Versatile Test Reactor Overview

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Mission Need

The mission of the VTR program is to provide leading edge capability for accelerated testing and qualification of advanced fuels and materials enabling the U.S. to regain and sustain technology leadership in the area of advanced reactor systems.

INDUSTRIAL INTEREST

- Fuels/Materials/Instrumentation & Sensors Testing
  - Sodium-cooled reactors
  - Lead/LBE-cooled reactors
  - Gas-cooled reactors
  - Molten salt reactors
- Accelerated testing for reactor materials

INDUSTRIAL INTEREST

Domestic deployment for clean energy transition

- Some concepts may be ready for a demonstration unit within 10 years
- VTR will help with continuous improvements in operations and economics beyond initial demonstration within 10 years
  - E.g. LWR technology evolution history (progress from 60 to 90% availability)

Global market share

NATIONAL SECURITY/SCIENTIFIC INTERESTS

- State-of-the-art knowledge of fast reactor technology
  - Global safety and security policies
  - Safeguards technologies
- Research on long-term fuel cycles
- Potential scientific research on
  - Fusion materials
  - Neutrino science/detector development

Science and technology leadership with strong influence on international standards and policies for the civilian use of nuclear energy and associated fuel cycles.
### Preliminary requirements/assumptions for VTR

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>High neutron flux</td>
<td>$\geq 4 \times 10^{15}$ n/cm$^2$-s</td>
</tr>
<tr>
<td>High fluence</td>
<td>$\geq 30$ dpa/yr</td>
</tr>
<tr>
<td>High test volume in the core</td>
<td>$\geq 7$ L (multiple locations)</td>
</tr>
<tr>
<td>Representative testing height</td>
<td>$0.6 \leq L \leq 1$ m</td>
</tr>
<tr>
<td>Flexible test environment</td>
<td>Rabbit &amp; Loops (Na, Pb, LBE, He, Salt)</td>
</tr>
<tr>
<td>Advance instrumentation &amp; sensors</td>
<td>In-situ, real time data</td>
</tr>
<tr>
<td>Experiment life cycle</td>
<td>Proximity to other infrastructure</td>
</tr>
<tr>
<td>Driver fuel life cycle management</td>
<td>Existing facilities as much as possible</td>
</tr>
</tbody>
</table>

#### ASSUMPTIONS:

- Mature Technology: Sodium-cooled pool type reactor
- Metallic alloy fuel (HALEU, LEU+Pu, DU-Pu)
- Novel testing capabilities
- Start date: 2026
### Preliminary VTR Sizing Studies

<table>
<thead>
<tr>
<th>Fuel Composition</th>
<th>Peak Fast Neutron Flux n/cm²-s</th>
<th>Fuel Current TRL</th>
<th>Annual HM Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>U-20Pu-10Zr with 5% ²³⁵U</td>
<td>~ 4.5×10¹⁵</td>
<td>High</td>
<td>330 kg/y Pu and 1170 kg/y U with 5% ²³⁵U</td>
</tr>
<tr>
<td>(BASELINE)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U-27Pu-10Zr with depleted or natural U</td>
<td>~ 5.0×10¹⁵</td>
<td>Low</td>
<td>450 kg/y Pu and 1050 kg/y U</td>
</tr>
<tr>
<td>U-10Zr with ~20% ²³⁵U</td>
<td>~ 2.5×10¹⁵</td>
<td>High</td>
<td>1500 kg/yr of U with ~20% ²³⁵U</td>
</tr>
</tbody>
</table>

**Legend:**
- **U(5%U-235)20Pu10Zr (RG)**
- **U(20%U-235)10Zr**
Versatile Test Reactor (VTR) Program Timeline

**Research and Development Phase**

- **2017**: Program Initiation Completed
- **2018**: Mission Need Developed
- **2020**: CD-0: Approve Mission Need, for DOE Approval

**Final Design, Construction, and Startup Phase**

- **2020**: Alternative Selection Completed
- **2022**: CD-1/3A: Approve Alternative Selection and Cost Range, and Long-lead Procurement Approval, for DOE Approval
- **2024**: CD-2/3: Approve Performance Baseline and Approve Start of Construction, for DOE Approval
- **2026**: Start of Operations Complete
- **2027**: Reactor Start-up Initiated
To achieve the lowest risk acquisition, the following principles guide the acquisition:

- Use proven technology and materials with modern design and construction tools
- Reduce scope to the absolute minimum, utilizing or modifying existing facilities
- Streamline acquisition processes to achieve the least overall risk.
- Use the best resources.
- Understand and mitigate the nuclear design/construction risks.

