U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

DOE Support for Advanced Reactor Demonstrations

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Office of Nuclear Energy

NETWG Q2 Meeting

March 15, 2022

- In the United States, we are committed to getting to:
  - 100 percent clean energy on our transmission grid by 2035, and
  - net-zero carbon emissions by 2050.

- Investments in clean energy technologies will ensure the U.S. is the global leader in research, development, and deployment of critical energy technologies to combat the climate crisis, create good-paying union jobs, and strengthen our communities in all pockets of America.

Advanced Reactors: Integrated Grid for Net-zero Future

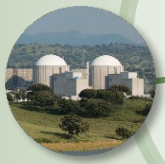
TODAY

Baseload Electricity Generation

FUTURE

Large Light Water Reactors

Small Modular Reactors



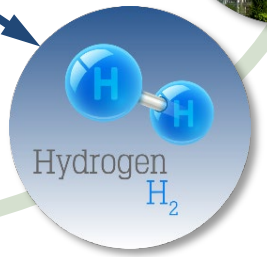
Microreactors

Heat

e⁻

Flexible Electricity Generation

Industrial Applications

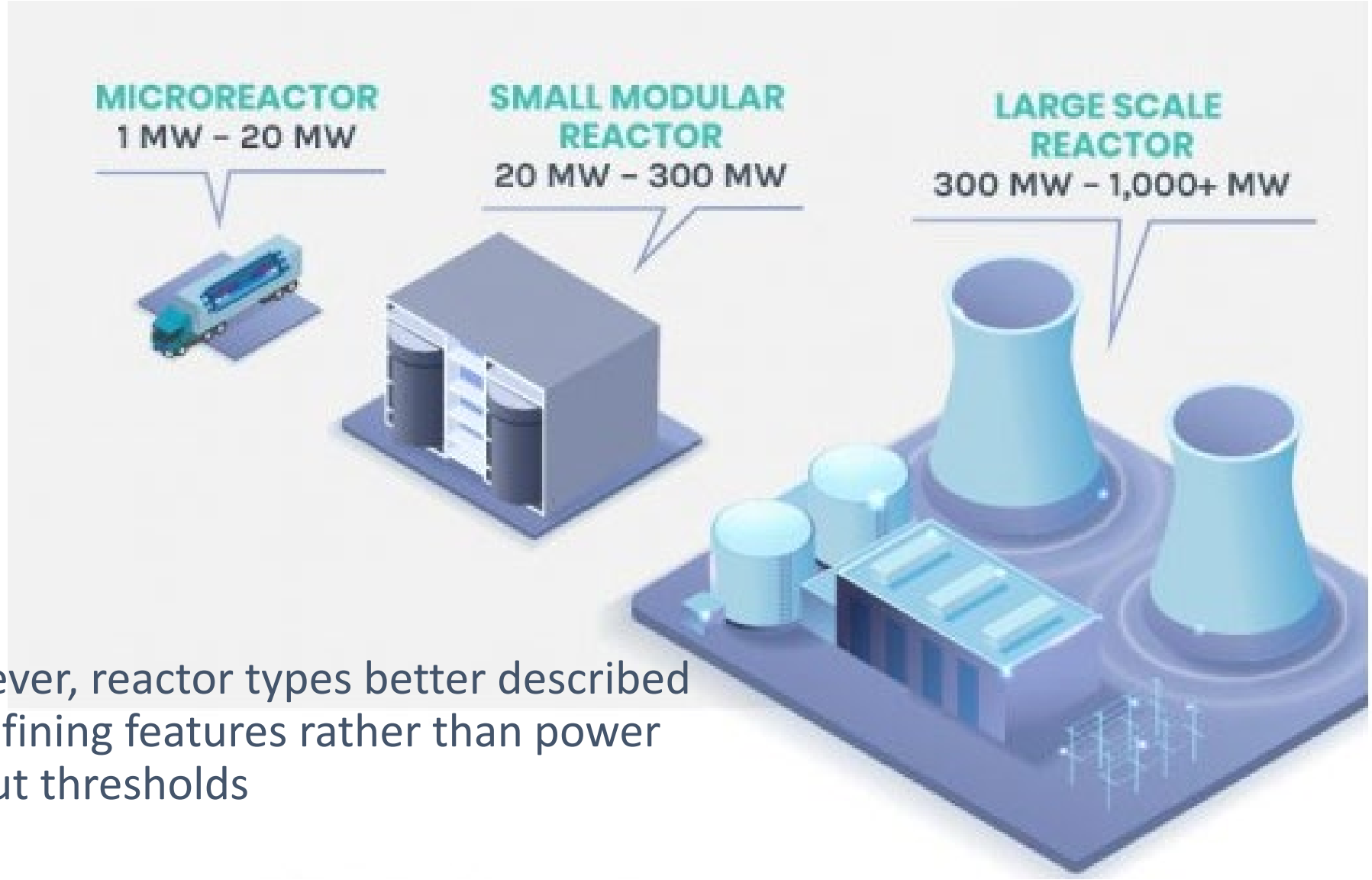


Hydrogen for Vehicles and Industry

New Chemical Processes

Clean Water

