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NuScale Overview & District Heating

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Artistic concept of the NuScale Power Plant

Our Mission

NuScale Power provides scalable advanced nuclear technology for the production of electricity, heat, and clean water to **improve the quality of life for people around the world.**

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Who is NuScale Power?

- NuScale Power was formed in 2007 for the sole purpose of completing the design and commercializing a small modular reactor (SMR) – the NuScale Power Module™.
- Initial concept had been in development and testing since the 2000 U.S. Department of Energy (DOE) MASLWR program.
- Fluor, global engineering and construction company, became lead investor in 2011.
- In 2013, NuScale won a $226M competitive U.S. DOE Funding Opportunity for matching funds.
- >400 patents granted or pending in nearly 20 countries.
- >350 employees in 6 offices in the U.S. and 1 office in the U.K.
- Making substantial progress with a rigorous design review by the U.S. Nuclear Regulatory Commission (NRC).
  - Phase 4 of NRC Review is on schedule for completion December 2019.
- Total investment in NuScale to date ~US$800M.
- On track for first plant operation in 2026 in the U.S.

NuScale Engineering Offices Corvallis

One-third scale NIST-1 Test Facility

NuScale Control Room Simulator

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A bold, new energy source

- **Smarter energy** – flexible design can support multiple applications, integrate with renewables resources, provide highly reliable power to mission critical facilities, and serve as clean baseload power.
- **Cleaner Energy** – 100% carbon-free energy – as clean as wind or solar – with a small land footprint.
- **Safer Energy** – should it become necessary, NuScale's SMR shuts itself down and self-cools for an indefinite period of time, with no operator action required, no additional water, and no AC or DC power needed.
- **Cost Competitive –** the NuScale SMR is far less complex than other designs. Off-site fabrication and assembly reduce cost. Components are delivered to the site in ready-to-install form. All of this results in construction occurring in a shorter, more predicable period of time.

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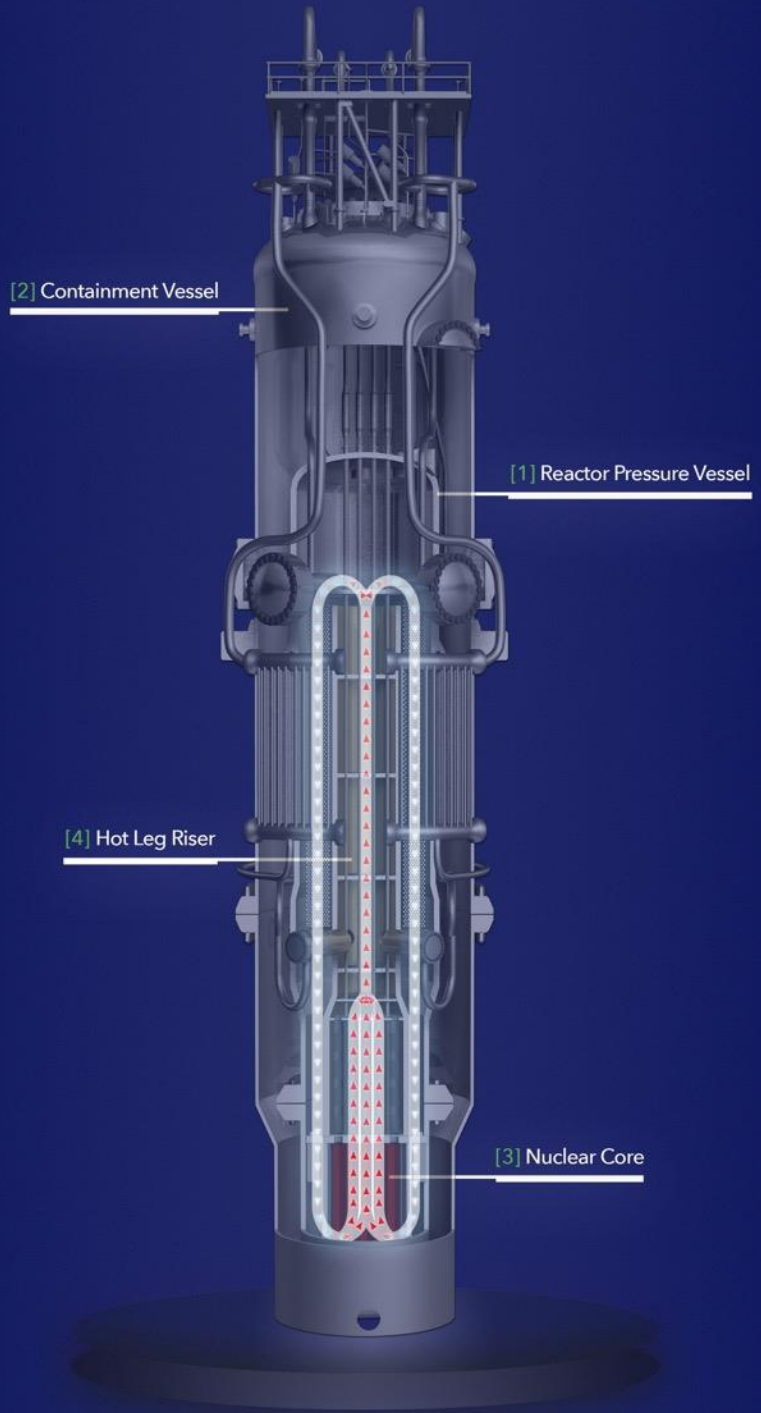

