BWX Technologies, Inc.

August 31, 2022

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U.S. Nuclear Regulatory Commission
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Rockville, MD 20852-2738

Subject: BWXT Advanced Technologies Regulatory Engagement Plan for BANR

Enclosed for your review is the BWXT Advanced Technologies, LLC's (BWXT AT) Regulatory Engagement Plan (REP) for the BWXT Advanced Nuclear Reactor (BANR) Risk Reduction project under the Department of Energy's Advanced Reactor Demonstration Program (ARDP). This plan is intended to guide communications between BWXT AT and the NRC for the planned submittal of several technical and topical reports in support of the BANR project. BWXT intends to work with NRC Staff to schedule a meeting to discuss comments on the plan and provide a technical update on the project.

BWXT AT recognizes the value in early communication of planned licensing activities with the NRC. To that end, Enclosure 1 contains the "BWXT Advanced Nuclear Reactor Regulatory Engagement Plan", BANR-PLAN-111554, Revision 0.

This letter and the enclosure make no regulatory commitments nor do they make any revisions to existing regulatory commitments.

If you have any questions or need further information, please contact me at (434) 363-7517 or swschilthelm@bwxt.com.

Sincerely,

Steve Schilthelm
Digitally signed by Steve Schilthelm
Date: 2022.08.31 09:48:42 -04'00'

Steve Schilthelm
Director, Regulatory and Mission Assurance
BWXT Advanced Technologies LLC

CC:
Michael Orenak, NRC

Enclosure: "BWXT Advanced Nuclear Reactor Regulatory Engagement Plan", BANR-PLAN-111554, Revision 0

BWX Technologies, Inc.

BWXT ADVANCED NUCLEAR REACTOR (BANR) REGULATORY ENGAGEMENT PLAN BANR-PLAN-111554 Revision 0 August 2022

Safety Class	Files Attached	Total No. Pages
Non-safety	☐Yes ☒No	13

SIGNATURES			
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Approved By:	Steve Schilthelm	Steve Schilthelm	Digitally signed by Steve Schilthelm Date: 2022.08.30 19:06:44 -04'00'
	Name	Signature	Date

RECORD OF REVISION

Revision No.	Date	Preparer	Description of Changes
0	8/31/2022	AJ Donahue	Initial Issue

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1. PURPOSE

The purpose of this Regulatory Engagement Plan (REP) is to guide communications between BWXT Advanced Technologies (BWXT AT) and the Nuclear Regulatory Commission (NRC) for the BWXT Advanced Nuclear Reactor (BANR) project. BWXT AT is working on enhancing the commercial viability of the BANR design under the U.S. Department of Energy (DOE) Advanced Reactor Demonstration Program (ARDP) Risk Reduction efforts. This REP identifies the planned regulatory approach and tentative licensing submittal schedule, defines interactions, roles and responsibilities to enhance communication with the intent to increase regulatory certainty. The REP is expected to be a living document and is expected to be updated as the project evolves. The structure of this REP is informed by NEI 18-06, Guidelines for Development of a Regulatory Engagement Plan.

2. CONTACT INFORMATION

The point of contact for written correspondence with BWXT AT and the lead point of contact relating to the BANR project and coordination of interactions is the Director, Regulatory Affairs and Mission Assurance, at the following address:

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3. BANR ARDP RISK REDUCTION PROJECT

The primary objective of the BANR ARDP Risk Reduction program is to demonstrate the commercial viability of the small, versatile, advanced nuclear demonstration reactor within seven years by optimizing the existing high technology readiness level (TRL) high temperature gas reactor (HTGR) baseline design. The baseline design is discussed in Section 3.1. Sections 3.2 and 3.3 discuss the project goals, objectives and target areas for technology maturation for the project. The Risk Reduction scope required to meet the primary project objective include designing, building, testing and licensing technological upgrades to our baseline solution, leading to commercializing a new Advanced Nuclear Reactor. The Risk Reduction scope is captured in six focus areas, discussed in Section 3.4

3.1 Design Background

The BANR project is developing a modular, factory-fabricated system that is small and light enough to be transported via rail, ship or truck and that can deliver 50 MW of thermal power from nuclear fission. It employs mature and manufacturable HTGR technology with inherent safety features and a high working fluid temperature. It provides flexible options for energy

output - including electricity, steam for process heat, or both in a mode called “cogeneration” - while minimizing greenhouse gas emissions. Figure 1 depicts the BANR design.