GE-HITACHI & BECHTEL DELIVERABLES

- Adapt PRISM concept for VTR mission... delete/add/modify SSCs
- Advance conceptual/preliminary design
- High confidence cost assessment
- High confidence schedule assessment
- Subcontracts are in place with 12 Universities (13 Awards) under 9 collaboration areas.
- An additional call will go out in January, expecting ~5-7 additional subcontracts.
- Industry stakeholders will be engaged to participate in the development of experimental vehicles for sodium, lead, gas fast reactor, and molten salt reactor fuels.
- First year goal for industry partners is to concepts for test vehicles required to inform core design.

<table>
<thead>
<tr>
<th>Collaboration Area</th>
<th>Lead Lab</th>
<th>University Collaborator</th>
<th>Industry Collaborator</th>
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</thead>
<tbody>
<tr>
<td>Sodium Cooled Fast Reactor</td>
<td>ANL</td>
<td>University of Wisconsin Madison</td>
<td>Framatome</td>
</tr>
<tr>
<td>Lead/Lead LBE-cooled Fast Reactor</td>
<td>LANL</td>
<td>University of New Mexico</td>
<td>Westinghouse</td>
</tr>
<tr>
<td>Molten Salt Reactors</td>
<td>ORNL</td>
<td>University of Utah, University of Idaho</td>
<td>TerraPower</td>
</tr>
<tr>
<td>Gas Cooled Fast Reactor</td>
<td>INL</td>
<td>Texas A&amp;M University</td>
<td>General Atomics</td>
</tr>
<tr>
<td>Virtual Design &amp; Construction</td>
<td>INL</td>
<td>North Carolina State University</td>
<td>General Electric - Hitachi</td>
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<tr>
<td>Structural Materials Testing</td>
<td>LANL</td>
<td>Oregon State University</td>
<td>EPRI</td>
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<tr>
<td>Data Analytics Combined with M&amp;S</td>
<td>INL</td>
<td>Abilene Christian University, Colorado School of Mines, Georgia Tech, Massachusetts Institute of Technology</td>
<td>Hierarchical Data Format (HDF) Group</td>
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<tr>
<td>Rabbit Systems</td>
<td>PNNL</td>
<td>Texas A&amp;M University</td>
<td></td>
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<tr>
<td>Strategic Initiatives</td>
<td>INL</td>
<td>University of Pittsburgh</td>
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International Collaborations

- South Korea
  - MOU in final review

- France
  - IA under discussion

- Japan
  - MOU under discussion

  - DESIGN & SAFETY ANALYSES BENCHMARKS
  - FUELS AND MATERIALS DATA
  - EQUIPMENT/COMPONENT TESTING
  - EXPERIMENTS DESIGN
  - INSTRUMENTATION & CONTROL SYSTEMS
    - Data Analytics
  - MODELING & SIMULATION TOOLS
  - SUPPLY CHAIN
Conclusion

• DOE-NE is investing in the R&D infrastructures to assure a sustainable advanced reactor industry in the long-run.
  • Multiple facilities and upgrades for PIE, ATR Upgrades, TREAT already restarted
  • Versatile Test Reactor (VTR) targeted for availability within by 2026.

• VTR will be operated under the DOE authority but we will work closely and engage with the NRC.
  • An engagement framework (MOU) is being developed.

• Strong stake-holder engagement throughout the project
  • **VTR Task Force under NEI Advanced Reactor Working Group is established.**

• DOE capital acquisition processes (413.3B) will be tailored and used to minimize acquisition risk.

• Strong reliance on modern digital engineering platform

• Strong bi-partisan congressional support
  • The FY 2018 authorization of $35M and FY 2019 of $65M
  • NEICA, S. 97