



[6450-01-P]

DEPARTMENT OF ENERGY

Notice of Intent to Prepare an Environmental Impact Statement for a Versatile Test Reactor

AGENCY: Office of Nuclear Energy, Department of Energy.

ACTION: Notice of intent.

SUMMARY: As required by the “Nuclear Energy Innovation Capabilities Act of 2017” the Department of Energy (DOE) assessed the mission need for a versatile reactor-based fast-neutron source. Having identified the need for such a fast-neutron source, the Act directs DOE to complete construction and approve the start of facility operations, to the maximum extent practicable, by December 31, 2025. To this end, the Department intends to prepare an environmental impact statement (EIS) in accordance with the National Environmental Policy Act (NEPA) and its implementing regulations. This EIS will evaluate alternatives for a versatile reactor-based fast-neutron source facility and associated facilities for the preparation, irradiation and post-irradiation examination of test/experimental fuels and materials.

DATES: DOE invites public comment on the scope of this EIS during a 30-day public scoping period commencing [INSERT DATE OF PUBLICATION IN THE *FEDERAL REGISTER*], and ending on [INSERT DATE 30 DAYS AFTER OF DATE OF PUBLICATION IN THE *FEDERAL REGISTER*]. DOE will hold webcast scoping meetings on August 27, 2019 at 6:00 pm ET/4:00 pm MT and on August 28, 2019 at 8:00 pm ET/6:00 pm MT.

In defining the scope of the EIS, DOE will consider all comments received or postmarked by the end of the scoping period. Comments received or postmarked after the scoping period end date will be considered to the extent practicable.

ADDRESSES: Written comments regarding the scope of this EIS should be sent to Mr. Gordon McClellan, Document Manager, by mail at: U.S. Department of Energy, Idaho Operations Office, 1955 Fremont Avenue, MS 1235, Idaho Falls, Idaho 83415; or by e-mail to *VTR.EIS@nuclear.energy.gov*. To request further information about the EIS or to be placed on the EIS distribution list, you may use any of the methods listed in this section. In requesting to be added to the distribution list, please specify whether you would like to receive a copy of the Summary and Draft EIS on a compact disk (CD); a printed copy of the Summary and a CD with the Draft EIS; a full printed copy of the Summary and Draft EIS; or if you prefer to access the document via the internet. The Draft EIS and Summary will be available at:

<https://www.energy.gov/nepa>.

FOR FURTHER INFORMATION CONTACT: For information regarding the Versatile Test Reactor (VTR) Project or the EIS, contact Mr. Gordon McClellan at the address given above; or email *VTR.EIS@nuclear.energy.gov*; or call (208) 526-6805. For general information on DOE's NEPA process, contact Mr. Jason Sturm at the address given above; or email

VTR.EIS@nuclear.energy.gov; or call (208) 526-6805.

SUPPLEMENTARY INFORMATION:

Background

Part of the mission of DOE is to advance the energy, environmental, and nuclear security of the United States and promote scientific and technological innovation in support of that mission. DOE's 2014-2018 Strategic Plan states that DOE will "support a more economically competitive, environmentally responsible, secure and resilient U.S. energy infrastructure." Specifically, "DOE will continue to explore advanced concepts in nuclear energy that may lead to new types of reactors with further safety improvements and reduced environmental and nonproliferation concerns."

Many commercial organizations and universities are pursuing advanced nuclear energy fuels, materials, and reactor designs that complement the efforts of DOE and its laboratories in achieving DOE's goal of advancing nuclear energy. These designs include thermal and fast-spectrum¹ reactors targeting improved fuel resource utilization and waste management and utilizing materials other than water for cooling. Their development requires an adequate infrastructure for experimentation, testing, design evolution, and component qualification. Existing irradiation test capabilities are aging, and some are over 50 years old. The existing capabilities are focused on testing of materials, fuels, and components in the thermal neutron spectrum and do not have the ability to support the needs for fast reactors. Only limited fast-neutron-spectrum-testing capabilities, with restricted availability, exist outside the United States.

