Status Report - eVinci (United States of America)

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1. Overview

☐ **In Operation**

☐ **Under Construction**

☐ **Described in**

Link to PRIS	--

☑ **New Concept**

Number of Units	--
Year	2029

Reference Plant

Name of Site	--
Link to PRIS	--
Net Power Output (MWe)	5
Gross Power Output (MWe)	--

1.1 Introduction

The Westinghouse eVinci Microreactor is designed for energy generation in challenging locations and for users requiring high reliability and resilience. The design can produce both process heat and electricity for remote communities, industrial operations, data centers, military facilities, or critical infrastructure installations. The key attribute of the design is its transportability on road, rail and waterway. Transportability allows the reactor to be delivered with fuel and removed from the site intact with the spent fuel remaining in the canister. The design is based on heat-pipe technology which builds upon decades of experience and testing from Los Alamos National Laboratory and Westinghouse. Because of its compact and simplified design, the eVinci Microreactor will be manufactured and fuelled in a factory, and then transported to an end user site.

The projected commercial deployment time is 2029. This reactor has a net power output of 5 MWe with a 15 MWth reactor.

1.2 Development Milestones

2019	MOC between the US Nuclear Regulatory Commission (NRC) and the Canadian Nuclear Safety Commission (CNSC) for joint review of documents
2021	Heat pipe electrical demonstration and manufacturing trials; Initiated licensing engagement with US and Canadian Regulators
2022	Saskatchewan Research Council (SRC) and Westinghouse have signed MOU to advance very small modular reactors in Saskatchewan
June 2022	NASA selects Westinghouse for providing an initial design concept for a fission surface power system
June 2023	Manufacturing demonstration completed; 6 Vendor Design Review (VDR) focus area packages transmitted to CNSC
Oct 2023	Preliminary Design Review (PDR) complete
Dec 2023	Westinghouse chosen for the JETSON advanced space research program by the U.S. Air Force Research Laboratory's Space Vehicle Directorate
Apr 2024	Nuclear Test Reactor (NTR) Preliminary Safety Design Report (PSDR) submitted to Idaho National Laboratory (INL)
May 2024	Phase 2 Electrical demonstration testing
June 2024	NTR Preliminary Safety Design Report (PSDR) submitted to US Department of Energy (DOE)
2027/8	NTR Testing at INL's EBR-II Dome
2028/9	NRC Design Approval
2029	Commercialization

1.3 Design organization or vendor company

valorema@westinghouse.com

1.4 Links to designer/vendor website

www.westinghousenuclear.com; https://westinghousenuclear.com/energy-systems/evinci-microreactor/

1.5 Design Description

The eVinci Microreactor is a 5 MWe/15 MWth core design capable of operating for 8 or more years prior to refuelling/replacement. The reactor is powered by 19.75% U-235 enriched (HALEU) fuel in TRISO form. Heat pipes are employed to harness the thermal energy generated by TRISO fuel through passive heat transport, allowing for a simple and reliable means to remove heat. The Power Conversion System transforms this heat into electricity through an open-air Brayton cycle. The reactor implements additional passive safety features in addition to active systems such as control drums, which control reactivity by rotating and thus exposing either a neutron reflecting or an absorbing material to the core neutron fluxes, and shut down rods, which completely turn off the reactor when inserted into the fuel compacts during transportation and emergency scenarios. The Passive Heat Removal System (PHS) maintains a safe temperature for the reactor core by removing decay heat via natural convection and radiation transfer. The reactor and all associated systems and components are housed in less than 3 acre above-ground site that is remotely monitored through the Instrumentation and Control system with Westinghouse's Advanced Logic System version 2 (ALS v2) platform, an NRC-approved logic-based platform that targets safety-critical control systems.

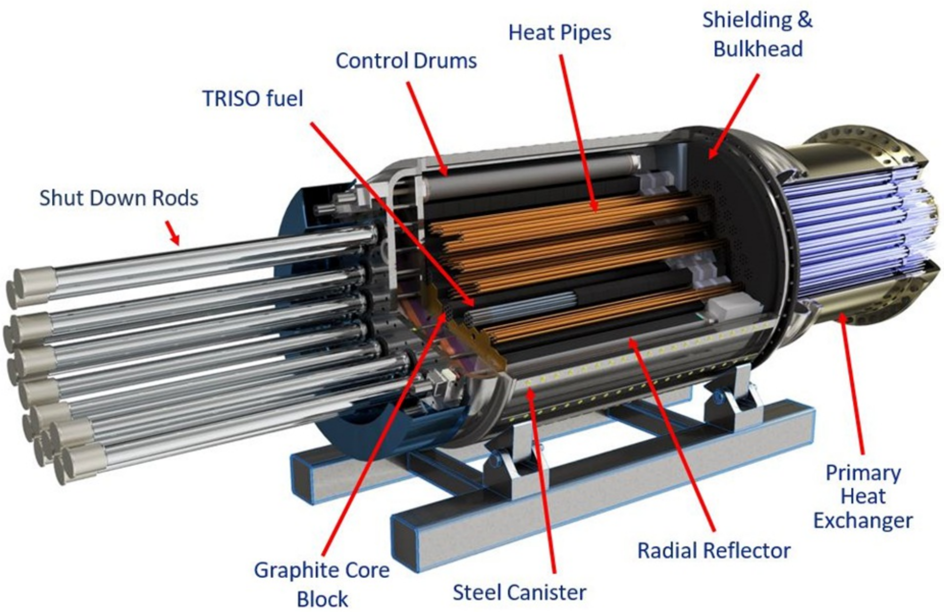

Figure 1: Sectional cut of the eVinci microreactor displaying the key technological components.