Core Technology: NuScale Power Module

- A **NuScale Power Module**™ (NPM) includes the reactor vessel, steam generators, pressurizer, and containment in an **integral package** – simple design that eliminates reactor coolant pumps, large bore piping and other systems and components found in large conventional reactors.

- Each module produces **up to 60 MWe**
  - small enough to be factory built for easy transport and installation
  - dedicated power conversion system for flexible, independent operation
  - incrementally added to match load growth
    - up to **12 modules for 720 MWe** gross (684 MWe net) total output

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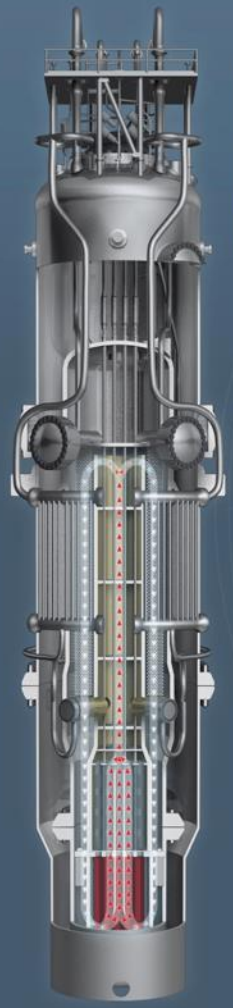
A New Approach to Construction and Operation



