EPZ Size,” in RG 1.242. RG 1.242, Appendix A, describes an acceptable approach for meeting the EPZ sizing requirements for 10 CFR 50.160.

An emergency plan supports planning and preparedness of emergency response organizations and State and local governments to take necessary actions to provide dose savings and protect the public health and safety in the event of an accidental release of radioactive material from a nuclear power plant. The PEP EPZ, which is the area where predetermined, prompt protective measures are necessary, is one tool in the emergency plan.

NUREG-1855, Revision 1, “Guidance on the Treatment of Uncertainties Associated with PRAs in Risk-Informed Decision Making” (ML17062A466), provides a generally acceptable approach for developing risk-informed supplemental evaluations. Non-light water reactor applicants who use the guidance in NUREG-1855 to develop risk-informed supplemental evaluations should describe and justify the use of reactor-technology-specific screening criteria and explain how specific sources of uncertainty were identified and addressed.

NEI 18-04, Revision 1, presents a technology-inclusive, risk-informed, and performance-based process for selection of licensing basis events (LBEs), safety classification of structures, systems, and components (SSCs) and associated risk-informed special treatments, and determination of defense-in-depth (DID) adequacy.

RG 1.233, Revision 0, endorses the Licensing Modernization Project (LMP) guidance provided in NEI 18-04, with clarifications as an acceptable method for informing the licensing basis and determining the appropriate scope and level of detail for parts of applications for licenses, certifications, and approvals for non-LWRs.

RG 1.247 (for trial use), “Acceptability of Probabilistic Risk Assessment Results for Non-Light-Water Reactor Risk-Informed Activities” (ML21235A008), describes an acceptable approach for determining whether a design-specific or plant-specific probabilistic risk assessment (PRA) used to support an application is sufficient to provide confidence in the results, such that the PRA can be used in regulatory decision-making for non-LWRs.<sup>1</sup> It endorses, with exceptions, American Society of Mechanical Engineers (ASME)/American Nuclear Society (ANS) RA-S-1.4-2021, “Probabilistic Risk Assessment Standard for Advanced Non-Light Water Reactor Nuclear Power

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<sup>1</sup> RG 1.247 has been issued for trial use. The NRC staff may use a trial RG as a reference in its regulatory processes. However, the NRC staff may withdraw or add positions to the trial use guide after the trial use period ends. Moreover, the trial use RG does not establish a staff position for the purposes of backfitting as that term is defined in 10 CFR 50.109, “Backfitting,” and as described in NRC Management Directive 8.4, “Management of Backfitting, Forward Fitting, Issue Finality, and Information Requests.” The trial RG also does not constitute forward fitting as that term is described in Management Directive 8.4, “Management of Backfitting, Forward Fitting, Issue Finality, and Information Requests.”

Plants,” (Non-LWR PRA Standard) and NEI 20-09, Revision 1, “Performance of PRA Peer Reviews Using the ASME/ANS Advanced Non-LWR PRA Standard” (ML20302A115).

### TECHNICAL EVALUATION

TR section 1, “Introduction,” provides the purpose, scope, interfacing documents, document layout, and outcome objectives. TR section 2, “Regulatory Requirements and Associated Guidance,” provides the regulatory basis and associated guidance for the PEP EPZ methodology. TR section 3, “Event Screening Methodology,” through section 7, “Conclusions,” provide the methodology on which X-energy requests the NRC staff’s review and approval. The NRC staff considered TR sections 1 and 2, as background information supporting the methodology and takes no position on the information therein.

The TR methodology determines a PEP EPZ based on the area within which the public dose, as defined in 10 CFR 20.1003 is projected to exceed 10 millisievert (mSv) (1 rem) TEDE over an exposure period of 96 hours from the release of radioactive materials from the facility, considering accident likelihood and source term, timing of the release sequence, and meteorology. TR section 1.4, “Document Layout,” provides an overview of the methodology, which includes the following steps:

- Compile LBEs from the PRA for all internal and external initiators (TR section 3.3, “Development of the Probabilistic Risk Assessment,” and section 3.4, “Hazards and Initiating Events”).
- Perform screening of non-seismic LBEs based on estimated dose or timing, including uncertainty (TR section 3.5, “Selection of Non-Seismic LBEs”).
- Perform screening and selection of seismic LBEs, including uncertainty (TR section 3.6, “Selection of Seismic LBEs”).
- Collect meteorological data and incorporate it into the radiological consequence analysis (TR section 5.1, “Meteorological Input”).
- Perform source term and radiological consequence analysis, with the projected PEP EPZ boundary and 30-day event sequence timing (TR section 4, “Radiological Source Term Evaluation Methodology,” and section 5.3, “Dose Estimation for Pathway Contributors”).
- Evaluate the radiological dose consequences against the established PEP EPZ dose and frequency criteria (TR section 3.3, “Development of the Probabilistic Risk Assessment,” and section 6.1, “Probabilistic Dose Aggregation”).
- Develop distances from 1 rem and 200 rem cumulative curves based on the criteria for non-seismic LBEs (TR section 6.1.1, “LBE Dose Criterion A” and section 6.1.2, “LBE Dose Criterion B”).
- Perform uncertainty and cliff-edge analysis (TR section 6.2, “Uncertainty and Cliff-Edge Analyses”).

- Compare Seismic LBEs to the proposed radiological dose criteria (TR section 3.3, “Development of the Probabilistic Risk Assessment” and section 6.3, “Assessment for Seismic Hazards”).
- Repeat event sequence and consequence analysis if necessary.
- Perform event sequence evaluation and radiological dose assessment and resulting protective measures evaluation from resulting distances (TR section 6.4, “Event Evaluation and Assessment” and section 6.5, “Protective Measures Evaluation”).
- Determine the final PEP EPZ distance based on results (TR section 6.6, “Plume Exposure Pathway EPZ Determination”).

The following sections of this SE describe the NRC staff’s technical evaluation of the TR.

## 1.0 Event screening methodology

TR section 3, “Event Screening Methodology,” provides a description of the methodology for determining appropriate LBEs to be evaluated for the PEP EPZ. The NRC staff’s evaluation is discussed below for the steps of the event screening methodology as described in each subsection.

