

Governor's Energy Matching Funds Initiative

Applicant: BWXT Advanced Technologies LLC

Project Title: Assessment of Microreactor Deployment, Applications and Development of Nuclear Microreactor Technologies and Knowhow in the State of Wyoming

Phase 1: Determine the specific user requirements to inform design choices tailored to BWXT AT's BANR design and commercial development plan to meet the needs of a lead Wyoming end user. Establish system requirements and design, with a view toward potential deployment of a fleet of microreactors that would provide an enduring economic benefit to the State of Wyoming and its constituents.

Phase 2: Detailed analysis and business development strategy for the potential manufacture and distribution of microreactor nuclear energy technology in the State of Wyoming. A physical outcome of Phase 2 includes fabrication of nuclear-quality components of BANR, thus demonstrating the capability of the state's supply chain for BWXT AT and for the nuclear industry more broadly.

Date: August 2023

Executive Summary

BWXT Advanced Technologies LLC ("BWXT AT"), a subsidiary of BWX Technologies, Inc.: Designs, builds, and tests nuclear products that enable new and novel energy use for its customers. These include terrestrial microreactors applications for commercial and defense customers, as well as space nuclear power and propulsion for the government.

Vision

BWXT AT envisions the potential deployment of a lead microreactor unit in Wyoming to demonstrate the coupling of nuclear heat and power to Wyoming industry while also maturing Wyoming's nuclear supply chain. Coupling nuclear heat and power to Wyoming industry has the ability to bolster Wyoming extraction sectors through carbon-free production of electricity and high-temperature process heat. The lead unit would serve as a pilot plant for a fleet of microreactors that would be deployed throughout the state and region.

Overall Project Goal

The project goal is to enable stakeholders to make a decision whether or not to deploy a lead microreactor unit in the state of Wyoming. In order to do this, a conceptual reactor design will be developed specific to the Wyoming end-user(s). The conceptual design allows for cost estimates for design, testing, fabrication, construction, and licensing to be developed, and determine and demonstrate the extent to which the existing Wyoming supply chain can be used as part of the lead unit as well as a broader fleet deployment model.

Qualifications of BWXT AT to Undertake Project

BWX Technologies, Inc. (BWXT) has extensive expertise and infrastructure to precision-manufacture nuclear-fueled reactors using safety, security, material accountability, uranium recovery, and operational processes required for high-consequence nuclear environments. BWXT's proven processes have been developed, demonstrated, and refined over the nearly 70 years of operations at its facilities.

BWXT owns and operates the only Nuclear Regulatory Commission (NRC)-licensed Category 1 commercial nuclear manufacturing facilities; meaning it is the only U.S. company that can handle

production quantities of highly enriched uranium (HEU). BWXT performs design, analysis, testing, fabrication development (i.e. prototyping), reactor manufacturing, and fuel fabrication for multiple customers using HEU and High Assay Low Enriched Uranium (HALEU). BWXT manufactures between eight and twelve research reactor cores per year. This requires safe and successful fabrication development, manufacturing, and production of nuclear components through the application of extensive and rigorous quality, safety, and security processes.

Its workforce consists of approximately 7,000 people, five U.S. manufacturing facilities, and over 4 million square feet of manufacturing space in North America. This provides the physical infrastructure, the established supply chain of 6,500 approved suppliers, and the capacity available to rapidly execute reactor design scope and transition seamlessly to fabrication. BWXT AT has begun moving into a new facility, the BWXT Innovation Campus (BIC), where all design, research, engineering, testing, and fabrication teams will be co-located. The facility contains an analytical chemistry lab, and a large 180,000 square foot advanced manufacturing space that is outfitted with the equipment and infrastructure and allows for close integration between design, testing, and fabrication staff.

Project Objectives

BWXT AT proposes to develop a conceptual design that is a variant of BWXT's Advanced Nuclear Reactor (BANR) that is specifically suited to the needs of Wyoming. BANR is a High Temperature Gas Reactor (HTGR) that is smaller than commercial nuclear power plants and possessing inherent and passive safety features. The goal of the Wyoming specific variant of BANR is to formulate a commercial product offering that aligns with Wyoming's energy user needs and the state's broader economic interests of having resilient and reliable power sources that can enable industry. The foundation of this work is BWXT's Advanced Reactor Demonstration Program (ARDP) award that is a cost shared effort with the US Department of Energy. This work with Wyoming will include partnering with local stakeholders as potential end users in the state to evaluate the potential for nuclear commercialization opportunities. BWXT AT will also integrate requirements of other Wyoming industries to define how large of a total market there may be that would benefit from a fleet of nuclear microreactors.

The project is divided across two phases that advance the technical and economic attributes of BANR to systematically address Wyoming stakeholder needs while developing a nuclear supply chain in the state.

Phase 1 Objective: To tailor the BANR design and commercial development plan to meet the needs of Wyoming, with a view toward potential deployment of a fleet of microreactors that will provide an enduring economic benefit to the State of Wyoming and its constituents.

Phase 2 Objective: Focus on detailed analysis and business development strategy for the potential manufacture and distribution of microreactor nuclear energy technology in the State of Wyoming. A physical outcome of Phase 2 includes fabrication of nuclear-quality component(s) for BANR within Wyoming. This will demonstrate the state's supply chain for BWXT AT and the nuclear industry more broadly.