Nuclear has the right-sized reactors to meet the energy needs of any community



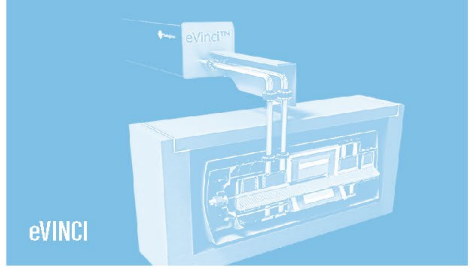
However, reactor types better described by defining features rather than power output thresholds

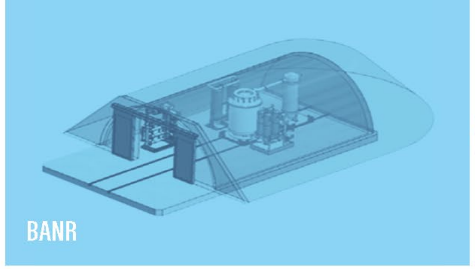
Defining Features

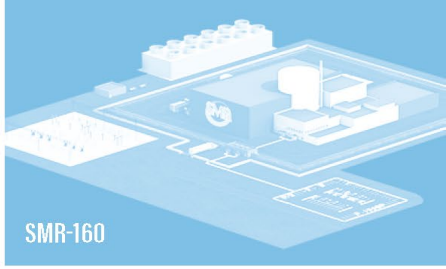
- **Larger Scaled Conventional Reactors - upper-hundreds to 1000+ MWe range**
  - Large output for carbon-free baseload power generation
  - Require substantial on-site preparation, construction, and assembly prior to operation

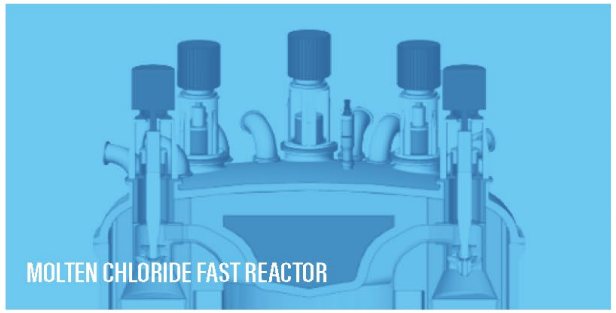
- **Small Modular Reactors – tens to mid-hundreds MWe range**
  - Siting and operational flexibility – load following and non-electric applications
  - Factory fabricated major plant components and systems that can be readily transported
  - Limited on-site preparation and reduced construction times
  - Shared control rooms, balance-of-plant systems – increased operational efficiencies and cost savings
  - Additional reactor modules can be added incrementally as demand for energy increases.

