TerraPower

June 8, 2021

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Project Number 99902087

U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
ATTN: Document Control Desk

Subject: Regulatory Engagement Plan for the Natrium™ Reactor

This letter transmits the TerraPower, LLC (TerraPower) Regulatory Engagement Plan. The plan is provided for information and outlines proposed interactions with the U.S. Nuclear Regulatory Commission (NRC) associated with the Natrium™ Reactor. The Natrium design is a TerraPower and GE-Hitachi technology. The Regulatory Engagement Plan for the Natrium Reactor, Enclosure 1, includes anticipated future dates for interactions or submittals, changes will be communicated to the NRC in advance.

If you have any questions regarding this submittal, please contact Ryan Sprengel at rsprengel@terrapower.com or (425) 324-2888.

Sincerely,

Ryan Sprengel
License Application Development Manager
TerraPower, LLC

Enclosure: 1. Natrium Reactor Regulatory Engagement Plan

cc: William Kennedy, NRC
Mallecia Sutton, NRC

ENCLOSURE 1

Regulatory Engagement Plan for the Natrium Reactor

PLAN

Document Number:	NATD-LIC-PLAN-0001	**Revision:**	0
Document Title:	Regulatory Engagement Plan for the Natrium Reactor		
Functional Area:	Licensing	**Engineering Discipline:**	N/A
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Approval

Title	Name	Signature	Date
Originator, License Application Development Manager	Ryan Sprengel	Electronically Signed in Agile	6/7/2021
Reviewer, Director Regulatory Affairs	George Wilson	Electronically Signed in Agile	6/7/2021
Approver, Project Director Natrium Demonstration Reactor	Tara Neider	Electronically Signed in Agile	6/7/2021

Export Controlled Content: **Yes** ☐ **No** ☒

QA Related: **Yes** ☐ **No** ☒

QA Criterion: N/A

REVISION HISTORY

Revision No.	Effective Date	Affected Section(s)	Description of Change(s)
0	6/7/2021	All	Initial Release.

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1 PURPOSE

This Regulatory Engagement Plan (REP) provides an overview of TerraPower, LLC (TerraPower) and supporting companies, a description of the Natrium™ reactor, an overview of the licensing strategy, and identifies potential regulatory engagements related to the Natrium reactor. Feedback from preliminary discussions with the Nuclear Regulatory Commission (NRC) staff has been reflected in this plan. The Natrium design is a TerraPower & GE-Hitachi technology.

The primary purpose of the REP is to reduce regulatory uncertainty by establishing a plan to provide presentations and submittals to facilitate the NRC's understanding of Natrium technology and its safety case as early in the regulatory process as possible. The REP focuses on near-term activities needed to support critical design decisions and the development of pre-application submittals. It identifies and describes proposed interactions with the NRC staff to reach a mutual understanding on the desired outcomes of defined interactions and schedules.

The REP is intended to provide information on future interactions and submittals to assist in NRC staff planning. Engagement with the NRC staff will inform expected outcomes from early interactions. If a particular outcome (e.g., conditional staff finding) is needed, the REP and associated NRC staff planning may be adjusted with that outcome in mind. The NRC staff will be worked with to establish a mutually agreeable review plan that includes a defined scope and level of review, desired outcomes in terms of regulatory observations, and particular areas of focus, review costs, and review schedules. Dates provided in this REP are anticipated months for interactions to be held or submittals to be provided to the NRC, changes will be communicated to the NRC in advance.

1.1 Contact Information

The following contact information will facilitate communication between TerraPower and the NRC staff.

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1.2 Company Information

TerraPower was founded a decade ago by Bill Gates and a group of like-minded visionaries that decided the private sector needed to act in developing advanced nuclear energy to meet growing electricity needs, mitigate climate change, and lift billions out of poverty. It was believed that business interests, with strong government support, could develop a scalable, sustainable, environmentally friendly, and cost-competitive energy source that would allow all nations to quicken their pace of economic development, reduce poverty, and improve the environment. An expert group of scientists and engineers was formed to analyze all energy generation technology options from a total systems perspective. After a thorough examination of all known and some heretofore unknown reactor concepts, including lead-cooled reactors and small modular helium-cooled reactors, TerraPower decided to focus development on improving the sodium-cooled reactor design that met all of the stated objectives of TerraPower's founding principles. TerraPower then embarked on the decade-long half-billion-dollar development program which is still underway.

