UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

March 17, 2023

Mr. George Wilson
Vice President, Regulatory Affairs
TerraPower, LLC
15800 Northup Way
Bellevue, WA 98008

SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION STAFF FEEDBACK REGARDING TERRAPOWER, LLC WHITE PAPER NATD-EQT-RPT-0001 "NATRIUM REACTOR TESTING PROGRAMS" (EPID NO. L-2021-LRO-0037)

Dear Mr. Wilson:

By letter dated September 30, 2022 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML22273A073), TerraPower, LLC (TerraPower) submitted for the U.S. Nuclear Regulatory Commission (NRC) staff's review a white paper entitled "Natrium Reactor Testing Programs." This paper provides an overview and description of the testing programs associated with TerraPower's Natrium™ reactor design.

The NRC staff was asked to perform a review of this white paper and provide written feedback on the white paper. The NRC staff's feedback is provided in the enclosure to this letter. If you have any questions regarding this matter, please contact Mallecia Sutton at 301-415-0673 or via email at Mallecia.Sutton@nrc.gov.

Sincerely,

Signed by Jessup, William
on 03/17/23

William Jessup, Chief
Advanced Reactor Licensing Branch 1
Division of Advanced Reactors and Non-Power
Production and Utilization Facilities
Office of Nuclear Reactor Regulation

Project No.: 99902100

Enclosure: As stated

Cc via ListServ: Distribution via TerraPower Natrium

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U.S. NUCLEAR REGULATORY COMMISSION STAFF FEEDBACK REGARDING TERRAPOWER, LLC WHITE PAPER NATD-EQT-RPT-0001 "NATRIUM REACTOR TESTING PROGRAMS" (EPID NO. L-2021-LRO-0037)

SPONSOR INFORMATION

Sponsor: TerraPower, LLC

Sponsor Address: 15800 Northup Way
Bellevue, WA 98008

Docket /Project No(s).: 99902100

DOCUMENT INFORMATION

Submittal Date: September 30, 2022

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Purpose of the White Paper: By letter dated September 30, 2022 (ML22273A073), TerraPower, LLC (TerraPower) submitted a white paper entitled "Natrium Reactor Testing Programs" (the white paper). This white paper provides an overview and description of the testing programs associated with TerraPower's Natrium™ reactor design.

Action Request: TerraPower requested that the NRC staff review the white paper and provide feedback regarding topics for which additional discussion or consideration may be beneficial.

FEEDBACK AND OBSERVATIONS

The white paper provides a useful overview of the testing programs associated with TerraPower's Natrium reactor design. The NRC staff has reviewed the white paper and provided feedback below in the following general observation and specific observation sections. These observations do not constitute final agency positions. NRC staff observations in this response are not intended to be comprehensive feedback. Lack of comment or observations regarding a certain aspect of the white paper should not be interpreted as NRC staff agreement with TerraPower's position.

General Observation

1. TerraPower should use the terms "verify" and "validate" carefully, as these are terms of art for computer codes/methodologies and for systems engineering that carry implications beyond the normal definitions. Particularly, usage of the phrase "verify and

validate" may cause confusion when not clearly in the context of codes/methodologies or systems engineering, as appears to be the case for instances in the Executive Summary and Section 1, “Introduction.” Other instances of these terms across the white paper generally appear to be acceptable.

2. Changes in plant design or structure, system, and component (SSC) classification may occur based on testing results or simply as the plant design matures. For example, SSCs may be identified as safety related (SR) or non-safety related with special treatment (NSRST) as a result of testing and thus would need to be brought within the scope of the testing program. It is not clear to the NRC staff how the testing program would handle such changes. TerraPower should clarify when and how new SSCs may be included within the testing program, how the testing program adapts to changing testing requirements as a result of increasing technical maturity and/or design changes, and how other factors could affect the scope of the program.

3. TerraPower should consider providing additional detail on how decisions about scaling are made (e.g., If scaled tests are performed, how is it determined what parameter is used to ensure similitude? What effects cannot be scaled without changing the effect?). When the NRC staff is reviewing test data used to support a safety claim, scaling is a key factor in the NRC staff’s determination about the adequacy and/or applicability of the data. For each test, therefore, a summary of how the tested conditions relate to the expected in-service conditions would be helpful to the NRC staff’s review.

4. It is unclear how the equipment qualification (EQ) program interfaces with the other testing programs. It appears some EQ testing feeds back into the technology maturation plan (TMP), but not all. Figure 3-1, “Technology Maturation Plan Development,” indicates that the EQ program is generally separate from other technology maturation testing, but is still incorporated into the TMP. However, for SSCs that do not need to undergo technology maturation, it appears that EQ would be its own process. Other portions of the white paper indicate that EQ contributes testing source documents that are separate from other aspects of the testing program. TerraPower should clarify the relationship between the EQ program and other testing.

5. The only reference to testing calibration and traceability in the white paper is in Section 4.2, “Equipment Qualification Testing Specification,” which states that "Testing is performed using test equipment calibrated and traceable in accordance with TerraPower QA Program [3]" but in the context of the EQ program. TerraPower should clarify whether this applies to all testing conducted under the testing program described in the white paper.