Factory Fabrication

NuScale Power Module™ including containment and reactor vessel

Housed in a 12 module reactor building

Shipped by truck, rail or barge

To the plant site

Low carbon, secure electricity

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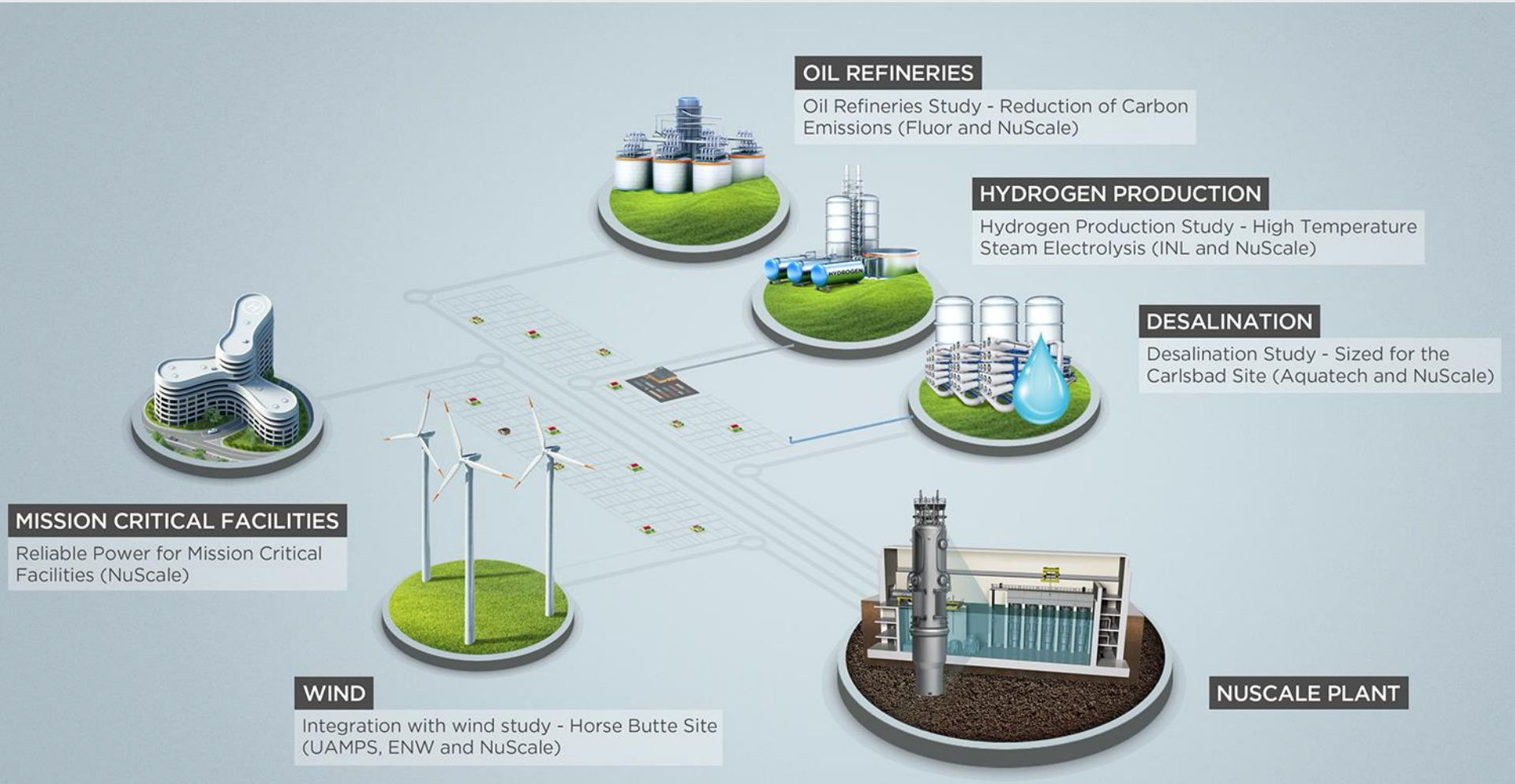
Beyond Baseload: NuScale Diverse Energy Platform



Reports for associated technical studies are available at: www.nuscalepower.com/technology/technical-publications