In 2019, TerraPower and GE-Hitachi Nuclear Energy Americas, LLC (GEH) joined forces to develop the Natrium technology, which features a sodium-cooled fast reactor (SFR) combined with a molten salt energy storage system. TerraPower and GEH are backed by Bechtel Power Corporation (Bechtel) and utility partners Energy Northwest, Duke Energy, and PacifiCorp. This unique combination will provide clean, flexible energy and stability, and integrate seamlessly into power grids with high penetrations of renewables.

The Natrium team combines the strengths and harnesses the synergies of two world-renowned advanced SFR and nuclear power technology developers and places them at the core of the Natrium design, procurement, construction, startup, and operations effort. TerraPower brings innovation and 12 years of SFR development experience, while GEH brings over 60 years of nuclear plant design, services, equipment supply, and fuel fabrication capabilities and the resulting licensing, testing, design, manufacturing, and operating experience and expertise.

2 NATRIUM REACTOR BACKGROUND

The Natrium reactor is a metal fueled, pool type SFR that takes advantage of the simple and robust safety profile of SFRs to dramatically reduce the complexities associated with nuclear design and construction. Safety functions are made integral to the reactor vessel, and support equipment is moved to separate structures with reduced requirements, resulting in a vastly simplified reactor building. The superior heat transfer characteristics of sodium and operating at low pressure permit the use of compact and lightweight equipment, unlike in other reactor types cooled with pressurized water or gas.

The Natrium reactor is coupled to an Integrated Energy System (IES), a molten salt loop that transports heat from the nuclear island to the energy island. This minimizes the amount of high-cost equipment and structures on the nuclear site and enables load following, coupling to thermal energy storage, and industrial heat applications. For heat transport, energy storage, and electricity generation the Natrium reactor will take advantage of the more recently

developed molten salt technology which reduces cost, enables thermal energy storage, and eliminates the difficulties of managing the sodium-to-steam heat transfer interface.

The higher operating temperature and constant thermal output make an ideal match for thermal energy storage using molten salt, a technology that is commercially deployed in the solar industry. Hot sodium from the reactor transfers its heat to a molten salt loop, which carries heat off the nuclear site where it can be stored, converted into electricity, or used for industrial process heating. This “decoupled” architecture minimizes the size of the nuclear site and allows the reactor to operate at constant conditions, while the energy island meets variable energy demands. The ratings for the Natrium reactor will be 840MW thermal. The energy island will have the capability to produce up to 500MW electric.

3 LICENSING STRATEGY

The information in this section provides context for regulatory engagements, particularly with respect to establishment of the expected regulatory path. Establishing certainty around the regulatory strategy, in terms of identifying key topics that need to be resolved early and gaining an understanding of how the planned submittals will provide required content and design information, can be the key to a predictable review schedule.

3.1 License Application Process for the Natrium Reactor

10 CFR Parts 50 and 52 licensing processes to design, site, license, and construct an advanced reactor were evaluated, with consideration for commencing start-up operations within 7 years. After weighing the risks associated with each process, it was determined that use of the 10 CFR 50 process was the optimum regulatory approach for the Natrium reactor. An advantage of using this process is the ability to start construction earlier. The Preliminary Safety Analysis report (PSAR) submitted with a Construction Permit Application (CPA) requires a different level of detail and will be able to be submitted earlier than a Final Safety Analyses Report (FSAR) submitted with a 10 CFR 52 application. After approval of the CPA and issuance of the Construction Permit (CP), construction can start. Final design details will be developed and included in the FSAR submitted with the Operating License Application (OLA).

3.2 Preliminary Safety Analysis Report Outline

The PSAR will be organized consistent with the current draft PSAR/FSAR outline and guidance originally provided by an NRC letter dated April 15, 2020 titled, “Updated Draft Outline for Licensing Modernization Project Advanced Reactor License Applications” (ADAMS Accession Number ML20107J565). This outline was released by the NRC to support the ongoing NRC and industry work to establish a technology-inclusive regulatory framework for advanced reactors. The expectation is that the level of detail provided in the application is commensurate with the safety significance of the topic. As

NRC and industry discussions are ongoing, the PSAR/FSAR organization may change over time to reflect the results of those discussions.

