

OFFICE OF NUCLEAR REACTOR REGULATION

REGULATORY AUDIT SUMMARY REPORT

TERRAPOWER, LLC TOPICAL REPORT

“PLUME EXPOSURE PATHWAY EMERGENCY PLANNING ZONE SIZING METHODOLOGY”

PROJECT NO. 99902100

1.0 BACKGROUND

By letter dated March 20, 2023, TerraPower, LLC (TerraPower) submitted topical report (TR) NAT-3056, “Plume Exposure Pathway Emergency Planning Zone Sizing Methodology,” Revision 0 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML23080A045) to the U.S. Nuclear Regulatory Commission (NRC) staff. The TR describes TerraPower’s proposed methodology for determining the plume exposure pathway (PEP) emergency planning zone (EPZ) for the Sodium sodium-cooled fast reactor design. The NRC staff finalized its completeness determination of the TR on June 12, 2023, and found that the TR contained sufficient information such that the NRC staff could begin its detailed technical review of the TR (ML23158A198).

TerraPower requested the NRC staff’s review and approval of the PEP EPZ methodology, as presented in the subject TR. The PEP EPZ methodology would be used by vendors applying to use TerraPower’s Sodium reactor design as part of future licensing submittals. TerraPower’s overall licensing approach for the Sodium 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). Regulatory Guide (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.

2.0 AUDIT REGULATORY BASIS

The basis for the audit included the following:

- Requirements for nuclear power reactor emergency planning, including the requirement for a PEP EPZ, in Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.47, “Emergency plans,” and 10 CFR 50, Appendix E, “Emergency Planning and Preparedness for Production and Utilization Facilities.”
- Requirements in 10 CFR 50.33(g) for nuclear power reactor EPZ sizing to be described in the emergency plan and the following requirements from 10 CFR 50.47(c)(2):

Generally, the plume exposure pathway EPZ for nuclear power plants shall consist of an area about 10 miles (16 km) in radius and the ingestion pathway EPZ shall consist of an area about 50 miles (80 km) in radius. The exact size and configuration of the EPZs surrounding a particular nuclear power reactor shall be determined in relation to local emergency

response needs and capabilities as they are affected by such conditions as demography, topography, land characteristics, access routes, and jurisdictional boundaries. The size of the EPZs also may be determined on a case-by-case basis for gas-cooled nuclear reactors and for reactors with an authorized power level less than 250 [megawatts] thermal. The plans for the ingestion pathway shall focus on such actions as are appropriate to protect the food ingestion pathway.

The NRC staff also considered relevant information from the 10 CFR 50.160, "Emergency preparedness for small modular reactors, non-light-water reactors, and non-power production or utilization facilities," rulemaking effort (RIN 3150-AJ68), which was underway during the audit. Published in the *Federal Register* on November 16, 2023, (88 FR 80076), the final rule amends the NRC's regulations to add alternative EP requirements for small modular reactors (SMRs) and other new technologies (ONTs), such as non-light-water reactors and non-power production or utilization facilities. The rule adopts a scalable PEP EPZ approach that is performance-based, consequence-oriented, and technology-inclusive. The requirement for the PEP EPZ size is based on a determination of the area in which the dose may exceed the Environmental Protection Agency early-phase Protective Action Guide levels for a spectrum of events with radioactive material released to the environment. This is the area where predetermined prompt protective measures are necessary.¹

3.0 AUDIT PURPOSE AND OBJECTIVES

The purpose of the audit was for the NRC staff to gain a detailed understanding of TerraPower's PEP EPZ sizing methodology for the Sodium reactor design and how the resulting PEP EPZ will demonstrate compliance with NRC regulations for emergency planning and preparedness, as discussed below. The audit was also performed to identify any information that required docketing to support the NRC staff's safety evaluation for the TR. The audit plan, including the initial set of audit questions, was issued on August 16, 2023 (ML23199A318).

4.0 SCOPE OF THE AUDIT AND AUDIT ACTIVITIES

The audit was conducted from August 17, 2023, to October 19, 2023, in a virtual format using the TerraPower electronic reading room (ERR). The audit followed the guidance in the Office of Nuclear Reactor Regulation Office Instruction LIC-111, "Regulatory Audits" (ML19226A274).

Members of the audit team included the NRC staff listed below.