1.6 Licensing Application Support Documents

N/A

1.7 Reactor Unit in PRIS

2. Category Fields

Table 1: ARIS Category Fields

ARIS Category	Value	Units of Examples
Current/Intended Purpose	Commercial – Electric/Non-Electric	e.g. Commercial – Electric/Non-electric, Prototype/FOAK, Demonstration, Experimental

Main Intended Application (once commercial)	Baseload, Dispatchable, Off - grid / Remote	e.g. Baseload, Dispatchable, Off-grid/Remote, Mobile/Propulsion, Non-electric (specify)
Reference Location	Inland	e.g. On Coast, Inland, Below-Ground, Floating-Fixed, Marine-Mobile, Submerged-Fixed (Other-specify)
Reference Site Design (reactor units per site)	Single Unit	e.g. Single Unit, Dual Unit, Multiple Unit (# units)
Core Coolant	Heat pipes (Na)	H2O, D2O, He, CO2, Na, Pb, PbBi, Molten Salts, (Other-specify)
Reactor Core Size (1 core)	Thermal Power < 30 MWth	e.g. Thermal Power < 30 MWth, 30 MWth ≤ Thermal power < 1000 MWth, 1000 MWth ≤ Thermal power ≤ 3000 MWth, Thermal power > 3000 MWth
Reactor Type	Others	e.g. PWR, BWR, HWR, SCWR, GCR, GFR, SFR, LFR, MSR, ADS
Reactor Size	Microreactor	e.g. PWR, SMR
Neutron Moderator	Graphite	e.g. H2O, D2O, He, CO2, Na, Pb, PbBi, Molten Salts, (Other-specify)
NSSS Layout		e.g. Loop-type (# loops), Direct-cycle, Semi-integral, Integral, Pool-type
Primary Circulation	Natural	e.g. Forced (# pumps), Natural
Thermodynamic Cycle	Brayton	e.g. Rankine, Brayton, Combined-Cycle (direct/indirect)
Secondary Side Fluid	Other	e.g. H2O, He, CO2, Na, Pb, PbBi, Molten Salts, (Other-specify)
Fuel Form	Coated Sphere	e.g. Fuel Assembly/Bundle, Coated Sphere, Plate, Prismatic, Contained Liquid, Liquid Fuel/Coolant
Fuel Lattice Shape	Cylindrical	e.g. Square, Hexagonal, Triangular, Cylindrical, Spherical, Other, n/a
Rods/Pins per Fuel Assembly/Bundle	N/A	e.g. #, n/a

Fuel Material Type	Other	e.g. Oxide, Nitride, Carbide, Metal, Molten Salt, (Other-specify)
Design Status	Detailed Design	e.g. Conceptual, Detailed, Final (with secure suppliers)
Licensing Status	DCR	e.g. DCR, GDR, PSAR, FSAR, Design Licensed (in Country), Under Construction (# units), In Operation (# units)
Neutron Spectrum		e.g. Fast, Thermal

3. Parameter Fields

Table 2: ARIS Parameter Fields

ARIS Parameter	Value	Units of Examples
Plant Infrastructure		
Design Life	8	Years
Lifetime Capacity Factor	99%	%, defined as Lifetime MWe-yrs delivered / (MWe capacity * Design Life), incl. outages
Major Planned Outages	1 day/ 8 years for replacement reactor/refuelling	# days every # months (specify purpose, including refuelling)
Operation / Maintenance Human Resources	TBD	# Staff in Operation / Maintenance Crew during Normal Operation
Reference Site Design	Single or multiple units	n Units/Modules
Capacity to Electric Grid	5 MWe	MWe (net to grid)
Non-electric Capacity	15 MWth Heat at 800C	e.g. MW(th) heat at x °C, m3/day desalinated water, kg/day hydrogen, etc.
In-House Plant Consumption	TBD	MWe
Plant Footprint	<20,00	m2 (rectangular building envelope)
Site Footprint	~13,000	m2 (fenced area)
Emergency Planning Zone	at site boundary	km (radius)

Releases during Normal Operation	No radioactive release	TBq/yr (Noble Gases / Tritium Gas / Liquids)
Load Following Range and Speed	20 – 100% 20% per minute	x – 100%, % per minute
Seismic Design (SSE)	1 g	g (Safe-Shutdown Earthquake)
NSSS Operating Pressure (primary side)	0.12	MPa(abs), i.e. MPa(g)+0.1, at core outlet
NSSS Operating Pressure (secondary side)		MPa(abs), i.e. MPa(g)+0.1, at secondary side outlet
Primary Coolant Inventory (incl. pressurizer)	N/A	kg
Nominal Coolant Flow Rate (primary)		kg/s
Nominal Coolant Flow Rate (secondary)		kg/s
Core Inlet Coolant Temperature		ºC
Core Outlet Coolant Temperature		ºC
Available Tempeature as Process Heat Source	800	ºC
NSSS Largest Component		e.g. RPV (empty), SG, Core Module (empty/fuelled), etc.
- NSSS Largest Component Length		mm
- NSSS Largest Component Diameter		mm
- NSSS Largest Component Thickness		mm
- NSSS Largest Component Weight		tonne
Reactor Vessel Material		e.g. SS304, SS316, SA508, 800H, Hastelloy N
Steam Generator Design		e.g. Vertical/Horizontal, U-Tube/ Straight/Helical, cross/counter flow
Secondary Coolant Inventory		kg
Pressurizer Design		e.g. separate vessel, integral, steam or gas pressurised, etc.