3.3 Deployment Overview

The Natrium reactor deployment schedule includes activities related to plant design, methods development, licensing, equipment qualification and testing, procurement, construction, startup, commissioning, operating program development, fuel development and supply, and program management. The plan for deploying first involves completing detailed design and obtaining an NRC CP. Extensive design and development work on the Natrium reactor has been performed with an understanding of the safety characteristics of SFRs and the high technology readiness of the Natrium reactor. In parallel, fuel and equipment will be done while working with the industry to establish High Assay Low Enriched Uranium (HALEU), metal fuel, and equipment supplies needed for the Natrium reactor.

Construction and start-up operations will benefit from innovative and simplified architecture and by leveraging the lessons learned from recent nuclear projects. These lessons learned include investing in detailed design prior to construction; the use of integrated 3D, 4D, and 5D Virtual Design and Construction (VDC) tools and constructability reviews throughout the design process; and the early involvement of our partner Bechtel with their deep experience in nuclear construction. During construction, fuel will be fabricated and operating staff trained while obtaining an NRC Operating License.

3.4 Licensing Modernization Project (LMP) and Technology Inclusive Content of Application (TICAP)

The methodology to be used for the licensing process for the Natrium reactor follows Regulatory Guide 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, which endorses, while providing clarification and points of emphasis, the methodology described in Nuclear Energy Institute *(*NEI)18-04 “Risk-Informed Performance-Based Technology Inclusive Guidance for Non-Light Water Reactor Licensing Basis Development,” Revision 1.

Risk insights will be used to develop a technically sound understanding of the potential failure modes, how the plant would respond to such failure modes, and how protective strategies can be incorporated into formulating the safety design approach. This allows the identification of design features that are responsible for preventing and mitigating radiological releases based on the integrated risk criteria. This also informs the performance requirements and design criteria that are developed within the process for Systems, Structures, and Components (SSC) classification. This process will determine the safety classification of each SSC and will be used to determine the level of quality assurance that is required and the Codes and Standards to which the SSC will be designed, fabricated, erected, maintained, and tested. This is also used in identifying the needed layers of defense for those plant capabilities and programmatic elements that

provide, collectively, independent means for the prevention and mitigation of adverse events that release radiation or hazardous materials, which describes and demonstrates the affirmative safety case for licensing.

The Defense-in-depth (DID) approach incorporates five defense lines (DL) that provide layered protection against unacceptable releases of radiation. The first and fifth DLs include programmatic elements and design properties, while the second (response to anticipated operational occurrences (AOOs)), third (response to design-basis events (DBEs)), and fourth (response to beyond-design-basis events (BDBEs)) DLs include design functions. Identification of design functions belonging to each DL and their adequacy against postulated initiating events (PIEs) is performed on an event-by-event basis, using model-based transient and safety analyses. Early establishment of the DID concept ensures that DID adequacy will be achieved as described in NEI 18-04 and provides some assurance prior to the performance of a full scope probabilistic risk assessment (PRA) and assessment of the Frequency-Consequence target. As the design and PRA mature, Licensing-Basis Events (LBEs) will replace the PIEs and PRA safety functions will be assigned to the appropriate DL.

4 SAFETY REGULATORY ENGAGEMENTS

The proposed meetings and submittals are intended to reduce regulatory uncertainty and facilitate the NRC's understanding of Natrium technology and its safety case. Adjustments both in timing, scope, and breadth can be made as plans evolve. Meeting scheduling and presentation content will consider NRC capabilities and resource availability. In coordination with the NRC staff, topics can be prioritized and interactions optimized to address design alternatives or those issues most important to the overall project plan. There is a focus on near-term activities needed to support critical design decisions and the development of pre-application submittals.

4.1 Quality Assurance

TerraPower submitted the Quality Assurance Program Description as a Topical Report for NRC staff review and approval on August 5, 2020. TerraPower has established a Quality Assurance Program that complies with 10 CFR 50 Appendix B, 10 CFR Part 21, ASME NQA-1-2015, and Regulatory Guide (RG) 1.28, Revision 5 for all nuclear safety related work (nuclear reactor projects), and in a graded manner to all other TerraPower work, when applicable.