¹ Fast neutrons are highly energetic neutrons (ranging from 0.1 to 5 million electron volts [MeV] and travelling at speeds of thousands to tens of thousands kilometers per second) emitted during fission. The fast-neutron spectrum refers to the range of energies associated with fast neutrons. Thermal neutrons are neutrons that are less energetic than fast neutrons (more than a million times less energetic [about 0.025eV] and travelling at speeds of less than 5 kilometers per second), having been slowed by collisions with other materials such as water. The thermal neutron spectrum refers to the range of energies associated with thermal neutrons.

Recognizing that the United States does not have a dedicated fast-neutron-spectrum testing capability, DOE performed a mission needs assessment to assess current testing capabilities (domestic and foreign) against the required testing capabilities to support the development of advanced nuclear technologies. This needs assessment was consistent with the Nuclear Energy Innovation Capabilities Act of 2017, or NEICA, (Pub. L. No. 115-248) to assess the mission need for, and cost of, a versatile reactor-based fast-neutron source with a high neutron flux, irradiation flexibility, multiple experimental environment (e.g., coolant) capabilities, and volume for many concurrent users. This assessment identified a gap between required testing needs and existing capabilities. That is, there currently is an inability to effectively test advanced nuclear fuels and materials in a fast-neutron spectrum irradiation environment at high neutron fluxes. Specifically, the DOE Office of Nuclear Energy (NE), Nuclear Energy Advisory Committee (NEAC) report, *Assessment of Missions and Requirements for a New U.S. Test Reactor*, confirmed that there was a need in the U.S. for fast-neutron testing capabilities, but that there is no facility that is readily available domestically or internationally. The NEAC study confirmed the conclusions of an earlier study, *Advanced Demonstration and Test Reactor Options Study*. That study established the strategic objective that DOE “provide an irradiation test reactor to support development and qualification of fuels, materials, and other important components/items (e.g., control rods, instrumentation) of both thermal and fast neutron-based advanced reactor systems.” To meet its obligation to support advanced reactor technology development, DOE needs to develop the capability for large-scale testing, accelerated testing, and qualification of advanced nuclear fuels, materials, instrumentation, and sensors. This testing capability is essential for the United States to modernize its nuclear energy

infrastructure and for developing transformational nuclear energy technologies that re-establish the U.S. as a world leader in nuclear technology commercialization.

The key recommendation of the NEAC report was that “DOE-NE proceed immediately with pre-conceptual design planning activities to support a new test reactor” to fill the domestic need for a fast-neutron test capability. The considerations for such a capability include:

- An intense, neutron-irradiation environment with prototypic spectrum to determine irradiation tolerance and chemical compatibility with other reactor materials, particularly the coolant.
- Testing that provides a fundamental understanding of materials performance, validation of models for more rapid future development, and engineering-scale validation of materials performance in support of licensing efforts.
- A versatile testing capability to address diverse technology options and, sustained and adaptable testing environments.
- Focused irradiations, either long- or short-term, with heavily instrumented experimental devices, and the possibility to do in-situ measurements and quick extraction of samples.
- An accelerated schedule to regain and sustain U.S. technology leadership and to enable the competitiveness of U.S.-based industry entities in the advanced reactor markets. This can be achieved through use of mature technologies for the reactor design (e.g., sodium coolant in a pool-type, metallic-alloy-fueled fast reactor) while enabling innovative experimentation.

A summary of preliminary requirements that meet these considerations include:

- Provide a high peak neutron flux (neutron energy greater than 0.1 MeV) with a prototypic fast-reactor-neutron-energy spectrum; the target flux is 4×10^{15} neutrons per square centimeter per second (neutrons/cm²-sec) or greater.

- Provide high neutron dose rate for materials testing [quantified as displacements per atom]; the target is 30 displacements per atom per year or greater.
- Provide an irradiation length that is appropriate for fast reactor fuel testing; the target is 0.6 to 1 meter.
- Provide a large irradiation volume within the core region; the target is 7 liters.
- Provide innovative testing capabilities through flexibility in testing configuration and testing environment (coolants) in closed loops.
- Provide the ability to test advanced sensors and instrumentation for the core and test positions.
- Expedite experiment life cycle by enabling easy access to support facilities for experiments fabrication and post-irradiation examination.
- Provide life-cycle management (spent nuclear fuel storage pending ultimate disposal) for the reactor driver fuel (fuel needed to run the reactor) while minimizing cost and schedule impacts.
- Make the facility available for testing as soon as possible by using proven technologies with a high technology readiness level.