6. The NRC staff notes that, while many of the codes and methods in the area of sodium fast reactor (SFR) design and analysis have a long history of successful usage, very few of them have been reviewed or approved by the NRC in a licensing context.

7. Reliability testing is mentioned in various places in the white paper, as are associated reliability requirements for SSCs. It is not clear to the NRC staff from the white paper how TerraPower determines reliability requirements.

8. Further pre-application engagement on human factors engineering (HFE) subjects, and in particular how HFE is integrated into the testing and evaluation program, would be beneficial.

Specific Observations:

1. Executive Summary

    a. It is unclear to the NRC staff whether the term “methods qualification” as used in the Executive Summary and Section 1 of the white paper is intended to be the same as the methodology verification and validation discussed in Section 5, “Methodologies Verification and Validation Test Plan,” of the white paper.

    b. The “major program areas” discussed in the Executive Summary appear to represent a reasonably complete set of possible testing needs, though this depends on the precise details of what is included in each area.

2. Section 1.2, “Scope”

    a. The white paper states that the Natrium testing program includes SSCs that are classified as SR or NSRST. The white paper should discuss the planned definitions of SR and non-SR SSCs for the Natrium reactor.

3. Section 1.3, “Objectives”

    a. The objective of the Natrium testing program is to verify and validate the performance characteristics, safety claims, and methods qualifications regarding the Natrium reactor design and to ensure that the requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) 50.43(e)(1) are met. The requirements in 10 CFR 50.43(e)(1) are intended to demonstrate the performance of safety features of designs that differ significantly from light-water reactor designs that were licensed before 1997, or use simplified, inherent, passive, or other innovative means to accomplish their safety functions. Beyond the 10 CFR 50.43(e) requirements for safety features of new reactor designs, the white paper should describe how the Natrium testing program will encompass the qualification of individual components and operational readiness of those components to perform their specified functions during plant operations.

    b. Section 1.3 references the requirements in 10 CFR 50.43(e)(1). The following language from 10 CFR 50.43(e)(2) provides another option for meeting the 10 CFR 50.43(e):

        > There has been acceptable testing of a prototype plant over a sufficient range of normal operating conditions, transient conditions, and specified accident sequences, including equilibrium core conditions. If a prototype plant is used to comply with the testing requirements, then the NRC may impose additional requirements on siting, safety features, or operational conditions for the prototype plant to protect the public and the plant staff from the possible consequences of accidents during the testing period.

        The white paper may benefit from a discussion of the applicability of the option allowed in 10 CFR 50.43(e)(2) for the Natrium reactor to satisfy the requirement in 10 CFR 50.43(e).

4. Section 2, “Testing Process”

    a. The term "open items" is used throughout Section 2 of the white paper. It is unclear to the NRC staff whether "open items" are test objectives not met from the test requirements document (TRD), if they are new objectives discovered from the test (e.g., higher sensitivity to synergistic effects than anticipated), both, or something else. TerraPower should clarify what "open items" are and how they are determined.

    b. Section 2.4, “Test Requirements Document,” states that one intended data use is "data set generation for code validation." It is unclear whether TerraPower intends to generate new empirical models for use in Natrium analyses. If so, the NRC staff notes that a best practice in this area is to set aside some data for later validation that will not be used to train the model.

    c. Section 2.4 states that "brief narratives of the data requirements and codes and methods requirements are provided". The requirements referred to are unclear to the NRC staff.

    d. Section 2.4 states that “a notional test matrix is provided” in the test requirements document (TRD) and that the number of tests required for each combination of variables is included in this test matrix. It is not clear to the NRC staff what is included in a test matrix; specific examples would help to clarify. It is also unclear how TerraPower determines the number of tests needed to meet a test requirement.

    e. Section 2.4 states that “the expected outcome of the test is provided” in the TRD. It is not clear to the NRC staff what is meant by “the expected outcome of the test” in this context, and whether it is a test objective (e.g., “the outcome of this test is that we will determine the orifice plate coefficient”) or a prediction/hypothesis (e.g., “we expect the orifice plate coefficient will be *x*”).

    f. Section 2.8, “Joint Test Group,” provides some details on the Joint Test Group (JTG). TerraPower should provide additional discussion on the composition of the JTG, how members are selected, and how members are determined to be subject matter experts for a given topic.

    g. It is unclear how Figure 2-1, “Integration of the Testing Program into the Design Process,” relates to the narrative of Section 2 of the white paper. For example, the narrative implies that the test matrix is defined as part of the test program, but the flow chart implies that the test matrix feeds into the test program. Also, it is not clear why some boxes on the diagram are light grey.

5. Section 3, “Technology Maturation Plan Process”

    a. Section 3.1, “Overview,” states that Technology Maturation Plans (TMPs) will only be used for technologies that are "new, novel, used in a modified way... [or for] existing technologies with outdated, minimal, or not properly documented supporting data." This appears to be reasonable, but it is not inherently obvious as to how the determination is made that these criteria apply to any given SSC.