Approach

To ensure that BANR addresses Wyoming stakeholder needs and is aligned with the state's economic interests and future energy needs, BWXT AT will collaborate with a trona mining company, L&H Industrial, and Wyoming Innovative Entrepreneurs (WIE) to evaluate nuclear commercialization opportunities, understand energy demands, and establish relationships with Wyoming suppliers.

BWXT AT also will work to identify potential nuclear supply chain companies within the State of Wyoming. This work will provide a proof-of-concept demonstration that high value and high consequence nuclear components can be manufactured within the existing industrial base of the state.

BWXT AT will leverage its quality and supply chain experience to help guide and strengthen Wyoming industry to enable their participation within the developing advanced reactor supply chain for BWXT AT and other nuclear reactor vendors.

The work is structured in two phases with milestones in each phase to provide the Wyoming Energy Authority (WEA) insights and oversight of the work products and results. This ensures that the WEA and State of Wyoming stay informed and have the necessary confidence in the direction of the project. At the conclusion of both phases of work, BWXT AT and the WEA will review viability of the project both technically and economically to make sure proceeding is still in the best interest of all parties.

Collaborators

- **A Trona Mining Company in Green River, WY** will provide support by serving as a potential Wyoming end user of the lead BANR unit. They plan to provide BWXT AT with information on their energy needs, energy optimization opportunities, and the economics of energy alternatives to help assess the viability of nuclear reactor deployment.
- **L&H Industrial** will be a subcontractor to BWXT AT and participate as the leader of industry for engagement with other Wyoming end users. L&H will also provide a connection to the Wyoming supply chain through the Wyoming Innovative Entrepreneurs.

Expected Outcomes

Overall: Arm the state of Wyoming with high quality assessments of microreactor technologies and opportunities to support decision-making about the nuclear industry more broadly and deploying microreactors specifically. For this work scope specifically, the information that will be made available to the State of Wyoming includes a demonstration use case of a microreactor product offering (BANR), end user market assessments, regulatory planning, supply chain planning, fleet planning, and commercialization planning. Scopes of work within Phases 1 and 2 contribute to portions of the siting and environmental reports required by the U.S. Nuclear Regulatory Commission (NRC) before construction activities can begin.

Phase 1: Phase 1 will solidify specific user requirements to inform design choices through direct interface with our collaborators. A lead site at a trona mine will be identified as well as other candidate sites throughout the region and state that could be part of a larger fleet deployment scenario. While the lead site identification ensures a “market of one” and will have significant influence over design requirements, the lead site requirements cannot come at the expense of the system’s ability to meet the needs of a fleet, as the economics of a lead unit inherently relies on the follow-on fleet.

Phase 2: Design and engineering activities needed to establish a conceptual design of major systems and design features for the lead site. These design and engineering efforts will allow for the development of more detailed economic models, cost estimates, market analysis and supply chain evaluation to identify the largest demonstration risks and opportunities. During Phase 2, a demonstration component of the reactor design will be fabricated by a Wyoming vendor.

Proposed Benefits to the State of Wyoming

There are five key areas of the proposed work that will jointly benefit Wyoming and BWXT AT’s commercial interests. Those five key areas are microreactor system design, end user market assessment, regulatory planning, supply chain planning, and fleet planning / fleet economics. By the end of Phase 2, the employment, manufacturing, and industrial opportunities for the State of Wyoming will be more fully understood and quantified ahead of a microreactor deployment decision. Both the WEA and BWXT AT will have a more detailed understanding of the opportunities and hurdles remaining to deploying microreactors in the State of Wyoming.

Benefits of Governor’s Energy Matching Funds (GEMF) Dollars

With the GEMF, BWXT AT is afforded the opportunity to accelerate the technological and commercial maturity of its microreactor system that is ongoing as part of BWXT AT’s cost shared effort with the US DOE Advanced Reactor Demonstration Program (ARDP). BWXT AT’s ARDP is focused on advancing specific technology attributes of commercial nuclear designs, such as the BANR system, which was stated goal when the ARDP was proposed in 2020 to allow the commercial nuclear market to develop. In the intervening years, market interest has accelerated in part due to geopolitical events and federal legislation. The GEMF dollars allow BWXT AT to further accelerate the development of BANR as a specific product offering that can meet both BWXT AT commercial needs and specific Wyoming industrial user needs. Additionally, it allows BWXT AT and Wyoming to assess and develop Wyoming supply chain participants for advanced nuclear systems.

To this end, the project plan is framed around advancing technical and economic attributes of BANR to systematically address key gaps that exist between BWXT AT’s current technology development efforts and a deployed, functional system required by a Wyoming end user. The goal of the project plan is to be prepared to make a microreactor demonstration decision that will be fielded in the State of Wyoming while more broadly and positively impacting the state’s economy.

GEMF Funding Request: \$9,999,802

BWXT AT Proposed Matching Funds

BWXT AT will match the Wyoming Governor’s Energy Matching Funds grant with in-kind funding from its existing development program for BANR, which is a \$111.2-million-dollar program performed over a seven-year period. Currently in year two of seven, BWXT AT’s work on BANR for ARDP will continue through December 2028. This is part of the U.S. Department of Energy’s ARDP, which enables demonstration of advanced reactors through cost-shared partnerships with U.S. industry.