### 1.1 Application of Risk-Informed Methods

TR section 3.1, “Application of Risk-Informed Methods,” describes the use of risk information to select the spectrum of events used in the PEP EPZ sizing methodology.

RG 1.242, Appendix A, lists a set of assumptions that support the generalized methodology in the RG. One of the assumptions states that adequate information on LBEs, radiological source terms, and, as appropriate, PRA is assumed to be available. Appendix B, “Development of Information on Source Terms,” of RG 1.242 provides additional guidance on the development of radiological source terms and the use of PRA.

TR section 3.1 states that, “[a]s outlined in RG 1.242, sufficient information on LBEs, radiological source terms, and PRA are available and utilized in the PEP EPZ sizing methodology described in this LTR.” The TR methodology uses risk information developed as part of the LMP approach to inform the PEP EPZ sizing methodology for the Xe-100 reactor. Specifically:

- A spectrum of LBEs is used that includes anticipated operational occurrences (AOOs), design basis events (DBEs), and beyond design basis events (BDBEs) as the basis for the PEP EPZ determination process.
- PRA event sequence families with a frequency of  $5E-7$  per plant year or greater, assessed at the 95th percentile, are included in the PEP EPZ determination.
- A technically adequate PRA is used, which considers internal and external hazards, all plant operating states, all sources of radioactive material at the plant, and includes event sequences involving single or multiple modules/units, as applicable. Additionally, sources of uncertainty have been addressed through quantitative uncertainty analyses

supported by sensitivity analyses. A source of uncertainty included in this TR is evaluated in section 4.1, “Probabilistic Dose Aggregation, Uncertainty, and Cliff-Edge Analyses,” of this SE.

The technical adequacy of the PRA, its key assumptions, and its sources of uncertainty are outside the scope of this TR. However, they are instrumental to the determination of the spectrum of events considered in this TR. Therefore, limitations and conditions numbers 1, 2, and 3 in this SE will ensure that the PRA is acceptable for use in this TR methodology.

TR section 3.1 states that the methodology follows the guidance of RG 1.242, which includes:

- Applying a probabilistic dose aggregation framework with consideration of frequencies, selecting event sequences with an acceptable spectrum of consequences, and using a spectrum of events as a basis for developing emergency response plans and determining PEP EPZ size as described in TR section 3.
- Design and operational features that provide multiple independent DID and release sequence frequencies, with consideration of uncertainty.
- Use of mechanistic models to calculate source terms and doses as discussed in TR sections 4 and 5.
- Integrated uncertainty and cliff edge analysis as discussed in TR section 6.2.
- Timing considerations may be used to determine if a scenario should be included in PEP EPZ assessment as discussed in section 3.5.2 of the TR.

The TR methodology also states that the PEP EPZ methodology relies on site-specific risk-informed performance-based information developed as part of the LMP approach.

Consistent with the LMP process in NEI 18-04, the NRC staff finds that position C.1.b in RG 1.233, applies to the PEP EPZ sizing methodology proposed in this TR. The NRC staff determined that the method of utilizing a spectrum of events derived from the LMP identified LBEs is acceptable with the following clarification:

The PEP EPZ methodology includes an upper bound event sequence frequency (i.e., 95<sup>th</sup> percentile) of  $5 \times 10^{-7}$  per plant-year or greater to define the lower range of LBEs included in the PEP EPZ determination process. Applicants should not consider this demarcation of lowest-event frequencies to be a hard-and-fast cutoff but instead should consider it in the context of other parts of the methodology. These other considerations include the role of the integrated decision-making process panel described in section 6.5, “Protective Measures Evaluation,” of the TR, the plant’s DID adequacy assessment(s), accounting for uncertainties, and assessing for potential “cliff-edge effects,” which involve a dramatic change in plant behavior caused by a small change in plant parameter.

Additionally, the NRC staff determined that the TR methodology to apply risk-informed methods in the event selection for the Xe-100 reactor is acceptable because it is consistent with the guidance in RG 1.242, staff positions A-3.1, B-2, and B-3 in Appendix A, “General Methodology for Establishing Plume Exposure Pathway Emergency Planning Zone Size,” and Appendix B, “Development of Information on Source Terms,” respectively. The TR methodology relies on

site-specific risk-informed performance-based information developed as part of the LMP approach and because this information is fundamental to the TR methodology, limitation and condition number 7 ensures that applicants have design bases that are developed in accordance with the guidance in NEI 18-04, as endorsed by RG 1.233.

## 1.2 Criteria for PEP EPZ determination

TR section 3.2 provides the dose-based criteria for PEP EPZ size determination. There are two criteria (Criterion A and B) used in the methodology.

Criterion A is that the projected doses from the LBEs do not exceed the Environmental Protection Agency (EPA) Protective Action Guides (PAG)<sup>2</sup> levels outside the PEP EPZ. The NRC staff notes that X-energy's use of the EPA PAGs as a basis for Criterion A is consistent with the rationale for the emergency planning basis as described in NUREG-0396, Appendix I, "Rationale for the Planning Basis," the PEP EPZ sizing methodology guidance in RG 1.242, and the dose criterion for the EPZ size in 10 CFR 50.33(g)(2)(i). Additionally, the timing of a potential major release is the basis for requiring pre-determined, prompt protective measures triggered by plant conditions or dose projections in response to a general emergency declaration. Since projected doses are not expected to exceed 1 rem, it is reasonable for Criterion A to indicate that pre-determined prompt protective measures are not expected to be needed beyond the derived distance. Therefore, the NRC staff determined that Criterion A is acceptable.