The NRC is presently reviewing the TerraPower Quality Assurance Program Description.

4.2 Safeguards Information Plan

This pre-application interaction is for review of the Plan for protection of safeguards information (SGI). NRC review and approval of the Plan will enable the NRC staff to provide SGI information as necessary for the Natrium reactor to consider safeguards and security in the design of the facility and the physical security program.

Presentation:

- June 2021

Plan Submittal:

- June 2021

4.3 Probabilistic Risk Assessment (PRA)

This pre-application interaction will provide an overview of the PRA methodology.

Meeting and Presentation on Basic Methodology:

- July 2021

Meeting and Presentation on Internal Event PRA (at-power Internal Events PRA, with peer review):

- August 2023

Meeting and Presentation on Final Design PRA (Final Design PRA, with peer reviews):

- October 2027

4.4 Natrium Plant

This pre-application interaction will provide an overview of the Natrium Plant design and operation including the Nuclear Island and the Energy Island. The overview will describe innovative features and related research and development activities.

Meeting and Presentation:

- August 2021

4.5 Applicability of Regulations:

This interaction will provide an overview of the process and methodology for establishing the initial set of Principal Design Criteria (PDC) and for evaluating applicable regulations. It will include an overview of the strategy for applying a modern, technology-inclusive, risk-informed, and performance-based (TI-RIPB) process as described in Revision 1 of NEI-18-04, “Risk-Informed Performance-Based Technology Inclusive Guidance for Non-Light Water Reactor Licensing Basis Development,” also known as the Licensing Modernization Project.

Meeting and Presentation:

- August 2021

4.6 Engineering Computer Codes for the Natrium Reactor

This pre-application interaction will provide an overview and background of expected Natrium engineering computer codes. The goal is to identify and discuss the expected suite of engineering computer codes, associated validation and verification, and how they will be used by Engineering.

Meeting and Presentation of Methodology:
- August 2021

Meeting and Presentation:
- January 2023

Topical Report Submittal:
- March 2023

4.7 RIPB PDC

This pre-application interaction is for discussion of the methodology used in identifying the Risk-Informed, Performance-Based (RIPB) PDC. These PDC will establish the necessary design, fabrication, construction, testing, and performance of safety significant SSCs.

Meeting and Presentation:
- October 2021

Topical Report Submittal:
- December 2021

4.8 Plant-Level Risk-Informed Performance-Based Systems, Structures and Components (SSC) Classification Methodology

This pre-application interaction will provide an overview of the approach for LBE selection, SSC classification, and defense-in-depth. The overview will include a description of how the RIPB process will be implemented for selection of LBEs; safety classification of SSCs and associated risk-informed special treatments; and determination of DID adequacy.

Meeting and Presentation:
- October 2021

Topical Report Submittal:
- December 2021

4.9 Energy Island Decoupling Strategy

This pre-application interaction will provide an overview of the decoupling concept and its implementation through the design.

Meeting and Presentation:
- October 2021

White Paper Submittal:
- December 2021

4.10 Digital Instrumentation and Control System

This pre-application interaction will provide an overview of the Digital Instrumentation and Control System and associated architecture.

Meeting and Presentation:
- November 2021

4.11 Consensus Codes and Standards

This pre-application interaction will provide an overview of the consensus codes and standards that will be used.

Meeting and Presentation:
- December 2021

White Paper Submittal:
- December 2021

4.12 Testing Plan and Methodology

This pre-application interaction will provide an overview of the testing plan and methodology that will be used.

Meeting and Presentation:
- December 2021

White Paper Submittal:
- December 2021

4.13 Source Term Methodology Plans

This pre-application interaction will provide an overview of the radionuclide transport methodology upon release from the fuel. The source term will include radiological source terms for effluents, radwaste system design, shielding design and equipment qualification. The initial source term calculation will be presented.

Meeting and Presentation:
- January 2022

Topical Report Submittal:
- April 2023

4.14 Core Flow Blockage Detection and Prevention

This pre-application interaction will provide an overview of core flow blockage detection and prevention.

Meeting and Presentation:

- January 2022

4.15 Design Basis Accident Transient Methodology

This pre-application interaction will discuss the design basis accident transient methodology.