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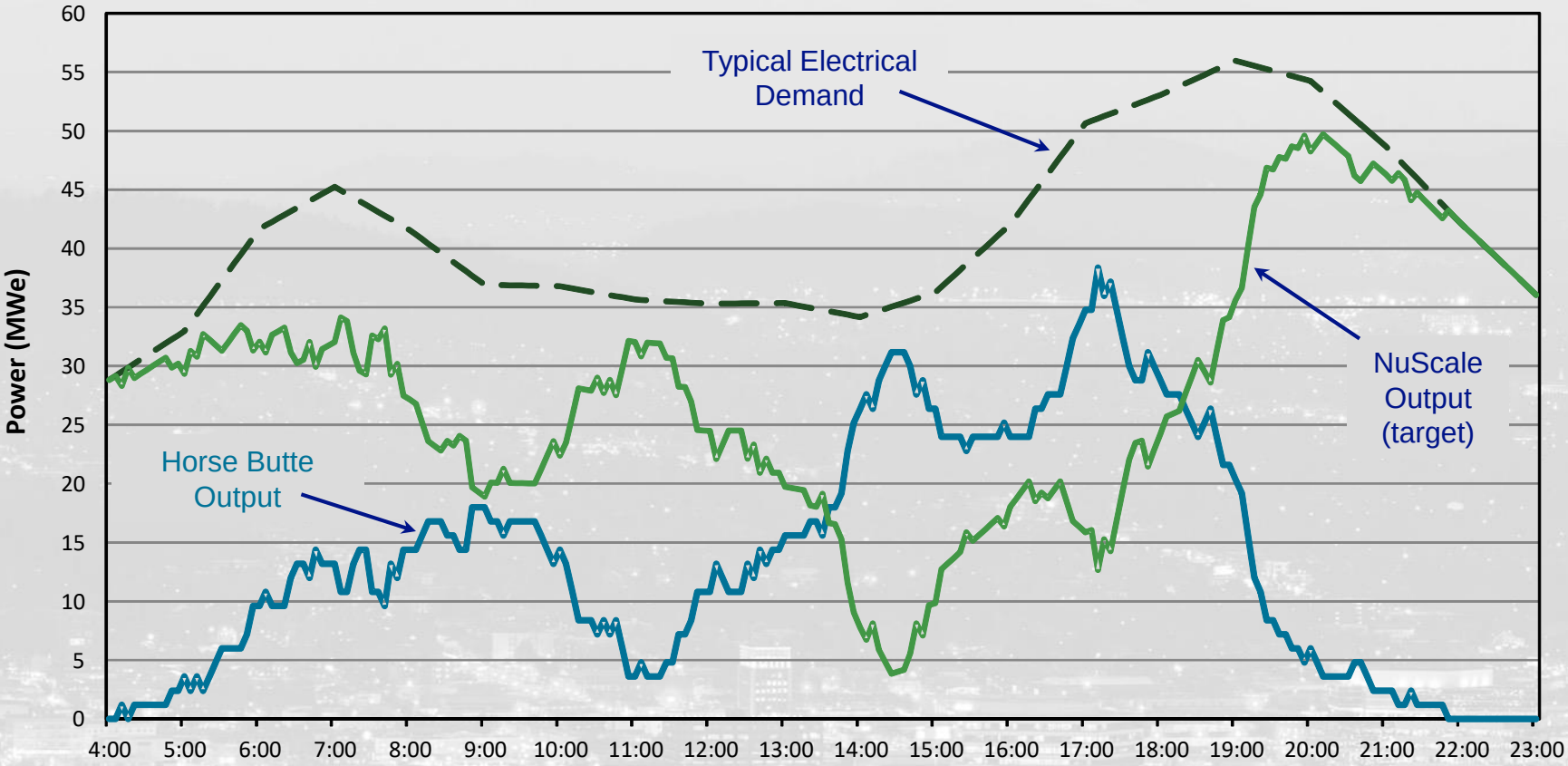
Load-Following with Wind



NuScale design meets or exceeds EPRI Utility Requirements Document (URD), Rev. 13, load following and other ancillary service requirements.

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Artistic concept of the NuScale Power Plant

District Heating

- Single NPM has a 200 MWth capacity and produces roughly 245,000 kg/hr of superheated steam with an outlet temperature of approximately 300°C.