Pressurizer Volume		m3 / m3 (total / liquid)
Containment Type		Dry (single/double), Dry/Wet Well, Inerted, etc.
Containment Volume		m3
Spent Fuel Pool Capacity and Total Volume		Years of full-power operation / m3
Non Electric Application		-
Core Delta Temperature		ºC
Fuel/Core		
Single Core Thermal Power	15	MW(th)
Refuelling Cycle	96+	months or "continuous"
Fuel Material	UCO TRISO	e.g. UO2, MOX, UF4, UCO
Enrichment (avg./max.)	19.75	%
Average Neutron Energy	<1	eV
Fuel Cladding Material	TRISO	e.g. Zr-4, SS, TRISO, E-110, none
Number of Fuel "Units"		Specify as Assembly, Bundle, Plate, Sphere, or n/a
Weight of one Fuel Unit		kg
Total Fissile Loading (initial)		kg fissile material (specify isotopic and chemical composition)
% of fuel outside core during normal operation		Applicable to online refuelling and molten salt reactors
Fraction of fresh-fuel fissile material used up at discharge	100	%
Core Discharge Burnup		MWd/kgHM (heavy metal, eg U, Pu, Th)
Pin Burnup (max.)		MWd/kgHM
Breeding/Conversion Ratio	<1	Fraction of fissile material bred in-situ over one fuel cycle or at equilibrium core
Reprocessing	none	e.g. None, Batch, Continuous (FP polishing/actinide removal), etc.

Main Reactivity Control	Control drums (reflectors)	e.g. Rods, Boron Solution, Fuel Load, Temperature, Flow Rate, Reflectors
Solid Burnable Absorber		e.g. Gd2O3
Core Volume (active)		m3 (used to calculate power density)
Fast Neutron Flux at Core Pressure Boundary		n/(cm²*s)
Max. Fast Neutron Flux		n/(cm²*s)
Core Control Rod Absorber		-
Core Soluble Neutron Absorber		-
Safety Systems		
Number of Safety Trains	Active / Passive	% capacity of each train to fulfil safety function
- reactor shutdown	Passive	- / 100 / -
- core injection	N/A	- / - / -
- decay heat removal	Passive	- /100 / -
- containment isolation and cooling	N/A	- / - / -
- emergency AC supply (e.g. diesels)	N/A	- / - / -
DC Power Capacity (e.g. batteries)	N/A	Hours
Events in which Immediate Operator Action is required	none	e.g. any internal/external initiating events, none
Limiting (shortest) Subsequent Operator Action Time	none	Hours (that are assumed when following EOPs)
Severe Accident Core Provisions	No core melt	e.g. no core melt, IVMR, Core Catcher, Core Dump Tank, MCCI
Core Damage Frequency (CDF)	N/A	x/reactor-year (based on reference site and location)
Severe Accident Containment Provisions	TRISO Fuel containment	e.g., H2 ignitors, PARs, filtered venting etc.
Large Release Frequency (LRF)	N/A	x/reactor-year (based on reference site and location)

<table>
<tr><th colspan="3">Overall Build Project Costs Estimate or Range (excluding Licensing, based on the Reference Design Site and Location)</th></tr>
<tr><td>Construction Time (nth of a kind)</td><td><12</td><td>Months from first concrete to criticality</td></tr>
<tr><td>Design, Project Mgmt. and Procurement Effort</td><td></td><td>Person-years (PY) [DP&P]</td></tr>
<tr><td>Construction and Commissioning Effort</td><td></td><td>PY [C&C]</td></tr>
<tr><td>Material and Equipment Overnight Capital Cost</td><td></td><td>Million US$(2015) [M&E], if built in USA</td></tr>
<tr><td>Cost Breakdown</td><td>%[C&C]/%[M&E]</td><td></td></tr>
<tr><td>- Site Development before first concrete</td><td></td><td rowspan="5">(e.g. 25/10)
(30/40)
(20/25)
(20/10)
(5/15)
(-----------)
(to add up to 100/100)</td></tr>
<tr><td>- Nuclear Island (NSSS)</td><td></td></tr>
<tr><td>- Conventional Island (Turbine and Cooling)</td><td></td></tr>
<tr><td>- Balance of Plant (BOP)</td><td></td></tr>
<tr><td>- Commissioning and First Fuel Loading</td><td></td></tr>
<tr><td>Factory / On-Site split in [C&C] effort</td><td></td><td>%/% of total [C&C] effort in PY (e.g., 60/40)</td></tr>
<tr><th colspan="3">Nuclear System</th></tr>
<tr><td>System Steam Flow Rate</td><td></td><td>kg/s</td></tr>
<tr><td>System Steam Pressure</td><td></td><td>MPa</td></tr>
<tr><td>System Steam Temperature</td><td></td><td>ºC</td></tr>
<tr><td>System Feedwater Flow Rate</td><td></td><td>kg/s</td></tr>
<tr><td>System Feedwater Temperature</td><td></td><td>ºC</td></tr>
<tr><th colspan="3">Reactor Core</th></tr>
<tr><td>Active Core Height</td><td></td><td>m</td></tr>
<tr><td>Equivalent Core Diameter</td><td></td><td>m</td></tr>
<tr><td>Average Linear Heat Rate</td><td></td><td>kW/m</td></tr>
<tr><td>Average Fuel Power Density</td><td></td><td>kW/kgU</td></tr>
<tr><td>Average Core Power Density</td><td></td><td>MW/m3</td></tr>
<tr><td>Outer Diameter Of Fuel Rods</td><td></td><td>mm</td></tr>
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4. Plant Layout, Site Environment and Grid Integration