Criterion B necessitates that immediate life-threatening doses from the LBEs, which include the worst-case radiological event sequences, are unlikely to occur outside the PEP EPZ. In 10 CFR 50.33(g)(2)(i)(A), the PEP EPZ is the area within which public dose (as defined in § 20.1003) is projected to exceed 10 millisieverts (1 rem) TEDE over 96 hours from the release of radioactive materials from the facility considering accident likelihood and source term, timing of the accident sequence, and meteorology. Although the regulatory requirement in 10 CFR 50.33(g)(2)(i), does not specifically provide dose metrics that vary with the likelihood of the release, the probabilistic dose aggregation guidance in RG 1.242, Appendix A, states that the likelihood of exceeding the TEDE of 10 mSv (1 rem) should be consistent with the evaluation in Appendix I to NUREG-0396. Criterion B gives an early health effects dose metric (i.e., immediately life-threatening dose metric) for very low probability radiological release sequences. NUREG-0396 determined that there was a low likelihood that immediately life-threatening doses would be projected outside of the 10-mile PEP EPZ for the evaluated set of large light-water reactor severe accidents with core melt and containment bypass or failure. Criterion B is similar to the criterion used in NUREG-0396, because it evaluates the worst core event sequences to determine that there is a low likelihood that immediately life-threatening doses would be projected outside of the PEP EPZ and differs from NUREG-0396, by using red bone marrow acute dose. As stated in TR section 3.2, "this TR applies the 200 rem threshold to the 24-hour red bone marrow dose ... This is supported by NUREG-0396, section III, "Recommended Planning Basis," subsection D, "Radiological Characteristics of Releases," and reflects that red bone marrow is typically the highest effective acute organ dose." Because red bone marrow acute dose is most sensitive to radiation exposure, the NRC staff determined that this dose metric is comparable to the dose metric of 200 rem whole body acute dose used in the

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<sup>2</sup> The EPA PAGs are reference values for radiation doses that warrant preselected protective actions (e.g., evacuation or sheltering-in-place) for public protection, if the projected dose received by an individual in the absence of protective action exceeds the PAGs. The most recent version of the PAGs is given in the January 2017, EPA PAG Manual (EPA-400/R-17/001), available at <https://www.epa.gov/radiation/protective-action-guides-pags>.

NUREG-0396 analyses for the worst-case core melt sequences and thus Criterion B is consistent with staff position A-3.7 of RG 1.242. Therefore, the NRC staff finds Criterion B to be acceptable.

The release frequencies for events selected in this application to be compared to Criterion B are important because the intent of this criterion is to align with the NUREG-0396 evaluation, which considered not only the likelihood of occurrence but also the characteristics of severe accident scenarios involving core damage and worst-case radiological releases. In NUREG-0396, the bounding assessment of the worst core melt sequences demonstrated that immediately life-threatening doses were unlikely to be projected beyond the 10-mile PEP EPZ. Consistent with this approach, Criterion B provides assurance that very low-probability, high-consequence events remain bounded within the proposed EPZ. The NRC staff notes that TR section 3.5 and section 3.6 describe the risk-informed selection of event sequences to compare to each of the dose-related criteria. The NRC staff's detailed evaluation of the TR event selection methodology is provided in the SE subsections 1.3 through 1.6, while subsection 4.1 describes the NRC staff's evaluation of TR section 6.1, dose-based comparison methodology.

### 1.3 Development of PRA

RG 1.242, Appendix A, staff position A-3.1 provides guidance on the selection of events to use in the radiological dose assessment to determine the facility-specific PEP EPZ size. The NRC staff position states that the applicant should consider the LBEs relevant to the facility described in the facility safety analysis report as candidates for the development of potential radiological releases. As discussed in TR section 3.3, the PRA being developed is both design-specific and site-specific, addressing all plant operating states and external hazards, including seismic event initiators and follows the guidance provided in RG 1.233 and NEI 18-04. The technology-inclusive, risk-informed, and performance-based methodology in NEI 18-04, as endorsed by RG 1.233, is used to determine LBEs and event selection in the PEP EPZ methodology. RG 1.242, Appendix A, staff position A-3.1 acknowledges that the development of the licensing basis in conformance with RG 1.233 is an option for non-LWRs.

The development and use of PRA is a fundamental part of the NEI 18-04 methodology. TR section 3.3 states:

The PRA is developed using the ASME/ANS RA-S-1.4-2021 standard, "Probabilistic Risk Assessment Standard for Advanced Non-Light Water Reactor Nuclear Power Plants," [13] as endorsed and clarified by RG 1.247, "Acceptability of Probabilistic Risk Assessment Results for Advanced Non-Light Water Reactor Risk-Informed Activities." [12] This standard ensures that the PRA encompasses the full spectrum of internal and external hazards that could challenge the plant's capabilities.

The TR also states that the PRA will undergo a peer review and meet all the requirements specified within the Non-LWR PRA Standard before the submittal of the final PEP EPZ sizing analysis. RG 1.233 states that the methodology in NEI 18-04 includes an expanded role for PRA and that the NRC staff's review of the PRA prepared by a reactor designer could be facilitated by the designer's use of the NRC staff-endorsed consensus codes and standards. RG 1.247 (for trial use) describes the acceptability of PRA for purposes such as supporting the NEI 18-04 methodology.

As discussed in TR section 3.3, the PRA is used to select the spectrum of applicable event sequences used in the PEP EPZ sizing methodology. The TR states that event sequences for all internal and external initiators, and for all plant operating states are compiled. The TR methodology includes a review of the assumptions and sources of uncertainty in the PRA to identify and address any potential impact on the PEP EPZ sizing methodology. Limitations and conditions numbers 1, 2, and 3 in this SE ensure that PRAs used to implement the proposed methodology are design- and site-specific, address all applicable hazards, all plant operating states, and all sources of radioactive material, and are technically acceptable. TR sections 3.4 through 3.6 describe the selection of events for the PEP EPZ sizing methodology.

#### 1.4 Hazards and Initiating Events

TR section 3.4 describes the methodology for evaluating a broad spectrum of events, including hazard groups from the Non-LWR PRA Standard. Applicants may screen out event sequences if they are clearly identified and justified in the applicants documentation. The TR methodology includes event sequence phenomena, as analyzed in the PRA, which are found to be applicable to the Xe-100 reactor design. As stated in TR section 3.4.1, "Hazard Groups," the methodology evaluates other hazards such as industrial and transportation initiating events, extreme weather, and soil and slope failures, with their inclusion or exclusion documented in the associated PRA and PEP EPZ sizing calculation. The NRC staff determined that the TR identification of hazards and initiating events is acceptable because the scope of potential events considers internal and external hazards, which is consistent with the Non-LWR PRA Standard, as endorsed by RG 1.247, and is consistent with the guidance in RG 1.242, staff position A-3.1.