Having identified the need for the VTR, NEICA directs DOE “to the maximum extent practicable, complete construction of, and approve the start of operations for, the user facility by not later than December 31, 2025.”

Secretary of Energy Rick Perry announced the launch of the Versatile Test Reactor Project on February 28, 2019 as a part of modernizing the nuclear research and development (R&D) user facility infrastructure in the United States.

An initial evaluation of alternatives during the pre-conceptual design planning activity recommends the development of a well-instrumented sodium-cooled, fast-neutron-spectrum test

reactor in the 300 megawatt-thermal power level range. This design would provide a flexible, reconfigurable testing environment for known and anticipated testing. It is the most practical and cost-effective strategy to meet the mission need and address constraints and considerations identified above. The evaluation of alternatives is consistent with the conclusions of the test reactor options study and the NEAC recommendation.

DOE expects that the VTR, coupled with the existing supporting R&D infrastructure, would provide the basic and applied physics, materials science, nuclear fuels, and advanced sensor communities with a unique research capability. This capability would enable a comprehensive understanding of the multi-scale and multi-physics performance of nuclear fuels and structural materials to support the development and deployment of advanced nuclear energy systems. To this end, DOE is collaborating with universities, commercial industry, and national laboratories to identify needed experimental capabilities.

Purpose and Need for Agency Action

The purpose of this DOE action is to provide a domestic versatile reactor-based fast-neutron source and associated facilities that meet identified user needs (e.g., providing a high neutron flux of at least 4×10^{15} neutrons/cm²-sec and related testing capabilities). Associated facilities include those for the preparation of driver fuel and test/experimental fuels and materials and those for the ensuing examination of the test/experimental fuels and materials; existing facilities would be used to the extent possible. The United States has not had a viable domestic fast-neutron-spectrum testing capability for over two decades. DOE needs to develop this capability to establish the United States' testing capability for next-generation nuclear reactors – many of which require a fast-neutron spectrum for operation – thus enabling the United States to

regain technology leadership for the next generation nuclear fuels, material, and reactors. The lack of a versatile fast-neutron-spectrum testing capability is a significant national strategic risk affecting the ability of DOE to fulfill its mission to advance the energy, environmental, and nuclear security of the United States and promote scientific and technological innovation. This testing capability is essential for the United States to modernize its nuclear energy industry. Further, DOE needs to develop this capability on an accelerated schedule to avoid further delay in the United States' ability to develop and deploy advanced nuclear energy technologies. If this capability is not available to U.S. innovators as soon as possible, the ongoing shift of nuclear technology dominance to other international states (e.g., China, the Russian Federation) will accelerate, to the detriment of the U.S. nuclear industrial sector.

Proposed Action

The Proposed Action is for DOE to construct and operate the VTR at a suitable DOE site. DOE would utilize existing or expanded, collocated, post-irradiation examination capabilities as necessary to accomplish the mission. DOE would use or expand existing facility capabilities to fabricate VTR driver fuel and test items and to manage radioactive wastes and spent nuclear fuel.

Versatile Test Reactor

The Nuclear Energy Innovation Capabilities Act of 2017 (Pub. L. 115-248) directed DOE, to the maximum extent practicable, to approve the start of operations for the user facility by not later than December 31, 2025. DOE recognized that a near-term deadline would require the technology selected for the user facility to be a mature technology, one not requiring

significant testing or experimental efforts to qualify the technology needed to provide the capability.

The generation of a high flux of high-energy or fast neutrons requires a departure from the light-water-moderated technology of current U.S. power reactors and use of other reactor moderating and cooling technologies. The most mature technology that could provide the high-energy neutron flux is a sodium-cooled reactor, for which experience with a pool-type configuration and qualification of metallic alloy fuels affords the desired level of technology maturity and safety approach. Sodium-cooled reactor technology has been successfully used in Idaho at the Experimental Breeder Reactor (EBR)-II, in Washington at the Fast Flux Test Facility, and in Michigan at the Fermi 1 Nuclear Generating Station.