SUMMARY FOR BOOKLET

The site for an eVinci microreactor requires an above ground installation with less than a 3-acre footprint and reduced ground disruption. No water is required for cooling or operation. The reactor is factory built and delivered to site, allowing for rapid, on-site deployment. Multiple units can be deployed simultaneously or added over time. The eVinci microreactor can also be integrated with existing power sources. The reactor can be operated remotely due to its advanced passive safety systems and Autonomous Control System (ACS).

4.1 Site Requirements during Construction

The overall plant site to house the eVinci microreactor is shown in Figure 2.

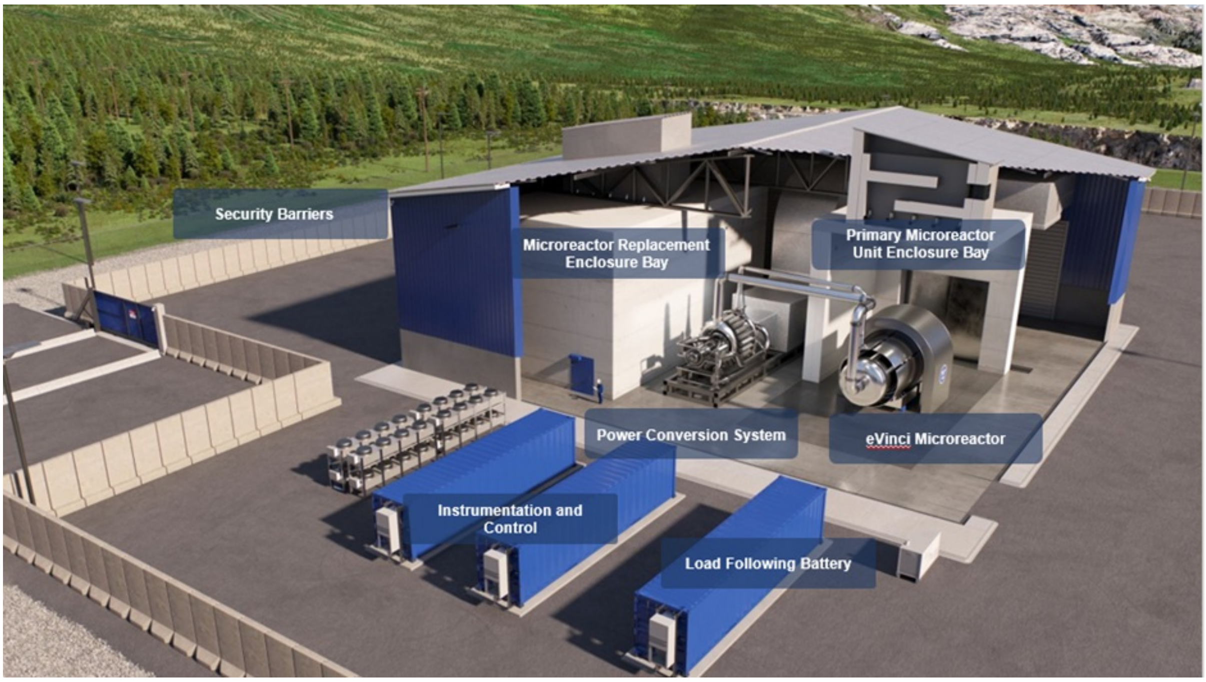

Figure 2. Rendering of eVinci microreactor plant site.

The whole system fits within a 60x60m building.

There are two enclosure bays located in the system building – one for the primary microreactor, and one for the replacement. These bays are stationed by the wall nearest to the surrounding system components outside of the building. The Power Conversion System (PCS) is located between the enclosure bays. Pipes run from the PCS and through the side wall of the primary reactor bay, acting as the interface between the two components.

Security barriers outline the perimeter of the system building and its outer components.

The instrumentation and Control and Load Following Battery lie outside the system component.

No spent fuel will be handled on-site. All fuel-related activities will be handled by Westinghouse at licensed facilities.

The reactor is fully assembled in a factory before being transported to the site, allowing for minimal onsite construction personnel to complete installation in 30 days.

4.2 Site Considerations during Operation

The eVinci microreactor will use the ambient surrounding air as the heat sink for passive heat removal.

Simplified decommissioning and return to greenfield at end-of-life.

4.3 Grid Integration

The eVinci microreactor can be seamlessly integrated with existing grids or to complement existing power sources, such as renewables and energy storage systems.