Key features of the BANR baseline design are:

- Safety – reactor designed with inherent, time-tested safety protocols and features
- Technology – uses HTGR technology, with 60+ year proven track record
- Scalability – transportable, modular solution designed to meet site-specific energy needs
- Partnership – designed and constructed by BWXT AT using existing facilities
- Lifecycle – high-power density fuel fabricated by the BWXT AT extends refueling to five years, up from the industry average of two years
- Reduced infrastructure – modular refueling eliminates the need for elaborate nuclear fuel handling facilities and large storage pools
- Transportability – meets standard shipping requirements for rail, trucks, and ships
- Cogeneration capabilities – flexible power conversion can provide process heat, electric power, or both
- Compatibility – connects to existing, on-site energy distribution systems
- Licensing – BWXT AT’s existing Category 1 licenses allow for expedited licensing in the U.S. for manufacturing scopes

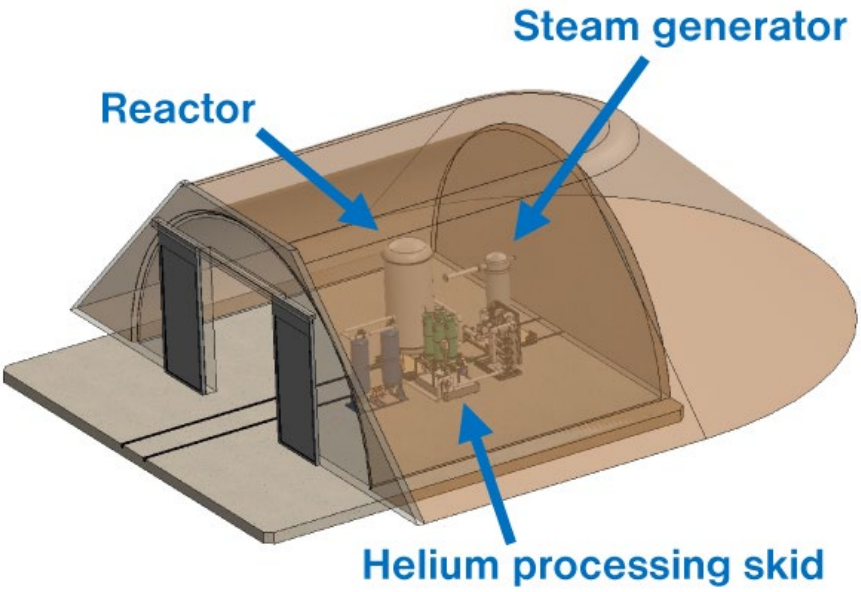

Figure 1: BANR Design

3.2 Project Goals and Objectives

The project scope will be upgrading the current Uranium Oxycarbide (UCO) tri-structural isotropic (TRISO) fueled BANR baseline HTGR reactor core and making it cost-competitive in the marketplace. The main thrust of the work is the development, production, and qualification of Uranium Nitride (UN) TRISO that is constituted into a three-dimensional printed silicon carbide (SiC) fuel element. The fuel elements will be qualified via irradiation, post-irradiation examination (PIE), and safety testing. UN TRISO is expected to increase power output and extend core life due to the higher uranium density and thus improve the plant economics.

3.3 Risk Reduction Target Areas for BANR Technology Maturation

BANR Risk Reduction project aims to enhance commercial viability of a mature design. The target areas to achieve this enhancement are:

- Higher power density fuel for increased power output and core life
- Reduced manufacturing, operating, and maintenance costs
- Enables autonomous operation and reduced staffing

The table below compares the baseline design, the targeted upgrades under Risk Reduction and the supporting rationale.