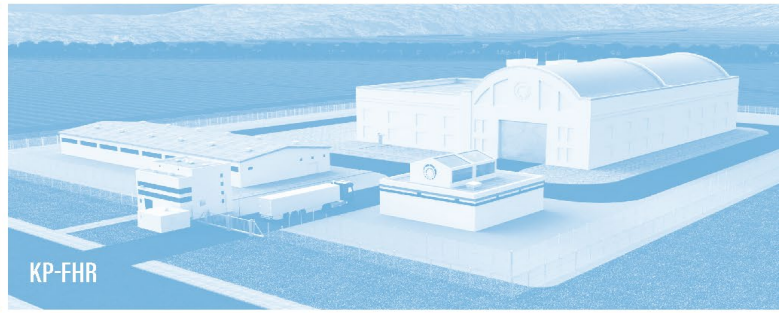
- **Microreactors – one to tens of megawatts-electric (MWe) range**
  - Factory fabricated with highly integrated systems
  - Readily transportable nearly fully assembled to operating site by truck, rail, aircraft, or ship
  - Minimal on-site preparation is required prior to operation
  - Employ passively safe operating and fuel designs
  - Semi-autonomous control systems with remote monitoring features with minimal on-site staffing
  - Long intervals without refueling (e.g., 10 years)
  - Developers exploring both mobile and fixed location designs











ADVANCED NUCLEAR TECHNOLOGY

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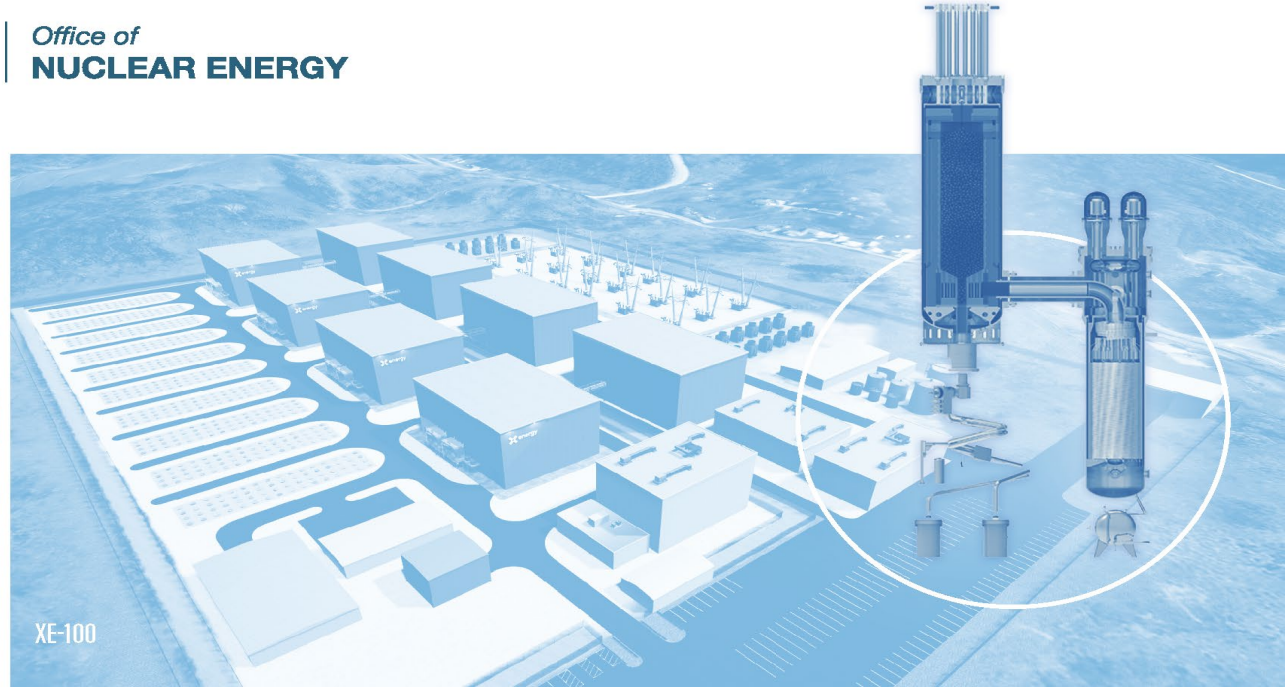
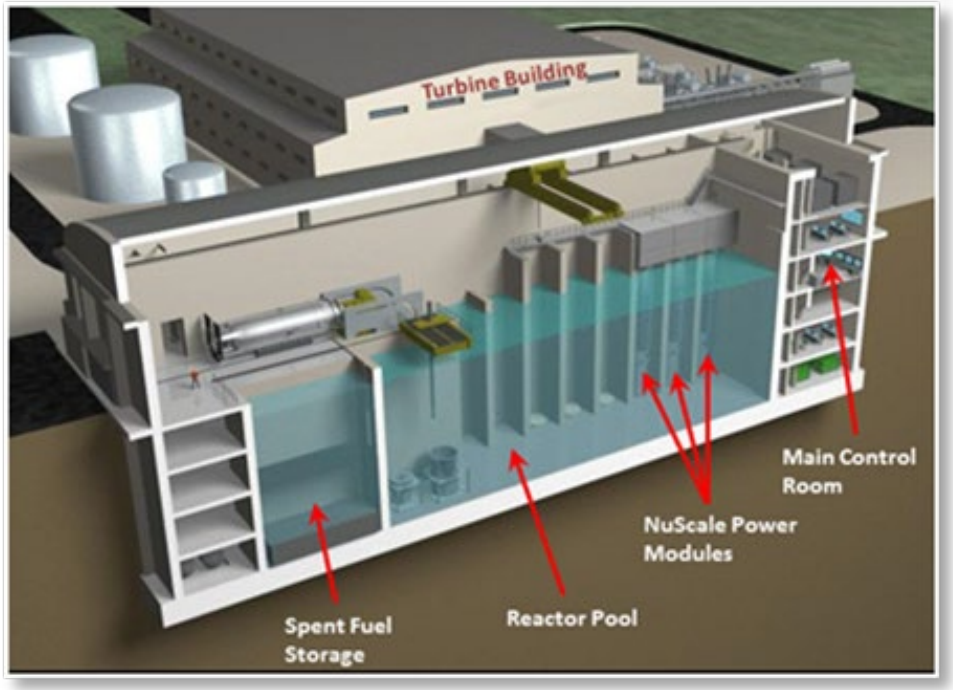