Load following characteristics:

- Minimum load: 20% reactor power
- Autonomous follow: <20% of operating power with no action
- Load increase >20%: instantaneous from 20% to 80% through battery
- Load shed instantaneous through turbine bypass valve

5. Technical NSSS/Power Conversion System Designn

SUMMARY FOR BOOKLET

The eVinci microreactor is a micro-modular reactor that utilizes passive heat pipes to circulate thermal energy from the reactor vessel to the working fluid in the Power Conversion System (PCS). The heat pipes, which are fully enclosed, contain sodium that uses capillary forces and pressure differences to naturally circulate the heat from one end of the pipe to the other. These components foster high reliability and operational simplicity compared, for instance, to forced circulation of a high-pressure coolant which may be featured in other micro reactor designs..

The reactor core of the eVinci microreactor is a solid-steel monolith structure containing channels, which are arranged in a hexagonal pattern, for fuel compacts, a graphite moderator, and heat pipes. The core is fuelled by UCO TRISO pellets, which are HALEU U-235 enriched uranium pellets coated in Oxycarbide layers.

The fuel handling system was designed so that all related activities will be performed off-site at licensed facilities. The spent fuel will be stored at these licensed facilities in casks until a Deep Geological Repository is constructed.

The PCS uses air as a working fluid, making the reactor appropriate to deploy in a large variety of environments. The use of air increases the overall efficiency of the eVinci microreactor by standardizing system components and effectively transferring heat.

The entire core of the reactor is encased by a canister containment subsystem (CCS) and a secure vault subsystem (SVS) to provide protection from external events. This allows the reactor to withstand harsh weather conditions, again increasing its deployment opportunities.

The eVinci microreactor implements an autonomous I&C system that uses the Westinghouse-owned ALS v2 platform. This system has been successfully demonstrated with various components of the reactor, from instrumentation to reactor trip logic.

5.1 Primary Circuit

The primary circuit of the eVinci microreactor consists of the reactor core and heat pipes and is interfaced to the PCS through the Primary Heat Exchanger (PHX).

The heat pipes transfer the thermal energy from the core through the natural circulation of sodium caused by pressure differences and gravity. A diagram describing the circulation of sodium in a heat pipe is shown in Figure 3. The inside of the heat pipes is lined with a porous structure called the wick. The evaporator end of a heat pipe receives heat from the core of the reactor and heats the sodium, causing it to flow through the central canal of the pipe. When the sodium reaches the condenser end, it transfers heat to the PHX and is absorbed by the wick, causing it to flow back down to the evaporator end.

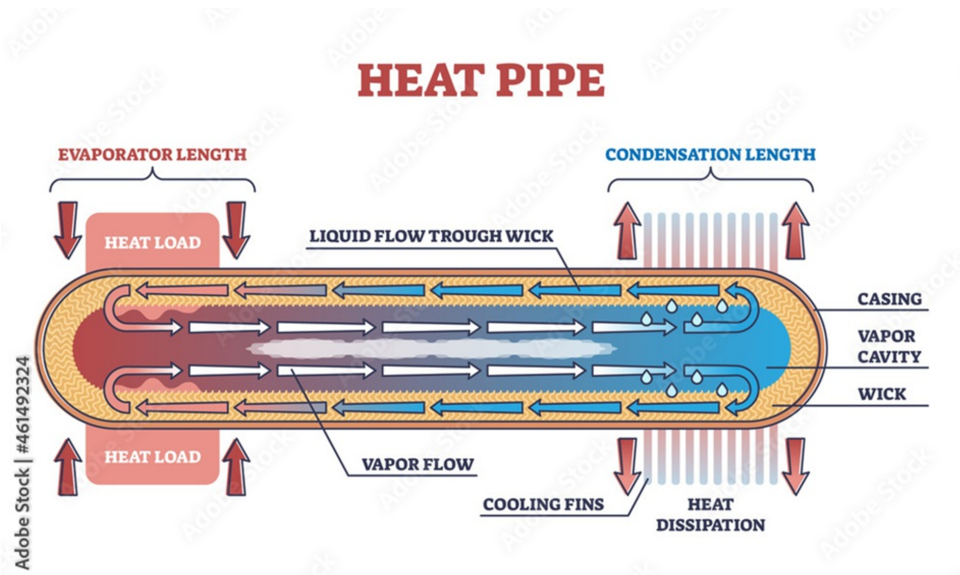

Figure 3. Circulation of working fluid in a heat pipe (source: bajeczneobrazy.pl).

The Passive Decay Heat Removal System (PHS) maintains the reactor core's temperature limits by transferring heat from the core to the heat sink (ambient air) through natural convection. This provides a simple and reliable safety case that does not require operators to maintain long term cooling of the reactor after shutdown.

The primary circuit is designed to operate in low-pressure environments, creating a more simple and durable design by reducing the amount of mechanical stress on its components.

5.2 Reactor Core and Fuel

The reactor core is a monolithic, hexagonal-shaped, graphite structure containing a pattern of channels for heat pipes and fuel compacts. It is fuelled by UCO TRISO particles, which consists of a U-235 HALEU-enriched kernel surrounded by a porous carbon buffer layer followed by an inner pyrolytic carbon layer, a SiC layer and an outer pyrolytic carbon layer that act as a primary containment structure for fission products.