The current VTR concept would make use of the proven, existing technologies incorporated in the small, modular GE Hitachi Power Reactor Innovative Small Module (PRISM) design. The PRISM design² meets the need to use a sodium-cooled, pool-type reactor of proven (mature) technology. The VTR would be a smaller (approximately 300 megawatt thermal) version of the GE Hitachi PRISM power reactor. The reactor, primary heat removal system, and safety systems would be similar to those of the PRISM design. VTR, like PRISM, would use metallic alloy fuels. The conceptual design for the first fuel core of the VTR proposes to utilize a uranium-plutonium-zirconium alloy fuel. Such an alloy fuel was tested previously in the EBR-II reactor. Later reactor fuel could consist of other mixtures and varying enrichments of uranium and plutonium and could use other alloying metals in place of zirconium.

² The PRISM design is based on the EBR-II reactor, which operated for over 30 years. PRISM received a review by the Nuclear Regulatory Commission as contained in NUREG-1368, *Preapplication Safety Evaluation Report for the Power Reactor Innovative Small Module (PRISM) Liquid-Metal Reactor*, which concluded that “no obvious impediments to licensing the PRISM design had been identified.”

The VTR core design, however, would differ from the PRISM core in order to accommodate several positions for test and experimental assemblies. Additional experiments could be placed in locations normally occupied by driver fuel in the PRISM reactor. The VTR is not a power reactor; there would be no PRISM power block for the generation of electricity. Heat generated by the VTR would be dissipated through air-cooled heat exchangers; no water would be used in reactor cooling systems.

The VTR would provide the capability to test fuels, materials, instrumentation, and sensors for a variety of existing and advanced reactor designs, including sodium-cooled reactors, lead/lead-bismuth eutectic-cooled reactors, gas-cooled reactors, and molten salt reactors. Test vehicles for coolants other than sodium would consist of closed loops containing the test material enclosed in cartridges that isolate the experiments from the primary coolant, allowing performance of tests on different coolant types. Due to the high flux possible in the VTR, accelerated testing for reactor materials would be possible. These experiments would extend the state-of-the-art knowledge of reactor technology. Tests and experiments could also be developed that would improve safeguards technologies. In addition to fast reactor test and experimentation, the VTR could be used for research on long-term fuel cycles, fusion reactor materials, and neutrino science/detector development.

The VTR would not be used as a breeder reactor. All of the driver fuel removed from the reactor core would be stored to allow radioactive decay to reduce dose rates, and then conditioned for disposal; no nuclear materials would be removed from the fuel for the purpose of reuse.

Post-Irradiation Examination Facilities

Concurrent with the irradiation capabilities provided by the VTR, the mission need requires the capabilities to examine the test samples irradiated in the reactor to determine the effects of a high flux of high-energy or fast neutrons. Typically, the test samples would be encapsulated in cartridges such that the material being tested is fully contained. The highly radioactive test sample capsule would be removed from the reactor after a period of irradiation, ranging from days to years, depending on the nature of the test requirements, and transferred to a fully shielded facility where the test item could be analyzed and evaluated remotely. The examination facilities are "hot-cell" facilities, which include concrete walls several feet thick, multi-layered, leaded-glass windows several feet thick, and remote manipulators that allow operators to perform a range of tasks remotely without incurring substantial radiation dose from the test samples within the hot cell; in some cases, an inert atmosphere is required to prevent test sample degradation. DOE intends that the hot-cell facilities where the test items are examined and analyzed after removal from the reactor would be in close proximity to the VTR to minimize on- or offsite transportation of the highly radioactive samples.

Other Support Facilities

Key nuclear infrastructure components required to support the VTR and post-irradiation examination include:

- Facilities for VTR driver fuel and test item fabrication
- Facilities for managing radioactive wastes
- Facilities for management of irradiated VTR driver fuel

Nuclear materials for the VTR driver fuel could come from several locations including from within the DOE complex, commercial facilities, or possibly foreign sources. The nuclear materials and zirconium would be alloyed and formed into ingots from which the fuel would be fabricated. The alloy ingots could be produced at one of the locations providing the nuclear materials or the materials could be shipped to a location within the DOE complex for creating the alloy. DOE anticipates fabricating driver fuel from the ingots at the Savannah River site or the Idaho National Laboratory.