TR section 3.4.2 discusses the exclusion of design basis accidents (DBAs) from the PEP EPZ sizing methodology. The TR discusses that in the LMP approach, DBAs are not selected or directly associated with a frequency, but rather derived from DBEs by assuming that only safety-related SSCs are available to mitigate the events. The TR methodology includes event sequences that are analogous to the DBAs (i.e., DBEs) within the PRA, which ensures that such event sequences are not neglected, but does not directly include the DBAs within the spectrum of events in the PEP EPZ analysis. The TR methodology only uses non-DBA LBEs as defined by the LMP process (i.e., AOOs, DBEs, BDBEs). The NRC staff determined that the use of non-DBA LBEs is consistent with RG 1.242, Appendix A, staff position A-3.1, in that applicants may opt to use RG 1.233, to determine their LBEs. The TR methodology utilizes the site-specific risk informed performance based LBE (i.e., AOOs, DBEs, BDBEs) information from the LMP approach as input to the spectrum of events. The LMP approach is described in NEI 18-04, which is endorsed by the NRC staff in RG 1.233, without exception. Therefore, the NRC staff determined that the use of non-DBA LBEs to develop the spectrum of events considered in the PEP EPZ sizing methodology is acceptable.

Although security-initiated events are not addressed by the Non-LWR PRA Standard, nor explicitly modeled in the PRA, the TR methodology as discussed in TR section 3.4.3, "Security Events," considers them during the hazard screening process for PEP EPZ determination, and is consistent with the guidance in RG 1.242. TR section 3.4.3 provides a method for applicants to address security events and potential consequences resulting from security events. Specifically, the TR methodology states that a qualitative or quantitative assessment of the security events are performed and documented as part of the PEP EPZ sizing calculation and that the inherent safety and design attributes of the Xe-100 plant and security by design features relevant to security event mitigation are part of the assessment. These features are designed to enhance the plant's ability to effectively respond to potential threats and ensure that any security-initiated impacts are minimized. The NRC staff determined that the performance

and documentation of a qualitative or quantitative assessment of security events in the PEP EPZ sizing calculation in addition to the comprehensive assessment of the site-specific risk informed performance based LBEs for the site is aligned with the guidance in RG 1.242, Appendix A, staff position A-3.1 regarding event selection, and is therefore, acceptable.

As discussed in TR section 3.4.4, “Event Sequence Groupings,” the PRA supports the categorization and evaluation of event sequences to be used in the PEP EPZ sizing analysis. The PEP EPZ sizing events are identified by using the PRA, including event sequences or event sequence families, as included in the PRA documentation. The Non-LWR PRA Standard, as endorsed by RG 1.247, includes guidance on event sequence grouping where event sequences are grouped into event sequence families having similar initiating events, plant responses, end states, and mechanistic source terms. The NRC staff determined that the use of PRA to support the categorization and evaluation of PEP EPZ event sequences is acceptable because it is consistent with the guidance in RG 1.247. The NRC staff also determined that the use of PRA in the LMP approach as described in NEI 18-04, as endorsed by the NRC staff in RG 1.233, without exception, is consistent with RG 1.242, Appendix A, staff position A-3.1, and is therefore, acceptable.

TR section 3.4.5 discusses the DID evaluation that follows section 5, “Evaluation of Defense-In-Depth Adequacy,” of NEI 18-04. The LMP methodology uses a “layers of defense” framework to minimize or prevent radionuclide releases across all modeled event sequences. The TR states that, “[t]he PEP EPZ is not credited as a defense line but instead serves to inform emergency response actions, and emergency planning is part of the 5<sup>th</sup> layer of DID as defined in NEI 18-04.” The TR also states that the specific DID methodology is addressed separately and is beyond the scope of this PEP EPZ TR. The NRC staff does not make a finding on TR section 3.4.5, but notes that the integrated risk-informed and performance-based evaluation of DID adequacy is part of the LMP process that identifies the DID attributes that have been incorporated into the design to prevent and mitigate event sequences and to ensure that the DID attributes reflect adequate SSC reliability and capability.

#### 1.5 Selection of Non-Seismic LBEs

TR section 3.5 discusses the screening criteria for the selection of non-seismic release sequences. The TR methodology uses site-specific risk-informed performance-based information that is part of the LMP approach, and the spectrum of LBEs for consideration primarily consists of previously identified LBEs with radionuclide release. Specifically, the TR methodology uses the LBEs from the AOO, DBE, and BDBE categories, which have been defined as event sequence families from the PRA, and are consistent with the screening criteria from NEI 18-04 and RG 1.233, and includes all non-seismic event sequence families from the PRA with a mean frequency of 5E-7 per plant year or greater, when assessed at the 95<sup>th</sup> percentile. The TR methodology considers LBEs to involve a radionuclide release when the mean 30-day TEDE at the site boundary is greater than 2.5 mrem.

The TR methodology further screens these LBEs based on the [REDACTED] and/or the time available to implement protective measures for the public considering both the timing of the event sequence and the need for predetermined, prompt protective measures. Specifically, the TR methodology screens out LBEs if [REDACTED]

[REDACTED] TR section 3.5.2, “Preliminary Screening,” provides considerations for timing assessments, and screens out LBEs if the timing

assessment determines that LBE timing and offsite response organization response data indicate that sufficient time is available for the offsite response organization to implement protective measures for the public without the need for predetermined prompt actions. Additionally, the TR methodology retains the screened-out LBEs for consideration as part of the emergency plan development. The NRC staff determined that this non-seismic release sequence screening approach is acceptable because it results in a spectrum of event sequences consistent with that evaluated in NUREG-0396, and discussed in RG 1.242.

#### 1.6 Selection of Seismic LBEs

TR section 3.6, "Selection of Seismic LBEs," outlines the methodology for the selection of seismic event sequences for consideration in EPZ sizing.

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

The resulting offsite dose is evaluated over a 96-hour exposure duration to produce the dose-versus-distance curve. As stated in TR section 6.3, the resulting dose-versus-distance curve is then compared to the 1 rem threshold to determine an associated distance for potential protective measures. Additionally, as described in section 6.3, the seismic analysis includes an evaluation of dose uncertainty, described in TR section 6.2.