The coatings surrounding the oxycarbide kernel make TRISO fuel extremely robust with high thermal stability and corrosion resistance to retain radioactive fission products under extreme reactor conditions. Its ability to perform in extreme reactor conditions has earned it approval from the Nuclear Regulatory Commission under the US Advanced Gas Reactor (AGR) fuel development and qualification program. In addition to its robustness, TRISO fuel offers the potential to support a higher discharge burnup.

5.3 Fuel Handling

All fuel handling will occur off-site at a licensed facility owned by Westinghouse.

When a reactor has reached the end of its life, the on-site replacement reactor will be installed, and a newly refuelled reactor will be transported to the site and stored in the replacement enclosure.

The spent core block will be transported to a facility where it will be refurbished, refuelled and prepared for deployment to another site. The spent fuel will be stored in a cask on-site at the facility until a Deep Geological Repository is constructed.

The eVinci microreactor can last for 8+ years of full power operation before needing to be refuelled.

5.4 Reactor Protection

Core reactivity and shutdown is controlled through the control drums and shutdown rods.

The control drums are rotating rods bearing neutron absorbing and reflecting materials that are located at the radial periphery of the core. They control the reactivity of the reactor by rotating to positions that either reflect neutrons to decrease neutron leakages and increase probability of fission reactions or absorb neutrons to decrease probability of fission reactions. Driver motors are located at one end of each of the control drums and receive signals from the Autonomous Control System (ACS) that inform their rotation.

The shut down rods are responsible for complete shutdown of the reactor in emergency situations. Bearing neutron absorbing material, these rods are designed to be inserted into the core by a fail-safe insertion that is activated on loss of power or communication with the ACS. Once inserted into the core, the rods suppress reactivity ensuring safe reactor shutdown.

The core of the eVinci microreactor is designed with resilient integrity. It employs a simple design with no circulating fluid to eliminate effects that would reduce its durability over time, such as coolant interactions, liquid-to-boiling transients, and flow induced corrosion/vibration. The Passive Heat Decay system provides a safe and reliable means for maintaining a safe temperature in the core by relying on natural convection to transfer excess heat to the ambient air as the ultimate heat sink without reliance on safety system actuations, controls, or mechanical moving parts. This feature will also allow the reactor to maintain indefinite cooling following its shutdown without the need for operator actions. The use of TRISO fuel to power the core increases its ability to safely retain fission products as each individual fuel kernel is encased by a three-layer functional containment barrier able to withstand extreme environments.

5.5 Secondary Side

The Power Conversion System (PCS) utilizes an open-air Brayton cycle to harness the thermal energy created by the reactor for generation of electricity. The heat pipes collect thermal energy from the reactor and release it to the air in the PCS through the Primary Heat Exchanger (PHX). The heated air then expands in a series of turbines, spinning an alternator to generate electricity. The expanded air is then exhausted into the atmosphere while new air is taken in and compressed before being heated in the PHX again.

The utilization of air as the working fluid is very advantageous for the PCS. Its main benefits are the standardization of its components to enable flexible deployment of the reactor and the removal of risks due to fluid-flow induced effects, such as corrosion and vibration. It also maximizes deployment opportunities and minimizes environmental effects by allowing the system to avoid dependency on water for cooling.

The PCS's load following capabilities are powered by the Instrumentation and Control System (I&C) and load following batteries. The I&C System monitors energy demands and communicates with the PCS when it needs to increase or decrease electricity generation. The load following batteries are used to store excess electricity created during periods of low energy demand. This stored electricity is employed during demand spikes to instantly satisfy energy needs while the PCS generates more electricity.

5.6 Containment/Confinement

The reactor containment system is composed of a canister containment subsystem (CCS) and a secure vault subsystem (SVS). The CCS encases the entire core of the microreactor and features a robust design to safely contain and manage the nuclear fuel and fission products within the reactor system. Its structural components will prevent the release of radioactive materials and maintain a safe operating environment within the reactor vessel. The CCS is further fortified by the SVS, which provides multiple layers of protection against external hazards to maintain the integrity of the reactor during accident scenarios.

The eVinci microreactor is designed to operate at atmospheric pressure, eliminating the risks of mechanical failure, implosion, or chemical reactions caused by high pressure environments.

The Passive Heat Decay system, previously described in section 2.4, maintains safe temperatures for operation of the reactor.

5.7 Electrical, I&C and Human Interface

The I&C system is composed of the Westinghouse-owned ALS v2 platform. The I&C System autonomously monitors the state of the microreactor by communicating with various subsystems connected to the various components of the reactor.

The generator has a voltage of 4160 V and a frequency of 60 Hz. It has a fast speed control with a rate of 1 ms and can perform fast switching at a 10 kHz frequency change. It can also be adapted to support other grid or microgrid connections.

5.8 Unique Technical Design Features (if any)

6. Technology Readiness

SUMMARY FOR BOOKLET

The conceptual design for the eVinci microreactor was completed in 2022 and led to Westinghouse initiating licensing engagements with regulators in the U.S. and Canada. In 2023, Westinghouse started procurement for the Nuclear Test Reactor (NTR) design and began prototyping various components of the reactor for testing. Procurement of the NTR was completed for fabrication of its components to begin in 2024, along with criticality, transient, and irradiation testing. The eVinci design for manufacturing was also finalized. In the next few years, Westinghouse plans to test the NTR at the Idaho National Laboratory DOME facility, continue testing various eVinci systems, and initiate manufacturing to prepare for regulatory licensing approvals and commercialization.