Potential in Finland (ThinkAtom Report)

- **District Heating (DH)**
  - One or two NPMs could provide 61-97% of required heat in 2,400 GWh DH network, such as Turku, Tampere, or Espoo
  - Three to five NPMs could provide 65-90% of required heat in Helsinki
- **Combined Heat and Power (CHP)**
  - 50-150 MWth for district heating plus 15-45 MWe for electricity per module with turbine bypass (fluctuating demand winter/summer)
  - Eight NPMs could produce nearly all of 7 TWh of heat needed in Helsinki per year, in addition to 1.8 TWh of electricity

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A New Level of Plant Resiliency

Island Mode/Loss of Offsite Power

A single module can power the entire plant in case of loss of the grid; no operator or computer actions, AC/DC power or additional water required to keep the reactors safe

First Responder Power

On loss of the offsite grid, through variable (0% to 100%) steam bypass, all 12 modules can remain at power and be available to provide electricity to the grid as soon as the grid is restored

Resilience to Natural Events

Reactor modules and fuel pool located below grade in a Seismic Category 1 Building

- Capable of withstanding a Fukushima type seismic event
- Capable of withstanding hurricanes, tornados, and floods

Resilience to Aircraft Impact

Reactor building is able to withstand aircraft impact as specified by the NRC aircraft impact rule

Cybersecurity

Module and plant protection systems are non-microprocessor based using field programmable gate arrays that do not use software and are therefore not vulnerable to internet cyber-attacks

Electromagnetic Pulse (EMP/GMD)

Resilience to solar-induced geomagnetic disturbances (GMDs) and electromagnetic pulse (EMP) events beyond current nuclear fleet.

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Current Progress in Commercialization: Licensing, Supply Chain, and Customers

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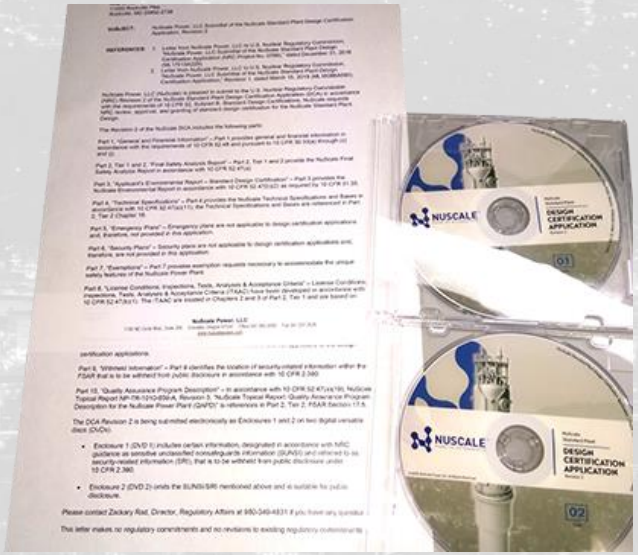
First SMR to Undergo Licensing in the U.S.

- Design Certification Application (DCA) completed in December 2016
- Docketed and review commenced by U.S. Nuclear Regulatory Commission (NRC) in March 2017
- Phase 4 of the NRC review on schedule for completion December 2019. Technical review would be completed.
- NRC has published its review and approval schedule; **to be approved in September 2020**



DCA Statistics

- 12,000+ pages
- 14 Topical Reports
- >2 million labor hours
- >800 people
- >50 supplier/partners
- Over $500M

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Image courtesy of Third Way Nuclear Reimagined

Right-sizing the Emergency Planning Zone (EPZ)

- NuScale's small core size and exceptional safety, defense-in-depth make the case for a **reduced EPZ to the site boundary**.
  - NuScale plants could be sited closer to population and industrial centers – where energy is needed most
- **Tennessee Valley Authority (TVA) demonstrating that site boundary EPZ possible for SMRs**
  - TVA analysis included information on Clinch River early site permit application using NuScale Plant design
  - Shows any accident radiological impact would be limited to within site boundary
  - Analysis provides basis for exemption from 10-mile EPZ
  - NRC preliminary findings agree with TVA analysis that reduced-size EPZs for SMRs are feasible