DOE would collaborate with a range of university, commercial industry, and national laboratory partners for experiment development. Fabrication of the test and experimental modules could occur at DOE facilities or at the university or commercial industry partners' facilities.

Preliminary Description of Alternatives

As required by the Council on Environmental Quality and DOE NEPA implementing regulations at 40 CFR parts 1500-1508 and 10 CFR part 1021, respectively, DOE will evaluate a range of reasonable alternatives for the construction and operation of a VTR and its associated

facilities. As required by NEPA, the alternatives will include a No Action Alternative to serve as a basis for comparison with the action alternatives.

Specific action alternatives proposed for analysis in the EIS include alternative DOE national laboratory sites for the construction and operation of the VTR and the provision of post-irradiation examination. Under all action alternatives and as described previously, the VTR would be a small (approximately 300 megawatt thermal), sodium-cooled, pool-type, metal-fueled reactor based on the GE Hitachi PRISM power reactor. DOE projects approval for the start of operations to occur as early as the end of 2026.

There are ancillary activities necessary to support any of the action alternatives. These include the fabrication of driver fuel, the assembly of test/experimental modules at existing, modified or newly constructed test/experiment assembly facilities, and the management of waste and spent nuclear fuel. After irradiation in the VTR, test/experimental cartridges would be transferred to post irradiation examination facilities. DOE would make use of existing facilities to the extent possible, but these post-irradiation examination facilities may require modification or expansion. These activities would be part of each action alternative.

1. Idaho National Laboratory (INL) VTR Alternative

Under the INL VTR Alternative, DOE would site the VTR at the Materials and Fuels Complex (MFC) at INL and use existing hot-cell and other facilities at the MFC for post-irradiation examination. This area of INL is the location of the Hot Fuel Examination Facility (HFEF), the Irradiated Materials Characterization Laboratory (IMCL), the Experimental Fuels Facility (EFF), the Fuel Conditioning Facility (FCF), and the decommissioned Zero Power Physics Reactor (ZPPR). The existing security fence would be expanded to include VTR.

The existing facilities within the MFC would be modified as necessary to support fabrication of VTR driver fuel or test items and to support post-irradiation examination of irradiated targets withdrawn from the VTR. These types of activities are ongoing within the MFC. Under the conceptual design, the existing infrastructure including utilities and waste management facilities would be utilized to support construction and operation of the VTR. While some modifications and upgrades to the infrastructure might be necessary, the current infrastructure should be largely adequate to support the VTR.

The post-irradiation examination capabilities at MFC, including existing facilities, equipment, technical, engineering and support staff, would be capable of supporting the anticipated post-irradiation examination activities that the VTR would create. The potential increase in workload among the MFC facilities in the post-startup timeframe might require increased technical and operating staff.

Driver fuel for the VTR would likely be manufactured at the MFC or the Savannah River site, depending on multiple factors including the source of the nuclear material and the availability and capabilities of DOE, commercial, or foreign suppliers.

2. Oak Ridge National Laboratory (ORNL) VTR Alternative

Under the ORNL VTR Alternative, the VTR would be sited at ORNL at a location to be identified.

Several existing facilities would be used and/or modified to provide operational support and needed post irradiation examination capabilities. The existing Irradiated Fuels Examination Laboratory (IFEL) Building 3525 and the Irradiated Materials Examination and Testing (IMET) Building 3025E hot cell facility would be used to support post irradiation examination and material testing. The IFEL is a Category 2 nuclear facility and contains hot cells that are currently used for examination of a wide variety of fuels. The IMET is a Category 3 nuclear facility and contains hot cells that are used for mechanical testing and examination of highly irradiated structural alloys and ceramics. Both facilities would need modifications to accommodate VTR work activities.

The existing Radiochemical Engineering Development Center (REDC) also would be used to support VTR operations. REDC consists of two hot-cell facilities, both constructed during the mid-1960s. REDC operates in conjunction with ORNL's High Flux Isotope Reactor (HFIR) in remote and hands-on fabrication of targets for irradiation and subsequent processing and recovery of valuable radioisotopes. The existing capabilities of the REDC may not be adequate to support the anticipated workload from the VTR and would need to be modified or expanded. Existing glovebox laboratories in Building 7920, currently used for chemical extraction and processing, could be used for fuel and/or test item fabrication. Building 7930 houses heavily shielded hot cells and analytical laboratories that could be used for remote examination of irradiated fuels and test items.