Michelle Hart	Senior Reactor Engineer, Audit Lead
Mallecia Sutton	Senior Project Manager, Lead Sodium Project Manager
Roel Brusselmans	Project Manager, Lead Audit Project Manager
Hanh Phan	Senior Reliability and Risk Analyst
Prosanta Chowdhury	Senior Emergency Preparedness Specialist
Edward Robinson	Senior Emergency Preparedness Specialist

Major contributors from TerraPower and their supporting vendors to this audit were Patrick Donnelly, John Biersdorf, Steven Gebers, and Shane Gardner (General Electric Hitachi Nuclear Energy).

¹ Subsequent to this audit, 10 CFR 50.160 was made effective on December 18, 2023.

On October 19, 2023, the NRC staff held an audit exit meeting with TerraPower and summarized the audit purpose, activities, and high-level results. The NRC staff did not acquire any documents during the audit. The NRC staff reviewed the following document during the audit:

- Draft NEI White Paper, “Selection of a Seismic Scenario for an EPZ Boundary Determination,” Revision 0 (ML23257A093)

5.0 SUMMARY OF OBSERVATIONS

The NRC staff’s audit focused on the review of supporting documents associated with the topics identified in the audit plan and the questions that were attached to the audit plan. The NRC staff reviewed information using the TerraPower ERR and held discussions with TerraPower staff to understand and resolve questions. In some cases, TerraPower proposed to revise the subject TR to resolve items discussed in the audit. The following summarizes the discussions between the NRC staff and TerraPower relative to the NRC staff’s audit questions.

Regarding regulations addressed by the TR, TerraPower clarified that its TR methodology is intended to be comprehensive such that it yields a site-specific PEP EPZ consistent with the criteria in the 10 CFR 50.160. TerraPower clarified its method to assess the second EPZ criterion that the PEP EPZ is the area where predetermined, prompt protective measures are necessary. Specifically, TerraPower indicated that it would first assume that events which screen into the evaluation would require prompt protective measures, then it would assess the release timing and other aspects to determine if prompt protective measures are necessary. TerraPower proposed to revise the subject TR to more clearly describe the method to assess whether predetermined, prompt protective measures are necessary. This revision was submitted to the NRC staff on November 17, 2023 (ML23321A036).

TerraPower also clarified its accident screening approach for the PEP EPZ size analysis. TerraPower proposed revisions to the subject TR to clarify that the non-seismic events screening uses information on radiological release scenarios from the probabilistic risk assessment (PRA) and does not directly use the licensing basis events categorization based on NEI 18-04, Revision 1. In addition, TerraPower proposed revising the TR to avoid the use licensing basis event terms such as design basis event (DBE) and beyond design basis event (BDBE) and clarify the discussion of safety margin evaluation and its relationship to emergency planning. During audit discussions, TerraPower also clarified how security events are considered and how events are screened based on release timing.

TerraPower discussed the selection of seismic release sequences and the relationship of its TR to an NEI draft white paper on seismic event screening for EPZ size determination that was provided to the NRC staff on August 31, 2023 (ML23257A093). During this discussion, TerraPower clarified that the TR methodology is intended to be consistent with the concepts in the draft white paper. TerraPower proposed to revise its TR to more clearly describe the screening of seismic release sequences.

TerraPower clarified that the radiological consequence and atmospheric dispersion methodology is out of scope and is part of a separate TR. The NRC staff gained a better understanding of the how the methodology is used to evaluate dose at distance. TerraPower proposed to revise the subject TR to clarify the discussion on exposure pathways, modeling of evacuation and other protective measures, the method to determine if any event requires

prompt protective measures, uncertainty and sensitivity analysis, and state that the reactor safety goals are not used to determine the PEP EPZ.

TerraPower clarified its TR discussion of design iteration in relation to the site-specific PEP EPZ size determination. TerraPower stated that it plans to submit a construction permit application (CPA) with the preliminary design described in the preliminary safety analysis report (PSAR). TerraPower stated that the CPA PSAR will describe the PEP EPZ commensurate with the potential releases for the preliminary design. TerraPower stated that its subsequent submittal of an operating license application and final safety analysis report will describe the reassessed PEP EPZ using final design information. TerraPower also stated that there were no example calculations available to inform the audit, nor was a seismic PRA available. The NRC staff expects these items to be available for audit as part of a future operating license application review.

There were no deviations from the audit plan.

6.0 REQUESTS FOR ADDITIONAL INFORMATION RESULTING FROM AUDIT

As a result of the audit, the NRC staff did not identify any requests for additional information related to this TR. However, as noted in the summary above, TerraPower submitted a revision to its TR on November 16, 2023 (ML23321A036), as a result of discussions with the NRC staff throughout the audit.

7.0 OPEN ITEMS AND PROPOSED CLOSURE PATHS

There are no open items resulting from this audit.