Versatile Test Reactor: Missing Piece of Nuclear Energy Innovation Infrastructure in the U.S.

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IANS – Lunch & Learn Webinar
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There is a Clear and Compelling Mission for VTR

**COMMERCIAL**
- Accelerated testing for fuels, materials & sensors for advanced reactors: Na, Pb, LBE, MS, He
- Accelerated testing for materials
- Clean energy market share

**NATIONAL SECURITY**
- Safeguard detectors/safeguards by design
- Global safety and security policies
- Export of reactors and reactor services

**SCIENCE & TECHNOLOGY**
(High-Energy Neutrons over Large Volumes)
- Fast reactor physics
- Materials in extreme environments
- Neutrino science

VTR is a state-of-the-art TEST REACTOR to enable continuous innovation in advanced nuclear energy technologies during its 60 years lifetime.
VTR Major Milestones to Date

1st Major Milestone

Critical Decision 0 achieved in 2019, focused on needs of:

• Commercial developers of advanced nuclear energy technologies
• National security interests
• Scientific community

2nd Major Milestone

Critical Decision 1 achieved in September 2020, focused on:

• Analysis of alternatives
• Conceptual design and conceptual safety design
• Cost and schedule ranges
National Environmental Policy Act

**Notice of Intent published in the Federal Register**
- Aug. 5, 2019

**DOE hosts public scoping meetings via webinar**
- Aug. 27-28, 2019

**Draft Environmental Impact Statement (EIS) undergoing DOE review**
- Aug. 17, 2020

**Draft EIS will be published and public review begins Public Review of Draft EIS**
- Nov. 2020
  - At least 45-day comment period
  - At least one public (via Webinar) meeting required with 15 days advanced notice

**DOE releases final EIS**
- Spring 2021
  - Respond to oral and written comments on the Draft EIS
  - 30 day waiting period (after EPA Notice of Availability is published)

**DOE issues record of decision**
- Summer 2021
  - Reactor site
  - Fuel fabrication site

- Draft EIS will look at:
  - No Action Alternative, Build VTR at INL and Build VTR at Oak Ridge National Lab
  - Will also look at fuel fabrication at INL and Savannah River Site
300 MWth pool-typed sodium cooled reactor

Core design optimized for meeting testing requirements (National Laboratories)
  ➢ Driver Fuel: U-20Pu-10Zr

GEH PRISM A for the balance of the reactor (GEH-Bechtel subcontract)

Innovative experimental vehicle designs (National Labs, Universities, Industry)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Target</th>
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<tbody>
<tr>
<td>High fast neutron flux (&gt;0.1 MeV)</td>
<td>≥ 4 x 10^{15} n/cm^2-s</td>
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<tr>
<td>High fluence</td>
<td>≥ 30 dpa/yr</td>
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<td>High test volume in the core</td>
<td>≥ 7 L/test location (multiple locations)</td>
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<td>Representative testing height</td>
<td>≥ 0.6 m</td>
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<tr>
<td>Flexible test environment</td>
<td>Loops (Na, Pb, LBE, He, Salt) Rabbit</td>
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<td>Driver fuel life cycle management</td>
<td>Existing facilities as much as possible</td>
</tr>
<tr>
<td>Schedule: Available ASAP</td>
<td>Target Date: 2026</td>
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<tr>
<td>COST(capital + operating):</td>
<td>Minimal</td>
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Sizing Studies Using Different Fuel Compositions

<table>
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<tr>
<th>Fuel Composition</th>
<th>Reactor Size (MWth)</th>
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<tr>
<td>U-20Pu-10Zr (0-5% U235, RG Pu)</td>
<td>300</td>
</tr>
<tr>
<td>HALEU-10Zr (20% U235)</td>
<td>~750</td>
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VTR Experiment Vehicles

- **Dismountable Test Assembly (DTA)**
  - A modified driver fuel assembly that will have an insert (DTA insert) that replaces 7-19 pins of the driver fuel. The DTA insert can remain for one cycle, or for as many cycles as the material limits of the insert allow. DTAs are non-instrumented or passively instrumented.

- **Normal Test Assembly (NTA)**
  - Standard non-instrumented or passively instrumented open test assemblies that are the same size, flat-to-flat, as the driver fuel assemblies.

- **Extended Length Test Assembly (ELTA)**
  - Test assemblies that have a long "stalk" that extends through the reactor head, and typically have various instrumentation leads, etc., for monitoring and controlling thermal-hydraulic conditions.

- **Rabbit Test Assembly (RTA)**
  - Special test assembly for rapid transfer of capsules that contain experiment specimens, which are propelled down a rabbit tube into a rabbit thimble, irradiated, and recovered intra-cycle or inter-cycle.

- **Support Areas**
  - VDC/BIM/DE, I&C, Cross-cutting technologies
ELTA example – Molten Salt Cartridge Loop

Overall Integration and Design
CD-1 Cost and Schedule Range

Point estimate includes ~20% contingency and management reserve
Cost range includes +60% and -30% for uncertainty range

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<thead>
<tr>
<th>Project Cost Range ($B)</th>
<th>Milestone</th>
<th>Fiscal Year</th>
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<tr>
<td>Point Estimate</td>
<td>CD-0</td>
<td>FY 2019, Q2</td>
</tr>
<tr>
<td>Upper Bound</td>
<td>CD-1</td>
<td>FY 2020, Q4</td>
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<tr>
<td>Lower Bound</td>
<td>CD-2/3</td>
<td>FY 2023 Q2 (target)</td>
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<tr>
<td></td>
<td>CD-4</td>
<td>FY 2026, Q4 – FY 2031, Q4</td>
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VTR Partnership

- 2018 –Department of Energy establishes VTR program after several studies highlight need.
- 6 national labs, 19 universities & 10 industry partners
- DOE 413.3B – Process for development of major systems projects.

The Blanket Master Contract for the Engineering Design and Construction phase of the project is being negotiated with Bechtel National, Inc (TerraPower and GE-Hitachi partners)
Summary & Conclusions

• When operational, VTR will be the world’s premier fast spectrum test reactor allowing technology developers and scientists access to state-of-the-art capabilities.

• VTR will provide the missing piece of research and development infrastructure and will help re-establish U.S. as the global leader in nuclear energy innovation.

• Even in the early design phase, VTR already is making an impact on nuclear energy innovation.
  - e.g. Integrated Digital Engineering framework

• VTR will be authorized and operated under the DOE authority, working closely with the Nuclear Regulatory Commission (NRC).
  - MOU signed in September 2019

• There is considerable international interest among our nuclear energy allies.
  - France, Japan collaborations