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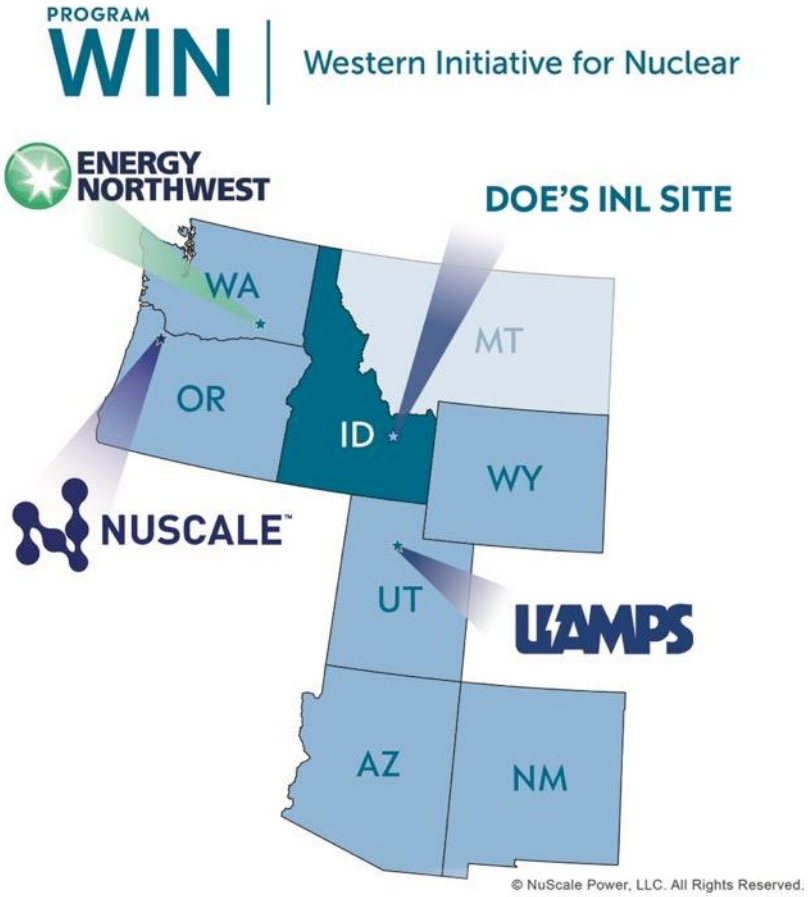
First Deployment: UAMPS Carbon Free Power Project



- **Utah Associated Municipal Power Systems (UAMPS)** provides energy services to community-owned power systems throughout the Intermountain West.
- First deployment will be a **12-module plant (720 MWe)** within the Idaho National Laboratory (INL) site, slated for **commercial operation in 2026.**
- DOE awarded $16.5 million in matching funds to perform site selection, secure site and water, and prepare combined operating license application to NRC.
- **Joint Use Modular Plant (JUMP)** Program: INL-DOE will lease one of the modules in the 12-module plant, for research purposes, an additional module may be used in a Power Purchase Agreement (PPA) to provide power to INL.

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The Future of Energy is Here

NuFuel HTP2 Testing

One-third scale NIST-1 Test Facility

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Economics

- **Simplicity of design provides competitive levelized cost of electricity (LCOE) compared to other low carbon options**
  - Lower up-front cost and lower operating cost as compared to large light-water nuclear reactors
    - Competitive overnight capital cost compared to large advanced nuclear
    - First plant target overnight capital cost ~ $4,200/KW
    - First plant target LCOE - $65/MWh
- **Up to 12 modules can be added to a facility incrementally (e.g., in response to load growth), reducing initial capital costs**
- **First module in situ can generate power and bring in revenue immediately**
- **NuScale Power Modules fabricated in an off-site facility, bringing cost savings associated with repetitive manufacture**
  - Realize benefits of repetitive factory fabrication