Table 1: Risk Reduction Upgrades and Rationale

	Baseline	Risk Reduction Upgrades	Rationale
Fuel	UCO TRISO	UN TRISO	Use of higher power density fuel allows for higher power output and / or extended core life
Reactor Core	UCO TRISO fuel in a graphite matrix cylindrical compact inside hexagonal graphite moderator elements	UN TRISO in SiC matrix in geometries made possible using advanced manufacturing (AM)	To produce a more optimized, integrated core design that will be faster and less expensive to manufacture, leading to higher manufacturing throughput and improved plant economics

	Baseline	Risk Reduction Upgrades	Rationale
Reactivity Control System	Combination of control rods and drums with externally mounted motor drives	Adapted for higher core power density and to take advantage of novel core geometries possible using AM	To reduce the manufacturing, operations, and maintenance costs associated with this system
Passive Cooling (for accident conditions)	Water tank surrounding the reactor vessel	Adapted for higher core power density and to take advantage of novel core geometries possible using AM	To reduce the manufacturing, operations, and maintenance costs associated with this system
Reactor I&C	Conventional (ex-core) instrumentation	High temperature sensors for in-core applications	To enable autonomous operation and thus reduce required staffing

3.4 Project Focus Areas

The objective of each project focus area is described below.

- **Focus Area 1**: UN TRISO Fuel Production, Irradiation, and Testing.

  Use of higher power density fuel allows for higher power output and / or extended core life, and obtain the data required for this fuel qualification.

  Activities in this area will include the production by BWXT of fuel consisting of UN TRISO fuel particles embedded in a SiC matrix; irradiation of the fuel in the Advanced Test Reactor (ATR); and PIE and safety testing performed by Idaho National Laboratory (INL) and Oak Ridge National Laboratory (ORNL) and modeling and simulation of the fuel performed by BWXT, ORNL, and INL.

- **Focus Area 2:** Core Development and Core Manufacturing Development.

  Produce a more optimized, integrated core design that will be faster and less expensive to manufacture.

  Activities in this area are centered around development of a core design optimized for use of UN TRISO fuel embedded in SiC matrix, and developing the associated advanced manufacturing techniques. Core development will be performed implementing an agile design process enabled by additive manufacturing and informed by manufacturing, assembly, and testing. Activities will include neutronics, thermal hydraulics, and mechanical design and analysis; producing mock-ups and using them to perform testing to inform design; development of advanced manufacturing processes; materials and mechanical testing; and irradiation and PIE of non-fuel materials. These activities will be performed primarily by BWXT and ORNL, with support from INL.

- **Focus Area 3**: Development of Reactivity Control and Passive Cooling Systems.

  Reduce the manufacturing, operations, and maintenance costs associated with these systems. In conjunction with the development of the reactor core (Focus Area 2), the reactivity control system and passive cooling approach (for emergency conditions) will be developed based on:

  - Higher uranium loading per unit volume
  - Opportunity for a more economical approach
  - Potential to capitalize on the geometries and material configurations possible with advanced manufacturing

  Activities will include development of functional and performance requirements specific to the TRISO UN advanced-manufactured core; development of system architectures; performing trade studies; performing design and analysis; and conducting testing required to mature these systems to at least TRL and manufacturing readiness level (MRL) 6. These activities will be performed by BWXT.

- **Focus Area 4**: Development and Testing of In-Core Sensors to Enable Autonomous Operation. Enable autonomous operations and thus reduce required staffing.

  Activities will include identification of in-core instrumentation needs, selection of candidate sensor technologies, and development and testing where needed in conjunction with the planned fuel irradiations in ATR. Development and fabrication of instrumentation for irradiation testing will be performed by INL

- **Focus Area 5**: Licensing. Communicate and interface with the NRC to establish successful licensing progress.

  Activities will include communication and interface with the NRC on pertinent elements of the engineering, testing, and planning work scope. An early deliverable in this focus is the development of an initial REP (this document), defining goals and objectives of the risk reduction activities including tentative schedules and expected outcomes, and an approach for effective BWXT AT and NRC collaboration via calls, meetings, and information exchange.

  This scope also includes engaging with NRC early to describe our approach to qualify UN TRISO, submitting a Fuel Qualification Technical Report, describing the manufacturing and testing program, NRC review and comment on the Fuel Qualification Technical Report and factoring this into the test program. [See Section 5.0 for additional details]

- **Focus Area 6**: Commercialization. Successful market development for the BANR.

  Activities in this area are centered around bringing the reactor to the market. Focusing on production, distribution, marketing, sales, customer support, and other key functions critical to achieving the commercial success of the reactor. BWXT will develop refined cost estimates based on the new fuel form, manufacturing methods, and material selections. This will involve technology trade studies where key decisions need to be made and evaluation of the supply chain for important make-buy decisions.