For the OLA stage, TR section 3.6 indicates that [REDACTED]

[REDACTED] The NRC staff notes that this process is performed as part of the seismic PRA (SPRA) that will be performed for the OLA stage and, as indicated in TR section 6.3, the limiting EPZ earthquake is retained at this stage for use in the PEP EPZ analysis. Section 3.6 of the TR further indicates that, based on the SPRA inputs and respective seismic LBEs, [REDACTED]

[REDACTED] Section 3.3 of the TR indicates that the PRA (including SPRA) is developed using the Non-LWR PRA Standard as endorsed and clarified by RG 1.247. Based on conformance to this standard and associated RG 1.247, the NRC staff finds the use of [REDACTED] and SPRA inputs for the OLA stage to be acceptable. Further, the NRC staff determined that the selection of seismic LBEs is consistent with guidance in RG 1.242 and is acceptable because it is based on a review of a full spectrum of site-specific seismic hazards and the selection of an EPZ earthquake that results in the selection of a bounding seismic scenario. Additionally, the selection of seismic LBEs is informed by a [REDACTED]

## 2.0 Radiological Source Term Evaluation Methodology

TR section 4, “Radiological Source Term Evaluation Methodology,” states that the source term methodology is used to develop mechanistic source terms associated with the release scenarios selected for PEP EPZ sizing and is consistent with the overall Xe-100 reactor assessment and projections. The NRC staff understands that the source term methodology will be used to develop the mechanistic source terms for the Xe-100 PRA and analyses in the safety analysis report. The source terms for the release scenarios are treated as input to the radiological consequences methodology, which is discussed in TR section 5.2, “Radiological Consequence Analysis.” The TR states that the source term input establishes the specific radionuclide inventory and the quantity released for the spectrum of events that are assessed in the PEP EPZ analysis. The TR also states that the source term methodology is addressed within the PRA framework consistent with ASME/ANS RA-S-1.4--2021, as endorsed by RG 1.247, which governs source term development and consequence analysis for PRA. The NRC staff determined that referencing radiological source terms from the PRA for the facility is acceptable, if the PRA is design- and site-specific and technically acceptable, because it is consistent with guidance in RG 1.242, Appendix B, staff position B-2. Therefore, the NRC staff imposes limitations and conditions numbers 1 and 2 below, on the use of this TR for applications that utilize the source terms derived from the PRA to ensure that the PRA supporting the proposed methodology is technically acceptable.

### 3.0 Radiological Dose Evaluation Methodology

TR section 5, “Radiological Dose Evaluation Methodology,” describes the methodology used to perform the evaluation of radiological doses for the event sequences determined in TR section 3. TR sections 5.1 through 5.3 describe the considerations to analyze for the radiological consequences of the selected event sequences. The NRC staff’s evaluation of the radiological consequence considerations as described in each subsection of TR section 5 is detailed below.

#### 3.1 Meteorological Input and Radiological Consequence Analysis

TR section 5.2, “Radiological Consequence Analysis,” states that the radiological consequence analysis, and its associated inputs, assumptions, and uncertainty analysis, is addressed separately in the Atmospheric Dispersion and Dose Calculation Methodology licensing TR (LTR). Specifically, the X-energy radiological consequence analysis methodology is described in document number 007116, “Xe-100 Licensing Topical Report Atmospheric Dispersion and Dose Calculation Methodology” (ML23268A454), which was approved by the NRC staff on September 12, 2024 (ML24242A251).

TR section 5.1, “Meteorological Input,” states that meteorological data is required for dispersion calculations of atmospheric releases and that initially meteorological data is treated in a prescriptive and conservative manner rather than a probabilistic best estimate approach. To minimize atmospheric mixing and dispersion, and thereby maximize the release concentration downwind, the TR methodology assumes a stability class F and a wind speed of 1 meter per second, instead of site-specific hourly weather data. The TR methodology states:

Site-specific meteorology collected at future sites is expected to result in more dispersion, and therefore lower doses, compared to the assumptions currently used. A bounding atmospheric dispersion factor approach is applied based on these assumed weather conditions, as discussed separately in the Atmospheric Dispersion and Dose Calculation Methodology LTR [17]. The dispersion factors applied, based on the assumed weather conditions, are estimated to be conservatively bounding. The methodologies associated with the collection of meteorological data and determination of radiological consequences are out of scope for this LTR. Meteorological data will be utilized within the radiological consequence analysis to properly assess doses at the PEP EPZ boundary.

The NRC staff determined that this approach is acceptable because it is consistent with the guidance in RG 1.242, Appendix A, staff position A-3.3, which allows an assumption of conservative transport and dispersion conditions. Limitation and condition number 5 in this SE ensures that for the final PEP EPZ size determination, the atmospheric dispersion assumptions used in this methodology are bounding for the specific site.

The NRC staff evaluated the subject TR discussion regarding the use of the output of the radiological consequences methodology as input to the PEP EPZ sizing methodology. The TR states that the methodology for the radiological consequence analysis for the PEP EPZ analysis is consistent with the LBE consequence analyses, except that dose integration is performed over a 96-hour (4-day) period rather than the 30-day period typically used for LBE evaluation. The NRC staff determined that the calculation of the 96-hour TEDE is acceptable, because it is consistent with the requirements in 10 CFR 50.33(g)(2)(i) and the guidance in RG 1.242.

