U.S. NUCLEAR INDUSTRY COUNCIL (USNIC)

Advanced Nuclear Reactor Development Benefits from Versatile Test Reactor

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Findings

To maintain U.S. global advanced nuclear leadership, it is important to have a versatile, high-energy neutron source. The U.S. Versatile Test Reactor (VTR) can provide that capability to accelerate research and test nuclear materials, fuel, and other components. The VTR can assist in developing innovative nuclear energy technologies that have inherent safety features, lower waste yields, the capability to consume waste materials, the ability to support both electric and non-electric applications, and other improvements over the current generation of reactors. Furthermore, the success of the VTR will advance the U.S. industry by not having domestic nuclear developers relying upon Russian or Chinese test facilities and allowing the U.S. to be a competitive international resource for irradiation and testing services. In addition, constructing the VTR will enable the U.S. government to demonstrate advanced reactor technologies.

The U.S. Nuclear Industry Council (USNIC), supports fully funding the U.S. Department of Energy's (DOE) appropriations requests to ultimately construct and operate the VTR. Inconsistent or inadequate funding will only increase the uncertainty of the schedule, resulting in cost increases and potentially project failure. DOE should continue developing the conceptual design, preparing the Environmental Impact Statement (EIS), establishing processes and procedures to construct the facility on-time and within budget, and pursuing creative domestic and international co-financing opportunities.

Background

The demand for next-generation nuclear power is expected to grow as the world expands energy production from clean, zero emitting sources. Advanced nuclear reactors use new coolants, fuels, materials, and designs to increase safety and efficiency, while reducing proliferation risk. While most of these advanced technologies were developed in the United States, test reactors could serve to facilitate the deployment of these promising technologies.

Test reactors produce neutrons to assess how fuels, materials, and components will perform if used in commercial power reactors. Such tests provide valuable data about how these components behave in harsh conditions, such as extreme heat and radiation. Well-controlled experiments can be tailored to demonstrate new designs and support safety or operational goals. This data enables scientists and engineers to design and license safer, longer lasting, and more efficient fuels and components. For example, researchers have used such test data to improve nuclear fuels and materials that has resulted in nearly doubling the current nuclear fleet's capacity factor from the 1970s through today.

The generation of a high flux of high-energy (i.e. fast) neutrons requires a change from the light-water-moderated technology of current U.S. nuclear power reactors, and the use of other technologies. Existing U.S. test reactors at national laboratories and universities cannot perform the tests required for the advancement of these next generation nuclear reactors. The Advanced Test Reactor (ATR) at the Idaho National Laboratory (INL) and the High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory (ORNL) are thermal (i.e. lower energy) neutron reactors. Modifications can be made to simulate fast neutron conditions and limited boosting of fast neutron fluxes in thermal reactors, but these modified irradiation conditions are not sufficient to create the data required for a fuels or materials development and qualification program for fast reactor designs.[1]

The DOE initiated the VTR Program following a DOE report that analyzed the need for a research reactor that could test materials, fuels, and other components at higher neutron energies and neutron fluxes than what is available today. Researchers from Argonne National Laboratory (ANL) and ORNL interviewed multiple reactor vendors in 2016, including GE Hitachi Nuclear Energy (GEH), TerraPower, Westinghouse Electric Company, Framatome, and General Atomics, to assess overall industry test reactor needs. The report, issued in February 2017, states, "all survey responders indicated they would utilize irradiation services that a fast-spectrum reactor can provide with rapid accumulation of displacements per atom under prototypical conditions for qualification of fuel, qualification of fuel manufacturing processes, extension of the useful lifetime of cladding and structural materials under irradiation, study of corrosion behavior of materials and advanced coatings under irradiation, and demonstration of fuel performance."[2]

According to DOE, the most mature technology that could provide the high-energy neutron flux is a sodium-cooled reactor, in which a pool-type configuration and qualification of metallic alloy fuels affords the desired level of technology maturity and safety approach.[3] Sodium-cooled reactor technology has been successfully demonstrated in Idaho at the Experimental Breeder Reactor (EBR)-II, in Washington at the Fast Flux Test Facility (FFTF), in Arkansas at the Southwest Experimental Fast Oxide Reactor (SEFOR), in California at the Sodium Reactor Experiment (SRE), 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 GEH Power Reactor Innovative Small Module (PRISM) design.[4]

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[1] https://inl.gov/trending-topic/versatile-test-reactor/frequently-asked-questions/

[2] https://www.energy.gov/ne/downloads/neac-report-assessment-missions-and-requirements-new-us-test-reactor