4. REGULATORY STRATEGY

4.1 REP Approach

This REP is informed by industry best practices and recent lessons learned. The REP is expected to mature proportional to project scope and design and engineering maturity. REP activities will include communication and interface with the engineering, testing, and planning work in the other risk reduction elements. Goals and objectives of the risk reduction activities including schedules and expected outcomes, maintaining the REP with annual updates, and NRC collaboration via calls, meetings, and information exchange. [See Section 5.0]

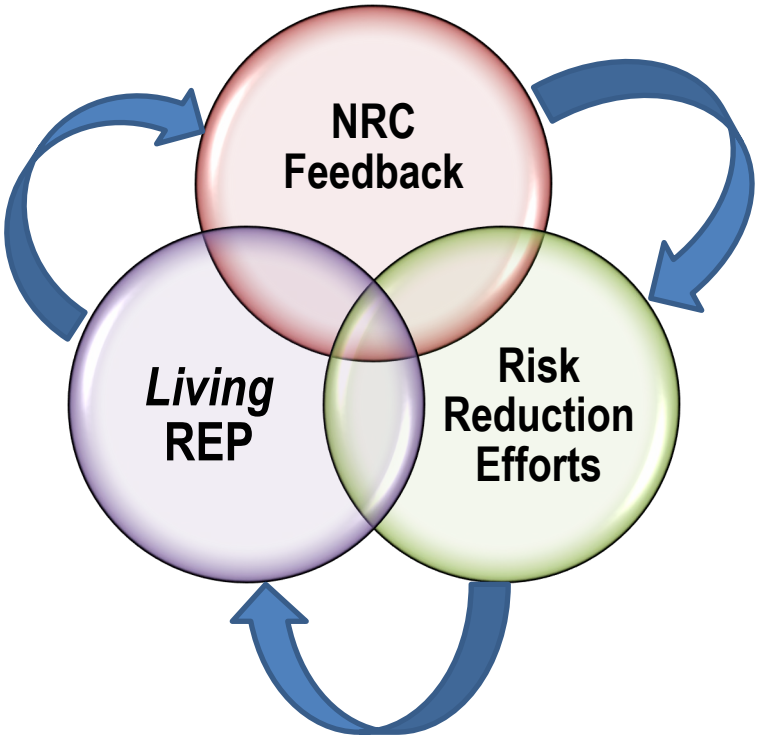

Figure 2: Regulatory Engagement Plan - Risk Reduction Efforts

For the successful implementation of the ARDP BANR project objectives, it is imperative to receive NRC Staff feedback on the risk reduction scope defined in Section 3.4, especially the fuel qualification approach. This REP aims to lay the foundation for an effective means to obtain timely, formal feedback from the NRC to inform risk reduction scope and activities.

4.2 Key Licensing Submittals

Currently, BWXT AT is not pursing a license application. However, the BANR project plans to submit technical and topical reports that align with project goals for NRC review, feedback and approval. A few key submittals are discussed below:

- **Quality Assurance Program Description (QAPD) Topical Report**

  BWXT AT's quality programs are fully compliant with Title 10 CFR Part 50, Appendix B by use of ASME NQA-1-2015. Consistent with industry best practices and NRC recommendation, BWXT AT plans to submit an early topical report to NRC for approval of our quality approach to these Risk Reduction efforts.

- **Fuel Qualification Technical Report**

  BWXT AT plans to engage with NRC in 2023 to describe the proposed approach for qualifying the new fuel in detail and will submit a fuel qualification technical report describing a manufacturing and testing program. The purpose of this submittal is to present in a stepwise approach the methodology and process to developing and qualifying a new fuel.

5. PREAPPLICATION ENGAGEMENT

BANR pre-application licensing strategy is as follows:

- Focus on establishing effective communications with the NRC to allow for the efficient and timely resolution of technical and licensing topics to meet project objectives
- Lay a strong technical foundation for successful licensing for the risk reduction phases of the BANR project
- Reduce regulatory uncertainty of technology focus areas, including those areas associated with topical report submittals (e.g., fuel qualification and advanced manufacturing), inform and align with the NRC Staff on BANR project objectives, Risk Reduction phase deliverables (fuel, advanced manufacturing techniques)

To that end, NRC engagements will be conducted in a methodical manner with alignment on objectives and deliverables, meeting frequencies captured in the REP.