Evolution of Industry Partnerships

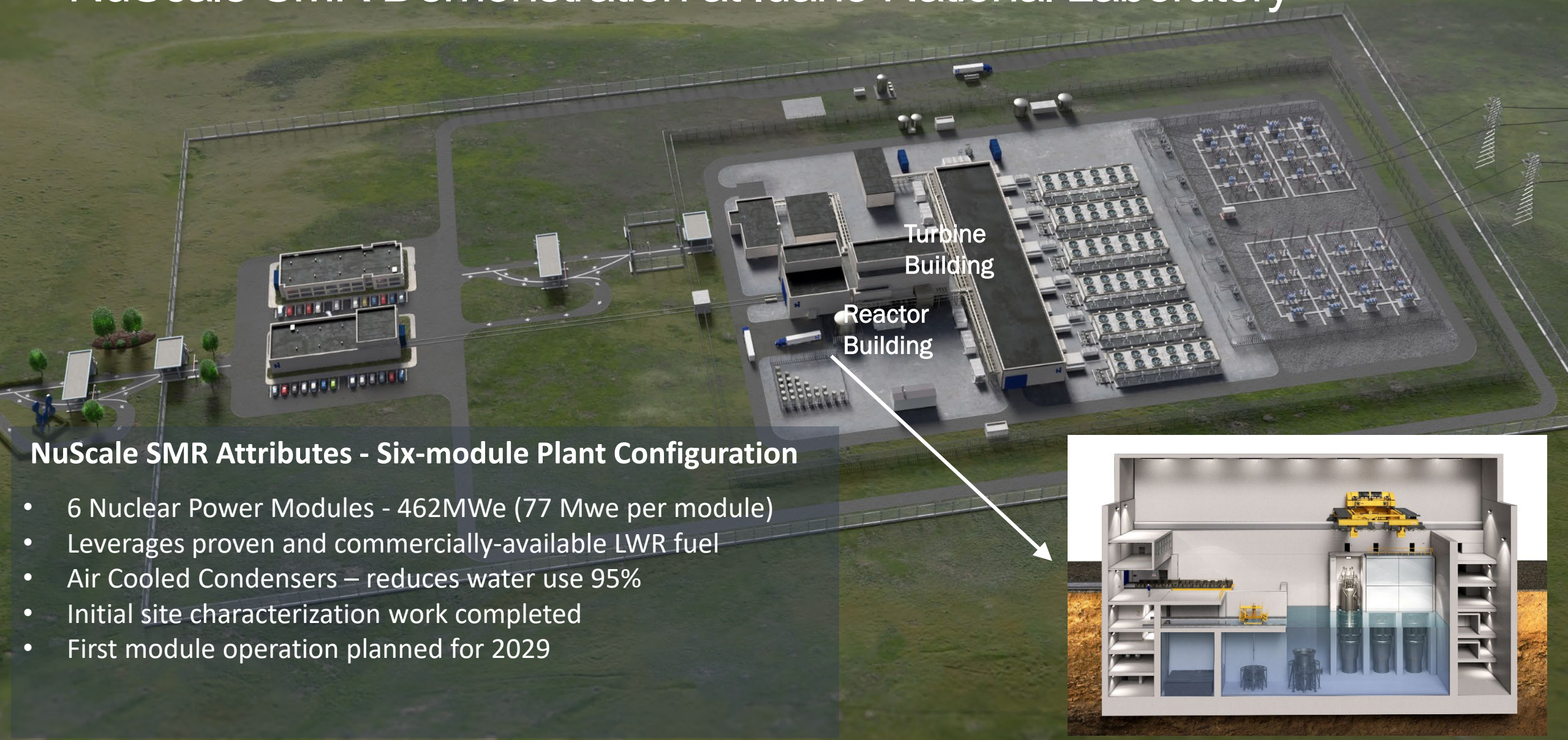
- **2005-2011 – Nuclear Power (NP) 2010 program**
  - Supported development of GEN 3+ advanced LWR designs (Westinghouse AP-1000 and General Electric ESBWR)
- **2012-2017 – Small Modular Reactor (SMR) Licensing Technical Support (LTS) Program**
  - Supported design and licensing of SMR designs (NuScale and B&W mPower)
  - Also conducted generic research and studies important to siting and licensing of SMR designs
- **2017-Present – activities to advance NuScale SMR technology through licensing and demonstration**
  - Design finalization and commercialization efforts supported through Industry FOA awards
  - NuScale SMR FOAK Nuclear Demonstration Readiness Project (2019-Present)
  - Carbon Free Power Project – a first deployment of a NuScale reactor at INL (2020-Present)
- **2020-Present – Advanced Reactor Demonstration Program**
  - Congressionally-driven program to demonstrate two commercial advanced designs in 7 years
  - Also provides risk reduction funding for a diverse set of less mature designs

DOE Support for NuScale SMR Licensing and Demonstration

- DOE private-public partnership with NuScale supports licensing, supply chain development and manufacturing readiness to enable a commercial demonstration by 2029
- NuScale submitted a Design Certification Application (DCA) to the Nuclear Regulatory Commission in January 2017
  - NRC issued final safety evaluation report August 2020
- Varying plant configurations are possible, with 6-module configuration as a baseline
- Carbon Free Power Project
  - First planned commercial demonstration at Idaho National Laboratory by 2029