### 3.2 Dose Estimation for Pathway Contributors

TR section 5.3, “Dose Estimation for Pathway Contributors,” states that each of the postulated LBEs for the Xe-100 were evaluated for released source terms in different calculations and reports and the activities and off-site doses are calculated for the LBEs using bounding considerations. The TR also states that the inputs, assumptions, and software methodology is described in document number 007116, “Xe-100 Licensing Topical Report, Atmospheric Dispersion and Dose Calculation Methodology.” X-energy uses a suite of tools to support the offsite dose analysis associated with the PEP EPZ sizing methodology. Specifically, the mechanistic source term is developed using the XSTERM suite of codes, which includes the XDIS module for performing atmospheric dispersion and dose calculations and supports both the radiological consequence and source term methodologies. X-energy also uses a suite of codes including Flownex and GOTHIC for the system-level thermal hydraulics portion of the analysis and XSTERM for the radionuclide production, transport, dispersion, and ultimate offsite release characterization. Together, these codes are used to calculate the offsite dose figure of merit (FOM) for each transient event sequence. Each FOM for the Xe-100 safety analyses is calculated using XDIS, which integrates the mechanistic source term with meteorological assumptions and transport models to determine TEDE values quantified at a point offsite distance from the plant. The XSTERM suite of codes, including XDIS, is described in document number 007116, “Xe-100 Licensing Topical Report Atmospheric Dispersion and Dose Calculation Methodology,” which was approved by the NRC staff on September 12, 2024. The NRC staff did not re-review the XSTERM suite of codes, including XDIS, in this review.

TR section 5.3 describes the exposure parameters and dose pathways modeled in the radiological consequences. These radiological consequences are evaluated for each release category in terms of TEDE and red bone marrow dose to an individual from atmospheric releases at distances over a period of 96 hours or 24 hours, respectively, for each LBE, considering the impact of each affected reactor unit. NUREG-0396, section III.D, discusses the radiological characteristics of releases which are used to estimate projected doses. NUREG-0396 provides three dominant exposure modes for atmospheric releases that can be used to estimate projected dose, which are: (1) whole body (bone marrow) exposure from external gamma radiation and from ingestion of radioactive material, (2) thyroid exposure from inhalation or ingestion of radiodines, and (3) exposure of other organs from inhalation or ingestion of radioactive materials. In Appendix I to NUREG-0396, the task force judged that the consequences of a spectrum of accidents should be the principal rationale behind the EPZ planning basis and provided critical dose values for which emergency planners should be concerned. TEDE is the sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures). The NRC staff determined that the TEDE is consistent with the requirements in 10 CFR 50.33(g), and both the TEDE and red bone marrow acute dose are consistent with NUREG-0396, Appendix I, and RG 1.242, staff position A-3.6. Exposure pathways include both external plume immersion (i.e., cloudshine) and internal exposure (i.e., inhalation of airborne radionuclides) but do not include groundshine. Instead of including groundshine, the TR methodology takes no credit for deposition of the radionuclides on the ground and conservatively assumes no dose reduction via delayed or dispersed surface exposure. The NRC staff finds that the exposure pathway parameters and contributors are consistent with or more conservative than that described in RG 1.242, Appendix A, staff positions A-3.5 and A-3.6, and are therefore, acceptable.

#### 4.0 Radiological Dose Aggregation

TR section 6, “Radiological Dose Aggregation,” describes the methodology for aggregating doses from different source terms with consideration of the associated frequencies to provide confidence that the appropriate PEP EPZ size has been determined and that risk to the public is minimized. The NRC staff’s evaluation of the radiological dose aggregation including a comparison to the dose-related criteria, determination of the necessity of predetermined prompt protective measures, and treatment of uncertainty is described below.

#### 4.1 Probabilistic Dose Aggregation, Uncertainty, and Cliff-Edge Analyses

TR section 6.1, “Probabilistic Dose Aggregation,” describes the evaluation of the two dose-related criteria in the TR methodology and states that the dose associated with each non-seismic LBE that includes a radionuclide release is evaluated at different distances from the plant, resulting in dose-versus-distance curves. The seismic hazard analysis uses an alternative hazard approach as described in TR section 3.6 and is assessed separately as described in TR section 6.3. The NRC staff’s evaluation of the alternative seismic hazard approach is in section 4.2 of this SE. Dose-versus-distance curves are developed for specific dose values and represent the frequency of an individual receiving a given dose at various distances for each LBE. Three dose-versus-distance curves are discussed in the TR methodology, 1 rem, 5 rem, and 200 rem. The TR methodology discusses that the 1 rem curve indicates exceedance of the EPA PAGs and aligns with 10 CFR 50.33(g)(2)(i)(A), while the 200 rem curve serves as an indicator of the potential for early health effects and aligns with historical criteria from NUREG-0396. The TR methodology also discusses that the 5 rem curve is used to assess the impact of modeling uncertainties on the 1 rem and 200 rem cumulative dose-versus-distance curves and corresponds to the upper bound of the early-phase EPA PAGs. The TR methodology uses mean values of LBE frequency and consequence with consideration of uncertainties.

TR section 6.2 discusses that the overall PRA process includes performance of Monte Carlo sampling on the PRA event frequencies to ensure that accurate percentiles are captured, and to build confidence in the specific mean and 95<sup>th</sup> percentile values used in the evaluation. The methodology for the source term uncertainty analysis is outlined in section 9.3 in document number 007834, “Xe-100 Licensing Topical Report Transient Safety Analysis Methodology.” These uncertainty distributions are used to derive exceedance frequencies, which inform the shape and location of the cumulative dose-versus-distance curves. The TR methodology evaluates the sensitivity of the PEP EPZ boundary to consequence uncertainties by using a supplemental cumulative dose-versus-distance curve at 5 rem. The 5 rem curve determines whether modeling uncertainties for the 1 rem curve could result in dose exceedances above 5 rem at or near the selected EPZ boundary. For the 200 rem curve, the 5 rem curve confirms that high consequence event sequences remain well-separated in both dose and frequency space and will provide reasonable assurance that uncertainties do not impact the bounding nature of the 200 rem curve. The NRC staff determined that this approach is acceptable because it considers the uncertainty to be consistent with the guidance in RG 1.242.

The PEP EPZ sizing requirements in 10 CFR 50.33(g)(2)(i)(A) and (B) state:

- (i) The plume exposure pathway EPZ is the area within which:
  - (A) Public dose, as defined in § 20.1003 of this chapter, is projected to exceed 10 mSv (1 rem) total effective dose equivalent over 96 hours from

the release of radioactive materials from the facility considering accident likelihood and source term, timing of the accident sequence, and meteorology; and

(B) Pre-determined, prompt protective measures are necessary.