TerraPower should clarify whether and how it will document the rationale for including or excluding technologies from the TMP program.

b. Section 3.1 mentions that technologies are validated, in part, through “analytical testing.” It is unclear what is meant by “analytical testing” and how TerraPower determines whether/when this method is appropriate to use in technology maturation.

c. Section 3.2, “Critical Technology Element Identification,” indicates that engineering judgment is used during the technology readiness assessment (TRA) to determine the technology readiness level (TRL) for critical technology elements. The NRC staff notes that, if engineering judgment is used in determining technology readiness levels, the basis for the judgment should be well-documented and justified.

d. Section 3.3, “Technology Readiness Assessment,” states that the TRA evaluates “program concepts.” It is unclear to the NRC staff what is meant by this in the context of a TRA.

6. Section 4, “Equipment Qualification Program”

a. Section 4.1, “Overview,” of the white paper states that "Environmental qualification considerations, which is included under the EQ Program, applies to all important to safety equipment." It is not clear to the NRC staff what is meant by "environmental qualification considerations" in this context. Specific examples would help to clarify.

b. Section 4.1 states that the EQ Program will follow NRC Regulatory Guide (RG) 1.100, “Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants,” Revision 4 (ML19312C677). The American Society of Mechanical Engineers (ASME) is preparing a reformatted version of the current edition of the ASME standard Qualification of Mechanical Equipment (QME)-1, “Qualification of Active Mechanical Equipment Used in Nuclear Facilities,” accepted in RG 1.100 to provide updated guidance for the qualification of components for their specified functions in new and advanced reactors. The white paper should describe any plans regarding the application of the reformatted QME-1, when issued.

7. Section 5, “Methodologies Verification and Validation Test Plan”

a. The NRC staff would like to better understand how the methodologies verification and validation test plan described in Section 5 of the white paper relates to or is informed by the evaluation model development and assessment process (EMDAP) provided in Regulatory Guide 1.203, "Transient and Accident Analysis Methods," Revision 0 (ML053500170). While the NRC staff recognizes that the plan provided in the white paper does not cover the whole scope of the EMDAP, there is substantial overlap with the assessment portions of that process.

b. It is unclear what is meant by "special models" and what is included in "design information" in the first paragraph of Section 5.

c. Section 5 states that, "Close collaboration with national laboratories ensures that key codes are appropriately modified to address the reactor design and V&V is conducted early in the design process." While modifications to the codes are likely outside the scope of this white paper, the NRC staff is interested in learning more about what modifications (if any) have been found necessary to apply national laboratory codes to the Natrium reactor. Such details will likely be important to the NRC staff's review of codes and methods for transient and accident analyses performed for Natrium.

d. The fifth paragraph of Section 5 mentions "methodology specific activities." It is unclear whether these activities are a part of the methodologies verification and validation (V&V) test plan, as indicated in Figure 5-1, “V&V Framework for the Methods Development and Testing Program Interface.” If this is the case, it is not clear why methodology specific activities are not considered to be part of the methodologies V&V test plan. The NRC staff is also not clear on what is meant by "scaling methodology and analysis."

e. The white paper does not provide the NRC staff with sufficient detail to understand how the assessment matrices discussed in the sixth paragraph of Section 5 are developed.

f. TerraPower should provide more detail on how the predictive capability and maturity model (PCMM) is worked into the methodology verification and validation test plan. According to Figure 5-1, “V&V Framework for the Methods Development and Testing Program Interface,” this appears to be a component of the overall test plan, but the NRC staff's understanding of PCMM is that it is a holistic method for assessing simulation credibility that would likely encompass many, if not most, other aspects of the plan.

g. The Methodologies Verification and Validation Test Plan describes the plans for the V&V process to ensure that methodologies and associated codes are adequate for the analysis and evaluation being performed. The white paper should describe the planned activities for verification (meet specifications) and planned activities for validation (meet needs) with respect to methodologies and codes to be used for the Natrium reactor.

8. Section 7, “Post-Construction Inspection, Testing and Analysis Program”

a. This section specifies that this program includes construction testing requirements, construction turnover process, and the initial test programs. The ASME is preparing a new Code for operation and maintenance of components in new and advanced reactors (referred to as the Operations and Maintenance (OM)-2 Code) that will include provisions for in service testing (IST) activities to assess the operational readiness of applicable components to perform their specified functions. The white paper should describe the plans to establish IST activities to assess the operational readiness of components in the Natrium reactor and any plans regarding the application of the new ASME OM-2 Code, when issued.

9. Section 8, “Alignment to Regulatory Roadmap – Testing”

    a. Section 8.1, “Identify and Define Test Objectives,” uses the term "subordinate objectives," which is not defined or found elsewhere in the white paper. TerraPower should clarify what is meant by "subordinate objectives."

    b. Section 8.6, “System Interaction Testing,” states that integrated system tests are undertaken "as determined to be appropriate." This is also implied in Section 4.2. TerraPower should clarify the process used to determine whether integrated system tests are needed.

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