Carbon Free Power Project:
NuScale SMR Demonstration at Idaho National Laboratory



NuScale SMR Attributes - Six-module Plant Configuration

- 6 Nuclear Power Modules - 462MWe (77 Mwe per module)
- Leverages proven and commercially-available LWR fuel
- Air Cooled Condensers – reduces water use 95%
- Initial site characterization work completed
- First module operation planned for 2029

ARDP Demonstration Pathway Award:
Terrapower's Natrium Sodium-cooled Fast Reactor

Natrium Attributes

- 345 MWe nominal electric power output
- Zero emission dispatchable resource
- Price follower… w/ reactor at 100% power 24/7
- Flex to 500 MWe for 5.5 hours through thermal energy storage
- Project includes establishment of a metal fuel fabrication facility

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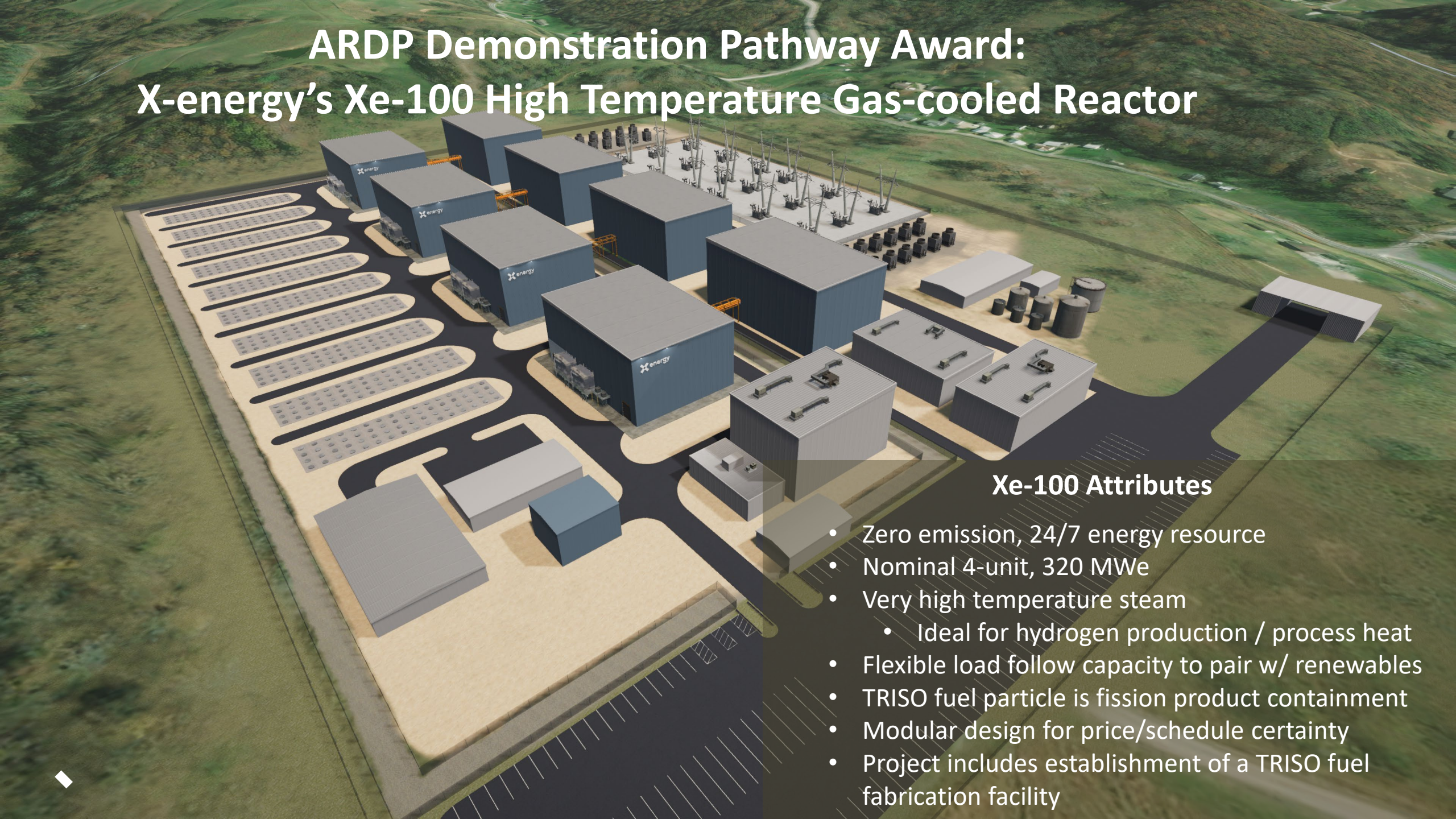
ARDP Demonstration Pathway Award:
X-energy's Xe-100 High Temperature Gas-cooled Reactor