The TR methodology develops cumulative frequency curves by summing the frequencies of the individual LBE curves that are retained for EPZ sizing. The cumulative frequency curves assess the potential dose consequences for the spectrum of LBEs along with their likelihood of occurrence. TR section 6.1.1, "LBE Dose Criterion A," and section 6.1.2, "LBE Dose Criterion B," describe the evaluation of the two dose-related criteria in the TR methodology. In LBE dose criterion A, the TR methodology uses the 1 rem TEDE over 96 hours cumulative dose-versus-distance curve at a frequency of 1E-5 per plant year to derive an associated distance and states that the derived distance from criterion A, serves as a baseline for establishing whether protective measures are required for the public. The TR methodology states that if the cumulative dose-versus-distance curve is below the frequency criteria, no PEP EPZ distance is derived from the comparison. In LBE dose criterion B, the TR methodology uses the 200 rem red bone marrow dose for a 24-hour exposure period cumulative dose-versus-distance curve at a frequency of 1E-6 per plant year to derive an associated distance. If the cumulative frequency comparison results in two derived distances, one from the 1 rem curve and another from the 200 rem curve, the methodology uses the larger distance. It is also possible that no distance is derived if both the 1 rem and 200 rem curves fall sufficiently below their frequency thresholds. The cumulative frequency curve approach is similar to the approach used in NUREG-0396, because it evaluates the probability of exceeding certain critical doses (i.e., 1 rem and 200 rem) as a function of distance from the facility for a spectrum of event sequences, which include the worst case core melt. The NRC staff determined that the cumulative frequency curve approach is acceptable since it is similar to the approach in NUREG-0396, and is consistent with staff position A-3.7, in Appendix A of RG 1.242. As discussed in section 1.2 of this SE, the NRC staff finds the dose metric in criterion A and criterion B to be acceptable.

The TR methodology states that the cliff-edge evaluation focuses on significant changes to the derived distance resulting from small changes in the cumulative dose-versus-distance curve. The TR methodology does not establish rigid numerical criterion for this evaluation but instead applies engineering judgement to flag any region where a dramatic dose or frequency shift is visually observed over a short distance and could impact EPZ sizing near the sizing criteria. If potential cliff-edge behavior is identified, a more detailed, focused analysis is conducted. The TR methodology documents the cliff-edge effect evaluation in the PEP EPZ sizing calculation. The NRC staff determined that the performance of the cliff-edge evaluation is consistent with the guidance in RG 1.242, which states that analysts should confirm that there are no cliff edge effects.

#### 4.2 Assessment for Seismic Hazards

TR section 6.3, "Assessment for Seismic Hazards," discusses that a 96-hour dose-versus-distance curve is determined for selected hazard events and that the methodology for calculating the 96-hour dose consequence for the bounding seismic scenario is consistent with the methodology used for non-seismic LBEs, as described in TR sections 4 and 5.

At the CPA stage, seismic frequency information is not directly used in the EPZ sizing methodology, instead a limiting earthquake scenario is defined by [REDACTED]

[REDACTED] are considered to determine the bounding release case. The resulting radiological consequence for the bounding seismic hazard release case is evaluated for a 96-hour exposure duration to develop the dose-versus-distance curve.

At the OLA stage, [REDACTED]

[REDACTED] This information is used to confirm or refine the bounding seismic hazard release case developed at the CPA stage. As discussed in TR section 3.6, a [REDACTED] is performed at the OLA stage, using the [REDACTED]

[REDACTED] The dose-versus-distance curve developed during the CPA stage for the limiting earthquake scenario, as refined by the [REDACTED], is used for the PEP EPZ analysis.

The resulting dose-versus-distance curve will be compared to the 1 rem threshold to determine an associated distance for potential protective measures. The TR methodology also includes a similar evaluation of the dose uncertainty as that stated in TR section 6.2, but with a specific focus on the consequence analysis. The seismic hazard events selected through the alternative approach are retained for further consideration in the emergency plan development. The NRC staff determined that the associated approach is acceptable since it considers uncertainty, which is consistent with the guidance in RG 1.242, and calculates the 96-hour dose consequence, which is consistent with the methodology used for non-seismic LBEs in TR sections 4 and 5, which was evaluated above in sections 2.0 and 3.0, of this SE. The NRC staff also determined that deriving a distance for the consideration of protective measures from the comparison of the resulting 96-hour dose-versus-distance curve to 1 rem TEDE is acceptable.

#### 4.3 Protective Measures Evaluation

The PEP EPZ sizing requirements in 10 CFR 50.33(g)(2)(i)(B) state that the plume exposure pathway EPZ is the area within which pre-determined, prompt protective measures are necessary. TR section 6.5 describes the use of site-specific attributes to identify the necessity of prompt protective measures for the event sequences included in the PEP EPZ sizing analysis. As described in TR section 6.5, a detailed protective measures evaluation is performed, including the consideration of site-specific attributes, if a distance is derived from either the LBE analysis or the alternative hazard assessment that extends beyond the site boundary and exceeds a dose of 1 rem TEDE. The evaluation is conducted by the interdisciplinary LMP integrated decision-making process panel (IDPP) to determine whether pre-determined, prompt protective measures are warranted as part of the plant's DID adequacy assessment. The TR methodology states that, "[t]he need for predetermined, prompt protective measures will be assessed individually for each event sequence, incorporating specific event sequence details, including timing, population distribution, and the characteristics of the radionuclide release." If any PEP EPZ event sequence is identified as requiring pre-determined prompt protective measures and exceeds any of the dose criteria, the TR methodology considers modifications to the plant design or an extension of the PEP EPZ boundary following the process described in TR section 6.1. If the evaluation determines that pre-determined, prompt protective measures are necessary, the TR methodology incorporates the findings into the PEP EPZ calculation and informs procedures within the emergency response plan, ensuring that all PEP EPZ event sequences are adequately addressed. The NRC staff determined that the use of site-specific

attributes and radiological release timing to determine the necessity of prompt protective measures is acceptable because it is consistent with the guidance in RG 1.242, Appendix A, staff position A-3.8.