5.1 Interactions

Initial discussions between BWXT AT and the NRC staff will focus primarily on the planned strategies for development and submittal of the key licensing submittals. The scope and objective of technical discussions will be clear and effectively communicated. The technical discussions may be held to inform the NRC, provide an update, or seek formal feedback. Topics for these discussions, as well as follow-up interactions, will be developed by BWXT AT Licensing in consultation with the NRC PM. Discussions may focus on individual topics or several topics combined. The type and frequency of interactions between the NRC and BWXT

will vary depending on the needs of both parties, and the availability of NRC and BWXT resources.

5.2 Project Management Discussions and "Drop-Ins"

"Drop-in" visits – periodic, nonpublic meetings between BWXT AT and NRC project management (which may include participation by various levels of BWXT and NRC management) will typically be conducted periodically to exchange general information on nontechnical topics such as planning for future interactions, and status/schedule updates. Limited discussion of technical issues can occur, but typically it will be in the context of status of review or identification of topics for separate discussion.

6. OTHER TOPICS

6.1 Schedule

A preliminary schedule for planning purposes is provided below. BWXT AT will periodically inform the NRC of any updates to the planned reports and schedule.

Table 2: Preliminary Schedule for Licensing Submittals

Topic	Purpose & Description	NRC Feedback Sought	Tentative Schedule
BWXT response to NRC RIS 2020-02	Identifies estimated NRC FY 2023-2025 resource needs associated with the BANR project	None	Completed April 2022 via the EIE submittal
Initial BANR project discussion with NRC management	Initial discussion in preparation of formal project kickoff	Support discussions and any pertinent feedback	Completed June 2022
Initial REP submittal to the NRC	Submit initial REP	REP acceptance, review and feedback	August 2022
Initial BANR pre-application public meeting, REP	Project kickoff and discussion of project goals and scope Detailed discussions to align on REP approach, meeting cadence and upcoming technical submittals	Project kickoff and alignment on high-level goals Feedback to the REP, project goals and scope, and innovative ways to obtain meaningful feedback to inform project efforts	September / October 2022

Quality Assurance Program Description (QAPD) Topical Report	Topical report for approval of our quality approach to BANR ARDP Risk Reduction efforts	Topical report acceptance, review, approval resulting in a safety evaluation report	4Q 2022
Fuel Qualification Plan Technical Report	Proposed approach for qualifying the new fuel in detail and will submit a fuel qualification technical report describing a manufacturing and testing program	Report acceptance, review and formal feedback on proposed approach and significant gaps, if any	4Q 2023
Advanced Manufacturing Reports	TBD	TBD	TBD
Fuel Qualification Topical Report	Topical report requesting new fuel qualification	Topical report acceptance, review, approval and safety evaluation qualifying the new fuel	Year 7 - 4Q 2028
Technical Update Meetings	Exchange general information on project updates, schedule, and technical topics.	Early identification of issues and staff feedback on technical approach.	Semi-annually

6.2 Budget

Budget considerations can be important consideration in establishing and maintaining BANR project objectives and schedule. To that end, NRC review times and associated fees will be estimated at the time of acceptance of licensing submittals. BWXT AT and NRC will communicate with each other any significant changes in the level of estimated NRC staff review fees or any funding restrictions.

7. DEFINITIONS, ABBREVIATIONS, AND ACRONYMS

7.1 Abbreviations and Acronyms

Abbreviation / Acronym	Term
AM	advanced manufacturing
ARDP	Advanced Reactor Demonstration Program
ATR	Advanced Test Reactor
BANR	BWXT Advanced Nuclear Reactor
BWXT AT	BWXT Advanced Technologies
DOE	Department of Energy
HTGR	high temperature gas reactor
INL	Idaho National Laboratory
MRL	manufacturing readiness level
NRC	Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
PIE	post-irradiation examination
QAPD	Quality Assurance Program Description
REP	Regulatory Engagement Plan
SiC	Silicon Carbide
TRISO	tri-structural isotropic
TRL	technology readiness level
UCO	Uranium Oxycarbide
UN	Uranium Nitride

8. REFERENCES

8.1 References

	Doc. Number	Rev#	Title
8.1.1	NEI 18-06	0	Guidelines for Development of a Regulatory Engagement Plan
8.1.2	ASME NQA-1-2015	2015 ed.	Quality Assurance Requirements for Nuclear Facility Applications