Meeting and Presentation:

- March 2022

Topical Report Submittal:

- May 2022

4.16 Human Factors Engineering

This pre-application interaction will discuss the human factors engineering methodology.

Meeting and Presentation:

- March 2022

4.17 General Plant and Site Information

This pre-application interaction is an overview of the general plant description including the important features, and general description of the site. This meeting will discuss the current plant design.

Meeting and Presentation:

- December 2022

4.18 Licensing Basis Events (LBE) without Releases Methodology and LBE with Releases Methodology

This pre-application interaction will discuss Phenomena Identification and Ranking Table (PIRT) and requirements, the status of the calculational devices selected, initial / historical methodology, and development needs for the Natrium reactor. The initial SSC classification with sufficient conservatism will be available to support the discussion. LBEs constitute the entire collection of event sequences identified in the design and licensing basis of the plant. LBEs include AOOs, DBEs, Basis and BDBEs.

Meeting and Presentation for LBE with Releases:

- April 2023

Topical Report for LBE with Releases Submittal:

- June 2023

Meeting and Presentation for LBE without Releases:

- June 2023

Topical Report for LBE without Releases Submittal:

- August 2023

4.19 Emergency Preparedness Methodology

This pre-application interaction will discuss the Emergency Planning Zone methodology.

Meeting and Presentation:

- February 2022

Topical Report Submittal:

- April 2022

4.20 Metal Fuel Operating Experience

This pre-application interaction will provide an overview of Metal Fuel operating experience.

Meeting and Presentation:

- August 2022

4.21 Radiological Release Consequences Methodology

This pre-application interaction will discuss the radiological release consequence methodology.

Meeting and Presentation:

- February 2023

Topical Report Submittal:

- April 2023

4.22 Reactor Stability Methodology

This pre-application interaction will discuss the Reactor Stability Methodology.

Meeting and Presentation:
- February 2023

Topical Report Submittal:
- April 2023

4.23 Partial Flow Blockage Methodology

This pre-application interaction will discuss the Partial Flow Blockage Methodology.

Meeting and Presentation:
- March 2023

Topical Report Submittal:
- May 2023

4.24 Regulatory Exemptions

This pre-application interaction will provide an overview of potential regulatory exemptions.

Meeting and Presentation:
- March 2023

4.25 Fuel and Control Rod Performance Analysis Methodology and Fuel Qualification Plans

This pre-application interaction will provide an overview of Fuel and Control Rod Performance Analysis Methodology Plans and Fuel Qualification plans including fuel testing and validation and verification of associated engineering computer programs. The qualification plans will include the fuel performance methodology and application.

Meeting and Presentation:
- January 2025

Topical Report Submittal:
- March 2025

5 ENVIRONMENTAL REGULATORY INTERACTIONS

5.1 Site Selection Process

This pre-application interaction will provide an overview of the submittal describing the Site Selection Process.

White Paper Submittal:
- December 2021

5.2 Environmental Coordination with Cooperating Environmental Agencies State and Federal

This pre-application interaction will provide an overview, background and approach for initiating consultations with various Federal, state, and local agencies to request input on potential environmental impacts.

Meeting and Presentation:

- January 2022

5.3 Environmental - Need for Power/Alternatives (Alternative Site Selection Process/Energy Alternatives)

This pre-application interaction will provide an overview of the planned environmental methodology to address the need for power and alternatives analysis given the unique purpose and need for the Natrium reactor.

Meeting and Presentation:

- February 2022

5.4 Severe Accident Mitigation Analysis (SAMAs)/Severe Accident Mitigation Design Alternatives (SAMDAs)

This pre-application interaction will review the process and approach for the Natrium SAMA/SAMDA analyses using the latest update to the plant's PRA.

Meeting and Presentation:

- March 2022

5.5 Environmental – Fuel Cycle Impacts

This pre-application interaction will provide an overview of the approach for the evaluation of environmental impacts from storage and transportation of spent nuclear fuel. The overview will address novel fuel form/fuel design and independent spent fuel storage installation (ISFSI) cask selection.

Meeting and Presentation:

- March 2022

6 PLANNED APPLICATION SUBMITTAL DATES

6.1 Construction Permit Application

Anticipated Submittal Date:

- August 2023

6.2 Operating License Application

Anticipated Submittal Date:

- March 2026

END OF DOCUMENT