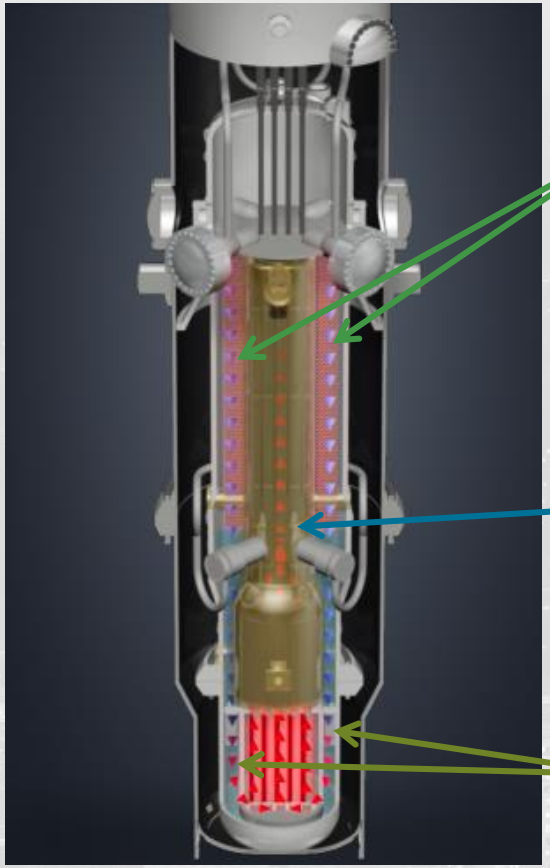
Simplicity Enhances Safety

Natural Convection for Cooling
- Passively safe - cooling water circulates through the nuclear core by natural convection eliminating the need for pumps

Seismically Robust
- System submerged in a below-grade pool of water in an earthquake and aircraft impact resistant building

Simple and Small
- Reactor core is 1/20th the size of large reactor cores
- Integrated reactor design - no large-break loss-of-coolant accidents

Defense-in-Depth
- Multiple additional barriers to protect against the release of radiation to the environment



***Conduction* – the water heated by the nuclear reaction (primary water) transfers its heat through the walls of the tubes in the steam generator, heating the water inside the tubes (secondary water) and turning it to steam. This heat transfer cools the primary water.**

***Convection* – energy from the nuclear reaction heats the primary water causing it to rise by convection and buoyancy through the riser, much like a chimney effect**

***Gravity / Buoyancy* – colder (denser) primary water "falls" to bottom of reactor pressure vessel, and the natural circulation cycle continues**

Second-to-none safety case – site boundary Emergency Planning Zone capable

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Factory Fabrication

- NuScale Power Modules™ are produced in a factory and then shipped onsite to be installed in the reactor building
- In 2018, **BWX Technologies, Inc. (BWXT)** was selected to provide manufacturing input leading to fabricating the first NuScale Power Modules™
  - The decision follows a rigorous 18-month selection process, with expressed interest from 83 companies based in 10 countries
- In 2019, BWXT and NuScale are collaborating to update the design optimizing for manufacturing and transportation and reducing overall costs of the NuScale Power Modules
- Manufacturing trials are planned for 2020

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What about the waste, i.e., used fuel?

- What you normally hear about as nuclear waste is actually the “used fuel” removed from a reactor, which still contains **~96% of the unused energy** that can be recovered to produce new fuel. This used fuel is currently stored in pools of water or in robust containers on a concrete pad (dry cask storage).
- All of the used nuclear fuel produced by the nuclear energy industry in the last 60 years has been safely managed and stored, primarily at plant sites in pools or dry cask storage.
- The NuScale power plant design includes a proven **safe and secure used fuel management system**.
- Used fuel management, storage, and disposal is regulated by U.S. Nuclear Regulatory Commission (NRC) and the **U.S. Department of Energy (DOE)** has responsibility for its ultimate disposal.
- **Recycling used fuel** could significantly reduce the burden of mining and disposing of used fuel, making our nuclear fuel cycle more sustainable.

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