6.1 Deployed Reactors
6.2 Reactors under Licensing Review

The eVinci microreactor is currently under licensing review in the U.S. with the Nuclear Regulatory Commission (NRC) and in Canada with the Canadian Nuclear Safety Commission (CNSC).

Westinghouse is leveraging its experience in licensing the globally operating AP1000 PWR to ensure global compliance of the eVinci microreactor. Westinghouse has been engaged with the NRC in the U.S. and the CNSC in Canada to ensure that the design meets the regulatory requirements set forth by each jurisdiction. This is supported by incorporation of safety standards established by international organizations, such as the International Atomic Energy Agency (IAEA), into the design and performance of comprehensive technical reviews of the reactor with regulatory experts. Westinghouse has also accounted for adaptability to local requirements in different regions in the eVinci microreactor’s design.

Westinghouse has employed an effective and comprehensive strategy to standardize and simplify the design of the eVinci microreactor. The microreactor features a modular design to help standardize its components and streamline its construction. The standardization of the components will simplify the production process and ensure consistency in quality and performance. All of the components of the eVinci microreactor are integrated into a single, compact unit, which reduces the reactor’s footprint and simplifies the installation process. The design’s complexity is also minimized to reduce maintenance requirements by incorporating passive systems that focus on natural physical processes, such as gravity and convection.

The eVinci microreactor features many novel design solutions and advancements with respect to conventional nuclear plants, such as pertaining to heat pipe technology, passive safety systems, load-following capabilities, autonomous operations, and long (8+ years) operation without refuelling. The reactor uses heat pipe technology to passively conduct heat transfer through the natural circulation of sodium, ensuring stable and effective thermal management by eliminating the need for mechanical pumps. Passive safety systems rely on natural physical processes, such as gravity, convection, and thermal conduction, and enhance the reactor’s inherent safety by functioning without external power or active control mechanisms. Load-following capabilities allow the reactor to adjust its power output to match varying demands of electricity, which is useful for integration with renewable energy sources that have variable outputs. These capabilities include instantaneous load increases greater than 20% of operating power through load following batteries, instantaneous load sheds greater than 20% of operating power through turbine bypass valves, and autonomous follows less than 20% of operating power with no action. The autonomous operation of the eVinci microreactor, which is enabled by Westinghouse’s developments in the areas of advanced control systems and remote monitoring technologies, significantly reduces the need for on-site personnel.

Westinghouse is collaborating with many institutions to advance R&D and design of the eVinci microreactor. The Department of Energy (DOE) has chosen the eVinci microreactor as a candidate for testing in Idaho National Laboratory's DOME facility and is awarding Westinghouse with HALEU produced from DOE-owned assets under the HALEU Availability Program (HAP). The Saskatchewan Research Council in Canada is providing their nuclear expertise to support the development of the reactor and to facilitate the licensing process under the CNSC. Prodigy has chosen to collaborate with Westinghouse for a transportable nuclear power plant (TNPP), a floating nuclear power plant that is docked close to where energy is needed, that will feature an eVinci microreactor to provide energy in remote or harsh climates. Westinghouse is also working with Emirates Nuclear Energy Corporation (ENEC) to explore deployment of the eVinci microreactor in the United Arab Emirates.

Westinghouse currently assesses that the eVinci microreactor is expected to be ready for deployment in 2029.

6.3 Reactors in the Design Stage

7. Safety Concepts

SUMMARY FOR BOOKLET

The eVinci is designed with diverse and redundant safety features, from accident-tolerant fuel to passive heat removal.

- Heat Pipes – passive, self-regulating heat transport devices eliminating the need for reactor coolant.
- TRISO Fuel – 19.75% enriched fuel is structurally more resistant to neutron irradiation, corrosion, oxidation, and high temperatures.
- Shut Down Rods – inserted during transport as well as providing defence-in-depth shutdown capabilities.
- Control Drums – adjust reactivity and provide shutdown capabilities.
- Passive Heat Removal System (PHS) – decay heat removal via natural convection and radiation heat transfer without the need for operator actions
- Remote Monitoring – the Instrumentation and Control system uses the ALS v2 platform, a Westinghouse-developed, owned, and tested system.

7.1 Safety Philosophy and Implementation

Westinghouse's safety concept and design philosophy for the eVinci microreactor prioritize inherent safety, simplicity, and reliability. This is achieved through the incorporation of robust, passive safety features, consisting of heat pipes, TRISO fuel, shut down rods, control drums, passive heat removal system, and remote monitoring.

Heat Pipes

The heat pipes are responsible for efficiently transferring thermal energy from the reactor core to the PHX in the PCS. They use the principles of phase change and capillary action with sodium to transfer heat. One end of the heat pipe is called the evaporator and receives heat from the reactor, while the other end is called the condenser and releases heat to the PHX. The inside of the heat pipes is lined with a porous metallic structure called a wick. The sodium circulates throughout the heat pipe by flowing down the central canal toward the condenser after it receives heat at the evaporator, then by being absorbed into the wick and flowing back towards the evaporator after it loses heat at the condenser. The heat pipes are a very reliable system that enables high-temperature operation with passive heat transfer at atmospheric pressure compared to other solutions requiring forced coolant flow and high-pressure operation that are thus subject to mechanical failures.