#### 4.4 PEP EPZ Determination

TR section 6.6, “PEP EPZ Determination,” discusses the possible outcomes for PEP EPZ size from this methodology. Based on the event sequence evaluation, dose assessment, and protective measures evaluation, the methodology has three possible outcomes for the PEP EPZ size determination. These outcomes are:

- No PEP EPZ: This outcome occurs when the event sequence evaluation and radiological dose assessment do not derive a distance where radiological doses exceed the established criteria in TR section 6.1. In this case, no further PEP EPZ is needed, indicating that protective measures for the public beyond the facility structures are not necessary.
- PEP EPZ at site boundary: This outcome occurs when radiological doses exceeding the established criteria in TR section 6.1, are projected beyond the facility structures but within the site boundary. It also applies when radiological doses exceeding the established criteria in TR section 6.1 are projected beyond the site boundary, and the IDPP determines that pre-determined, prompt protective measures are not necessary. For both scenarios, the licensee is responsible for implementing protective actions in accordance with the requirements of 10 CFR 50.160(b)(1)(iii)(B).
- PEP EPZ beyond site boundary: This outcome occurs when radiological doses exceeding the established criteria in TR section 6.1, are projected beyond the site boundary and the IDPP determines that pre-determined, prompt protective measures are necessary. For this scenario, the PEP EPZ is set at the derived distance beyond the site boundary, and the licensee is responsible for describing, in the emergency plan, the requirements under 10 CFR 50.160(b)(1)(iv)(B) and 10 CFR 50.160(b)(3).

The NRC staff finds these outcomes to be acceptable because they align with the requirements in 10 CFR 50.33(g)(2)(i) and 10 CFR 50.160(b)(3) and are possible outcomes of following the guidance in RG 1.242. However, as stated in the Statements of Consideration (specifically the 2023, final rule Statements of Consideration for 10 CFR 50.160 at 88 FR 80050):

The capability for taking protective measures is not dependent upon an established EPZ. The EPZ is a planning tool to ensure predetermined, prompt protective measures can and will be taken if accident conditions warrant. If both § 50.33(g)(2)(i) criteria are met, then an EPZ is required. However, if there is no need for predetermined, prompt protective measures, then the final rule [10 CFR 50.160] still requires licensees to develop and maintain capabilities to assess, classify, notify, and recommend protective measures as conditions warrant.

Therefore, the NRC staff finds that a determination of No PEP EPZ does not mean that protective measures for the public are never warranted.

As described in TR section 6.6, the EPZ sizing result derived using this TR methodology reflects the current state of the PRA and LBE definitions. The final EPZ size determination shall be based on the completed, approved LMP outputs. Since PRA updates and upgrades have the potential to impact the PEP EPZ size, they must be evaluated. The final PEP EPZ size is part of the emergency preparedness plan and therefore, any changes to the emergency preparedness plan resulting from the PRA update or upgrade, should be conducted under 10 CFR 50.54(q). Limitation and condition number 6 in this SE ensures that a periodic evaluation is performed to evaluate the impact on the final PEP EPZ size following an update or upgrade to the PRA.

### LIMITATIONS AND CONDITIONS

The NRC staff imposes the following limitations and conditions regarding the use and approval of the subject TR:

1. The PRAs used to implement the TR methodology are design- and site-specific and developed for all applicable hazards, all plant operating states, and all sources of radioactive material, using the guidance in RG 1.247, “Acceptability of Probabilistic Risk Assessment Results for Non-Light-Water Reactor Risk-Informed Activities” and Appendix A to RG 1.253, “Guidance for a Technology-Inclusive Content-of-Application Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light-Water Reactors” (ML23269A222). Prior to the initial fuel loading, any exceptions to meeting capability categories referred to in RG 1.247, are justified and documented.
2. An applicant that references this TR must justify the technical acceptability of the PRA(s) performed for the selected hazards and plant operating states (e.g., site-specific scoping level seismic PRA). Prior to the initial fuel loading, PRAs supporting this methodology must include all applicable hazards and plant operating states.
3. An applicant that references this TR must provide discussions of: (1) how PRA key assumptions and key sources of uncertainty for each analyzed hazard, plant operating state, and radioactive source were identified; (2) how the key assumptions and key sources of uncertainty identified as having the potential to significantly impact the PRA results have been characterized in a manner which is consistent with the current state of knowledge; and (3) how the impact of each identified key assumption and source of uncertainty was assessed and dispositioned.
4. An applicant that references this TR and exercises the methodology in TR section 3.6, “Selection of Seismic LBEs,” and section 6.3, “Assessment for Seismic Hazards,” to choose the seismic scenario for the EPZ sizing analysis must provide site-specific justification for the use of the [REDACTED].
5. A condition of the use of atmospheric dispersion assumptions in this TR methodology is that an applicant for a specific site referencing this TR must perform for the final PEP EPZ, size a dispersion analysis with site-specific data to either: (1) affirm that the results using these atmospheric dispersion assumptions are conservatively bounding, or (2) provide site-specific analysis results using dispersion factors developed during the site characterization.
6. A periodic evaluation of the plume exposure pathway EPZ sizing analysis must be performed following an update or upgrade to the user’s PRAs based on a review of changes to the plant SSC’s, operational practices, and applicable plant and industry operational experience. Any changes to the emergency preparedness plan as a result of the evaluation

should be conducted under 10 CFR 50.54(q).

7. This TR is limited to applicants that have design bases that are developed in accordance with the guidance in NEI 18-04, as endorsed by RG 1.233.

### **CONCLUSION**

The NRC staff has completed its review of document identification number 010229, “Xe-100 Licensing Topical Report Plume Exposure Pathway Emergency Planning Zone Sizing Methodology.” Based on its evaluation, the NRC staff determined that Revision 2 of this TR, subject to the limitations and conditions discussed above, provides an approach acceptable to the NRC staff to develop the necessary analyses to aid in the determination of a design- and site-specific PEP EPZ for the Xe-100 reactor design. Accordingly, the NRC staff concludes that, subject to the limitations and conditions laid out in sections 1.1, 1.3, 1.6, 2.0, 3.1, and 4.4 of this SE, the subject X-energy TR can be used to determine the PEP EPZ size to support emergency planning and preparedness in compliance with the regulatory requirements in 10 CFR 50.33(g)(2), and 10 CFR 50.160(b)(3), as applicable, for prospective X-energy Xe-100 reactor construction permit or operating license applications under 10 CFR Part 50.

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