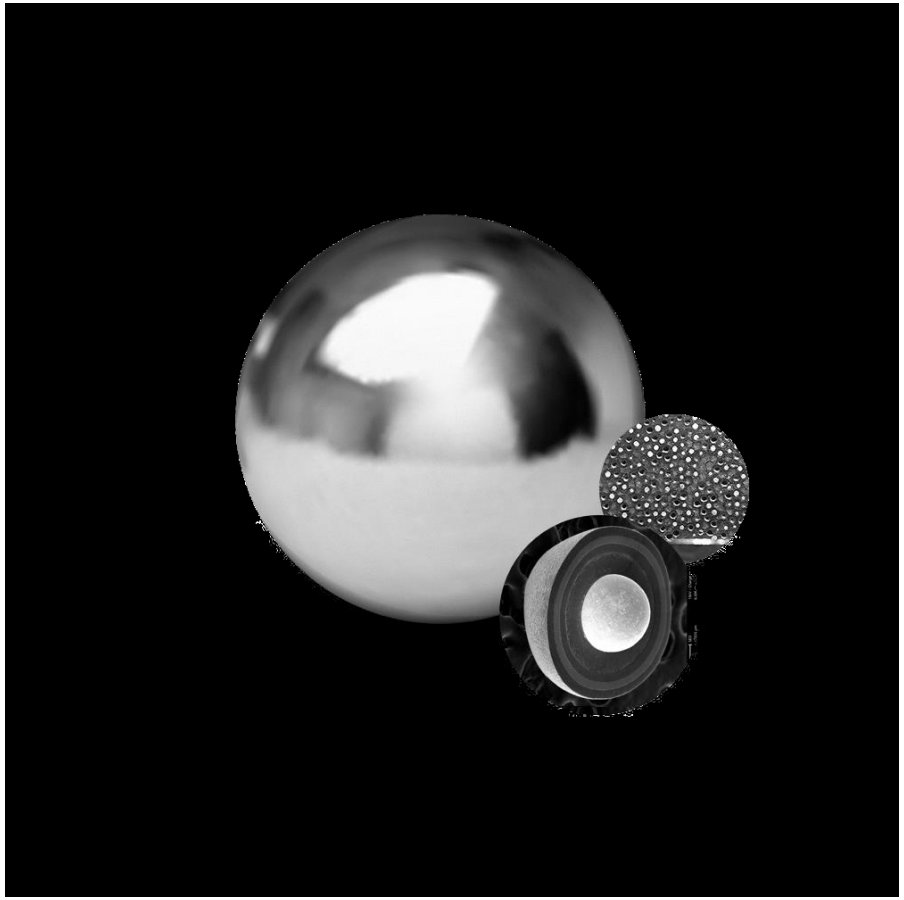


Xe-100 Attributes

- Zero emission, 24/7 energy resource
- Nominal 4-unit, 320 MWe
- Very high temperature steam
  - Ideal for hydrogen production / process heat
- Flexible load follow capacity to pair w/ renewables
- TRISO fuel particle is fission product containment
- Modular design for price/schedule certainty
- Project includes establishment of a TRISO fuel fabrication facility