TRISO Fuel

TRISO fuel is made up of particles containing a UCO kernel with 19.75% U-235 enriched uranium surrounded by a porous carbon buffer layer followed by an inner pyrolytic carbon layer, a SiC layer and an outer pyrolytic carbon layer. These particles are loaded into fuel compacts in the reactor core, to generate thermal energy through nuclear fission reactions. TRISO fuel is known for being extremely robust because it can retain radioactive fission products under extreme reactor conditions. The triple-coating layers create a barrier resistant to neutron irradiation, corrosion, oxidation, and high temperatures, preventing the release of radioactive particles.

Shut Down Rods

The shut down rods are not used during regular operation – they are only used for complete shutdown of the reactor during emergency scenarios or transportation of the reactor to a plant site. The rods bear neutron-absorbing materials and rely on fail-safe operation by using spring-loaded mechanisms to achieve insertion into the reactor core thereby suppressing fission reactions. The fail-safe operation of the shutdown rods does not require operator action for their actuation and insertion, and it remains functional if other systems go into failure mode.

Control Drums

The control drums are rotating rods bearing neutron absorbing and reflecting materials that can adjust the reactivity of the core as to compensate for fuel depletion effects and load following and associated reactivity changes. Located at the radial periphery of the core, the drums are controlled by the autonomous I&C system, which uses energy-usage data to determine rotational position of the drums. The control drums maintain criticality of the eVinci microreactor preventing excess fission reactions when the neutron absorbing part faces the active core, while reducing neutron leakages when the neutron reflective part is facing the active core.

Passive Heat Removal System (PHS)

The PHS is designed to remove excess heat from the reactor core via natural convection and thermal radiation to the heat sink (surrounding environment) or the heat exchanger. This system contributes to the overall safety and reliability of the microreactor by maintaining safe temperature limits without relying on active mechanical systems or operator intervention, thus reducing the risk of overheating and potential accidents.

Remote Monitoring

The eVinci microreactor is equipped with the Westinghouse ALS v2 platform to enable remote monitoring that provides continuous, real-time oversite of the reactor's operational status. Through continuous data collection, operational issues can be detected early and addressed promptly to ensure that the reactor operation is maintained within safe parameters. This system also features predictive maintenance diagnostic capabilities to anticipate servicing or replacements of components that may be subjected to future malfunctioning and provide additional enhanced security to protect the reactor from unauthorized access or tampering.

7.2 Transient/Accident Behaviour

Information regarding this topic is not available for public release at this time.

8. Fuel and Fuel Cycle

SUMMARY FOR BOOKLET

The eVinci microreactor uses 19.75% U-235 enriched UCO TRISO fuel arranged into fuel compacts that are loaded into the reactor's core. The reactor is able to operate for 8+ year refuelling cycles. Refuelling does not take place on customer site; instead, a spent reactor core will be transported to a licensed facility where refuelling and spent fuel storage will occur, with newly fuelled reactor cores will replace spent fuel reactor cores.

8.1 Fuel Cycle Options

The nuclear fuel loaded in the eVinci microreactor is the NRC-approved UCO TRISO fuel. Featuring U-235 enrichments up to 19.75%, the TRISO fuel kernels are coated in three protective pyrolytic carbon and SiC layers that act as a functional containment structure. These pellets are packed into fuel compacts, which are then loaded into the reactor core.

The fuel cycle for the eVinci core is 8 years when operating at full power. This period is extended if the reactor does not operate at full power during its deployment.

The refuelling process for the eVinci microreactor is very similar to changing a battery. When the fuel has exhausted its capability to sustain the chain reaction, the core will be removed from the site and transported to a licensed facility, while a new fuelled core is installed in its place. At the facility, the spent fuel will be removed from the core and stored in a cask on-site at the facility until a Deep Geological Repository is constructed, while the reactor will be refurbished and refuelled for redeployment to another site. This process ensures that no spent fuel needs to be handled on customer sites.

Excess reactivity is controlled by the autonomous I&C system and other passive safety systems, such as the control drums and shutdown rods. Descriptions of these systems can be found in the previous section.

8.2 Resource Use Optimization

Information regarding this topic is not available for public release at this time.

8.3 Unique Fuel/Fuel Cycle Design Features

9. Safeguard & Physical Security

SUMMARY FOR BOOKLET

Westinghouse consistently works to ensure the implementation of physical security and safeguards in the design of the eVinci microreactor.

9.1 Safeguards

Westinghouse consistently engages with the IAEA and other regulatory bodies to ensure that the necessary steps are taken to implement safeguards into the design of the eVinci microreactor.

The I&C system uses the ALS v2 platform, which is a Westinghouse-owned I&C platform. Westinghouse has successfully demonstrated the foundation of the autonomous I&C system hardware and software from instrumentation to reactor trip logic.

Measures taken to protect against material theft and misuse are currently not available to share with the public.

9.2 Security

Information regarding this topic is not available for public release at this time.

9.3 Unique Safeguards and/or Security Features

10. Project Delivery & Economics

SUMMARY FOR BOOKLET

Information regarding this topic is not available for public release at this time.

10.1 Project Preparation and Negotiation
10.2 Construction and Commissioning
10.3 Operation and Maintenance