Driver fuel for the VTR would likely be manufactured elsewhere, depending on a number of factors including the source of the nuclear material and the availability and capabilities of DOE, commercial, or foreign suppliers.

3. No Action Alternative—Do not construct a VTR

As required by NEPA, DOE will include a No Action Alternative to serve as a basis for comparison with the action alternatives. Under the No Action alternative, DOE would not pursue the construction and operation of a VTR and would make use of the limited capabilities of existing facilities to the extent they are capable and available for testing in the fast-neutron-flux spectrum.

Potential Environmental Issues for Analysis

DOE proposes to address the issues listed in this section when considering the potential impacts of the construction and operations of the proposed facilities (the VTR and associated pre- and post-irradiation facilities) and the transportation of materials (non-irradiated fuel, irradiated [spent] fuel and test materials, and waste):

- Potential effects on public health from exposure to radionuclides under routine and credible accident scenarios including natural disasters: floods, hurricanes, tornadoes, and seismic events.
- Potential impacts on surface and groundwater, floodplains and wetlands, and on water use and quality.
- Potential impacts on air quality (including global climate change) and noise.

- Potential impacts on plants, animals, and their habitats, including species that are Federal- or state-listed as threatened or endangered, or of special concern.
- Potential impacts on geology and soils.
- Potential impacts on cultural resources such as historic, archeologic, and Native American culturally important sites.
- Socioeconomic impacts on potentially affected communities.
- Potential disproportionately high and adverse effects on minority and low-income populations.
- Potential impacts on land-use plans, policies and controls, and visual resources.
- Potential impacts on waste management practices and activities.
- Potential impacts of intentional destructive acts, including sabotage and terrorism.
- Unavoidable adverse impacts and irreversible and irretrievable commitments of resources.
- Potential cumulative environmental effects of past, present, and reasonably foreseeable future actions.
- Compliance with all applicable Federal, state, and local statutes and regulations, and with international agreements, and required Federal and state environmental permits, consultations and notifications.

Public Scoping Process

NEPA implementing regulations require an early and open process for determining the scope of an EIS and for identifying the significant issues related to the proposed action. To ensure that a full range of issues related to the proposed action are addressed, DOE invites Federal agencies, state, local, and tribal governments, the general public and the international community to

comment on the scope of the EIS. Specifically, DOE invites comment on the identification of reasonable alternatives and specific environmental issues to be addressed. Analysis of written and oral public comments provided during the scoping period will help DOE further identify concerns and potential issues to be considered in the Draft EIS.

Webcast Scoping Meeting Information

DOE will host two interactive webcasts during the scoping period as listed under **DATES**. The purpose of the webcasts is two-fold – the first is to provide the public with information about the NEPA process and the VTR Project. The second purpose is to invite public comments on the scope of the EIS.

The webcasts will begin with presentations on the NEPA process and the VTR Project. Following the presentations, there will be a moderated session during which members of the public can provide oral comments on the scope of the EIS analysis. Commenters will be allowed 3 minutes to provide comments. Comments will be recorded. Note that providing oral comments will require joining the meeting by phone.

Members of the public who would like to provide oral comments can pre-register by sending an email to *VTR.EIS@nuclear.energy.gov*. Alternatively, participants will be able to request to speak during the webcast. Those who pre-register should indicate at which session they want to speak and their name.

If you are joining the webcast scoping meeting via internet, copy and paste the link below to login to the meeting site, then follow the prompts. If you are joining the webcast meeting via phone, dial the U.S. toll-free number below and follow the prompts. Comments will be accepted during the webcast meeting, by mail, and by email.

- Join webcast scoping meeting via the internet:

August 27:

<https://78449.themediiframe.com/dataconf/productusers/ldos/mediiframe/31759/index1.html>

August 28:

<https://78449.themediiframe.com/dataconf/productusers/ldos/mediiframe/31762/index1.html>

(Copy and Paste into web browser).

- Join webcast public meeting by phone: U.S. toll-free: 877-869-3847.

Signed in Washington, DC on July 29, 2019.

Dennis Miotla,

Chief Operating Officer for Nuclear Energy.

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