TRISO Fuel – Many Designs Leveraging Deep Investments

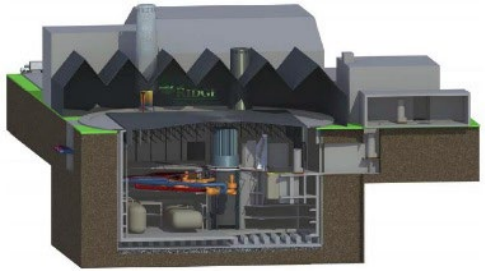
- TRISO coated-particle fuel has a proven pedigree – more than 30 years of operational and fabrication experience
- DOE has invested over $400M in the TRISO and graphite qualification programs
- Tested to 1800°C – remains safe and cannot melt even without active cooling
- Average fuel burnup that is approximately 4 times higher than existing reactors and significantly improves overall economics
- Excellent long-term robustness (thousands of years) which provides excellent spent fuel containment after use
- Fuel of choice for four of seven designs supported under Advanced Reactor Demonstration Program



Awards Made under ARDP Risk Reduction Pathway

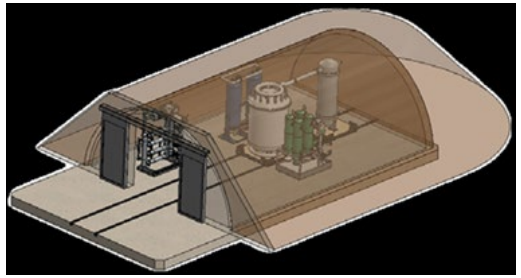
- Kairos KP-FHR fluoride salt-cooled, TRISO pebble fueled MSR
- Westinghouse eVinci microreactor – heat pipe cooled, TRISO compact fueled
- BWXT BANR – transportable microreactor, TRISO fueled
- Holtec SMR-160 – LWR-cooled SMR (only LWR design supported under ARDP)
- Southern/TerraPower Molten Chloride Fast Reactor (only liquid fueled design supported under ARDP)

- **Cooperative Agreements cost-shared at minimum 20% Industry/80% Government based on technology readiness levels**

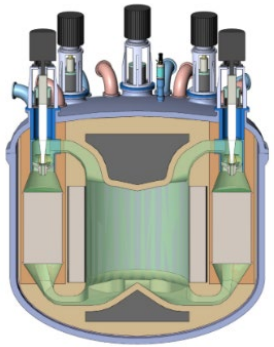


Kairos KP-FHR

Westingouse eVinci



BWXT BANR



TerraPower MCFR

Holtec SMR-160

Kairos Power Receives U.S. DOE ARDP Award

- Kairos Power is a recipient of an **Advanced Reactor Demonstration Program (ARDP)** award for Risk Reduction funding to support development of the Hermes reactor
- This is a cost-shared partnership between the DOE and industry to demonstrate advanced nuclear technology in the United States
- The total award value over the next seven years is **$629 million** (DOE share is $303 million)
- Kairos Power is partnering with Materion Corporation, Oak Ridge National Laboratory, Idaho National Laboratory, and Electric Power Research Institute on this project

OAK RIDGE National Laboratory

INL Idaho National Laboratory

EPRI ELECTRIC POWER RESEARCH INSTITUTE

MATERION

Courtesy of https://kairospower.consultation.ai/

Kairos Power Selects Oak Ridge Site to Deploy Hermes

- Kairos Power has acquired the former K-33 gaseous diffusion plant site at the East Tennessee Technology Park
- Hermes will achieve criticality in **2026**
- Hermes leverages proven technologies that originated in Oak Ridge with the Molten-Salt Reactor Experiment (MSRE) in the 1960s
- Kairos Power is investing **$100 million** and creating **55+ full-time jobs** to support construction and operation of Hermes
- Hermes is a collaborative effort by Kairos Power and our partners

Courtesy of https://kairospower.consultation.ai/


Thank you!
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