[3] https://www.federalregister.gov/documents/2019/08/05/2019-16578/notice-of-intent-to-prepare-an-environmental-impact-statement-for-a-versatile-test-reactor

[4] https://www.genewsroom.com/press-releases/ge-hitachi-and-prism-selected-us-department-energys-versatile-test-reactor-program

The VTR would be a smaller (approximately 300 megawatts thermal) version of the GEH PRISM power reactor; and accommodate test and experimental assemblies. The facility is designed to test multiple types of reactor fuels, and the conceptual design for the first core of the VTR proposes to utilize a uranium-plutonium-zirconium alloy fuel. Later reactor fuel could consist of other mixtures and varying enrichments of uranium and plutonium, or use other alloying metals in place of zirconium. The reactor core is being designed to provide the flexibility for well-controlled experiments to support multiple advanced reactor concepts.

As part of the National Environmental Policy Act (NEPA) process, DOE has invited public comment on what the department should include in the scope of the upcoming draft version of the EIS, which is expected to consider locations at the INL and ORNL.[5] Innovative and creative partnerships can maximize the chance of success and ensure that the VTR can meet stakeholder needs, while simultaneously allowing the federal government to demonstrate advanced nuclear technology.

Discussion: Reasons why Americans Need the Versatile Test Reactor

USNIC agrees with the U.S. Assistant Secretary for Nuclear Energy Rita Baranwal, who said, "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 such as China and the Russian Federation will accelerate, to the detriment of the U.S. nuclear industrial sector."[6]

Advancements in our carbon-free nuclear fleet are needed to address rising atmospheric temperatures from the continued use of fossil fuels and to replace our existing large water-cooled nuclear reactor fleet. The VTR enables some of these advanced technologies to be appropriately designed and tested. In order to accelerate the strong bipartisan support for advanced nuclear reactors, we need to provide sufficient funding to create this critical testing capability.

Internationally, many heavily populated and developing countries are investing in nuclear power to help provide low-carbon, reliable electricity to their citizens. U.S. technology leadership in the area of advanced reactors is important both from economic (market share) and national security (international safety and security protocols) perspectives.

The VTR is a national strategic scientific tool that can operate for decades and will spur brand new innovations. The VTR, with its fast neutron spectrum testing capability, is valuable for strengthening the scientific understanding of new U.S. non water-cooled reactors and improving future versions of reactor designs. Having access to state-of-the-art test capabilities is a catalyst to innovation, and the VTR offers the long-term benefit of being a resource available to support a thriving advanced reactor ecosystem.

Fast neutron and high temperature testing offered by the VTR may also accelerate the path to licensing and permitting for some advanced reactors technologies.

[5] https://www.regulations.gov/docket?D=DOE-HQ-2019-0029
[6] https://www.energy.gov/ne/articles/doe-announces-preparation-environmental-impact-statement-examine-building-versatile-test

The VTR design— and technologies that can be developed using the facility— also enables usage of fuel from Oak Ridge or Savannah River National Laboratories. Plutonium from Savannah River could be used as reactor fuel, allowing the DOE to utilize its plutonium supply in a useful and productive manner. Additionally, the VTR can exercise key elements of the supply chain, which is a near term potential benefit to advanced reactor commercialization.

Finally, building the VTR has geopolitical implications. Existing U.S. reactors do not have the capability for this kind of testing. The only current capability for testing fast spectrum neutrons accessible to U.S. companies is the BOR-60 reactor in Russia. U.S. researchers and developers encounter multiple barriers when seeking access, including export control concerns for materials and fuels testing, intellectual property rights, and international transportation issues. We can't allow U.S. advanced reactor technologies potentially to be held hostage because our country did not possess the capabilities demonstrated by the VTR.

Conclusions

The VTR represents a key advanced reactor technology enabler and accelerator that is currently under formal development for deployment in the U.S. It has been authorized, initial funds have been appropriated, and it has momentum— all of which are important to accelerate the U.S. nuclear industry that needs forward momentum. It will enable the demonstration of advanced reactor technologies today and provide a platform for continued innovation in the years to come. To be cost-effective and successful, a carefully controlled construction project with well thought out testing plans and enough operating funding is needed. This will require partnership among the advanced reactor community, Congress, DOE, and national laboratories. USNIC is excited to see this progress.

About USNIC
The United States Nuclear Industry Council (USNIC) is the leading U.S. business advocate for the promotion of nuclear advancement and the American nuclear supply chain globally. USNIC represents over 80 leading companies engaged in nuclear innovation and supply chain development, including technology developers, manufacturers, construction engineers, key utility movers, and service providers. USNIC encompasses multiple working groups and task forces including an Advanced Nuclear Task Force.

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