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NuScale: Resilient Power

United States Association for Energy Economics (USAEE) Webinar

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Acknowledgement and Disclaimer

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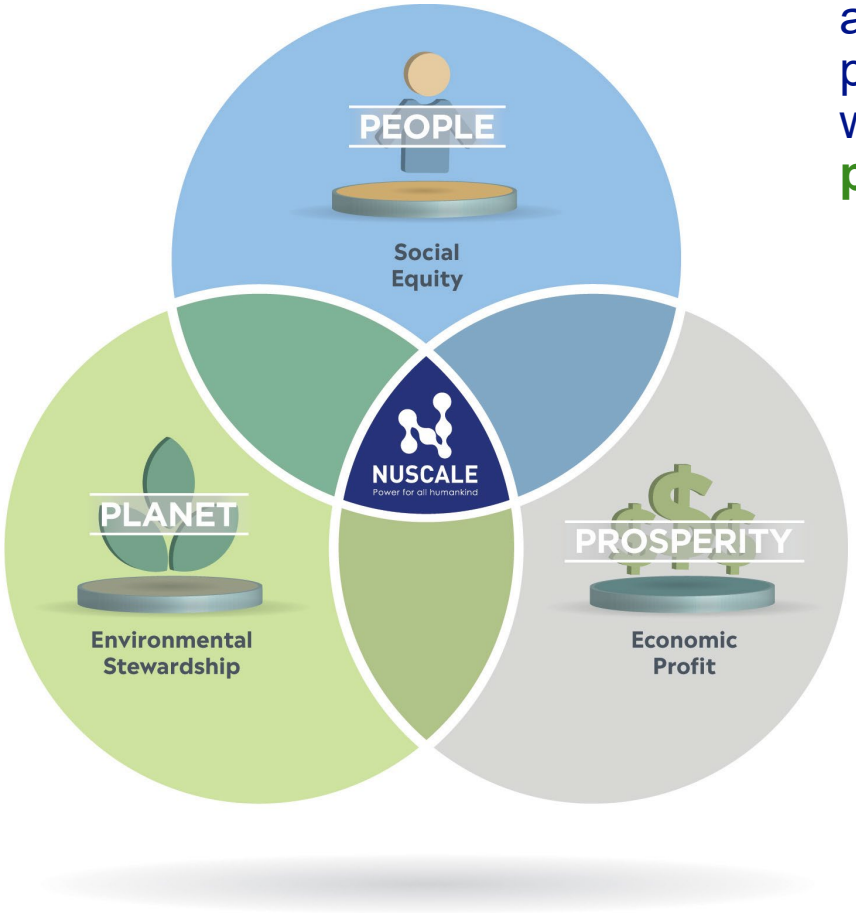
Commitment to People, Planet, Prosperity



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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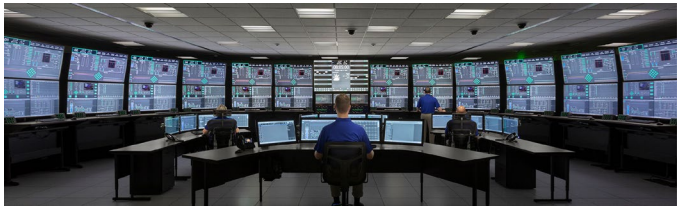
Who is NuScale Power?

- Initial concept had been in development and testing since the 2000 U.S. Department of Energy (DOE) MASLWR program.
- 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™.
- Fluor, global engineering and construction company, became lead investor in 2011.
- In 2013, NuScale won a competitive U.S. DOE Funding Opportunity for matching funds, and has been awarded over $300M in DOE funding since then.
- >520 patents granted or pending in nearly 20 countries.
- >380 employees in 6 offices in the U.S. and 1 office in the U.K.
- Rigorous design review by the U.S. Nuclear Regulatory Commission (NRC) to be completed in 2020.
- Total investment in NuScale to date is greater than US$900M.
- On track for first plant operation in 2027 in the U.S.

NuScale Engineering Offices Corvallis

One-third Scale NIST-2 Test Facility



NuScale Control Room Simulator

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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 completed December 2019; technical review is complete.
- 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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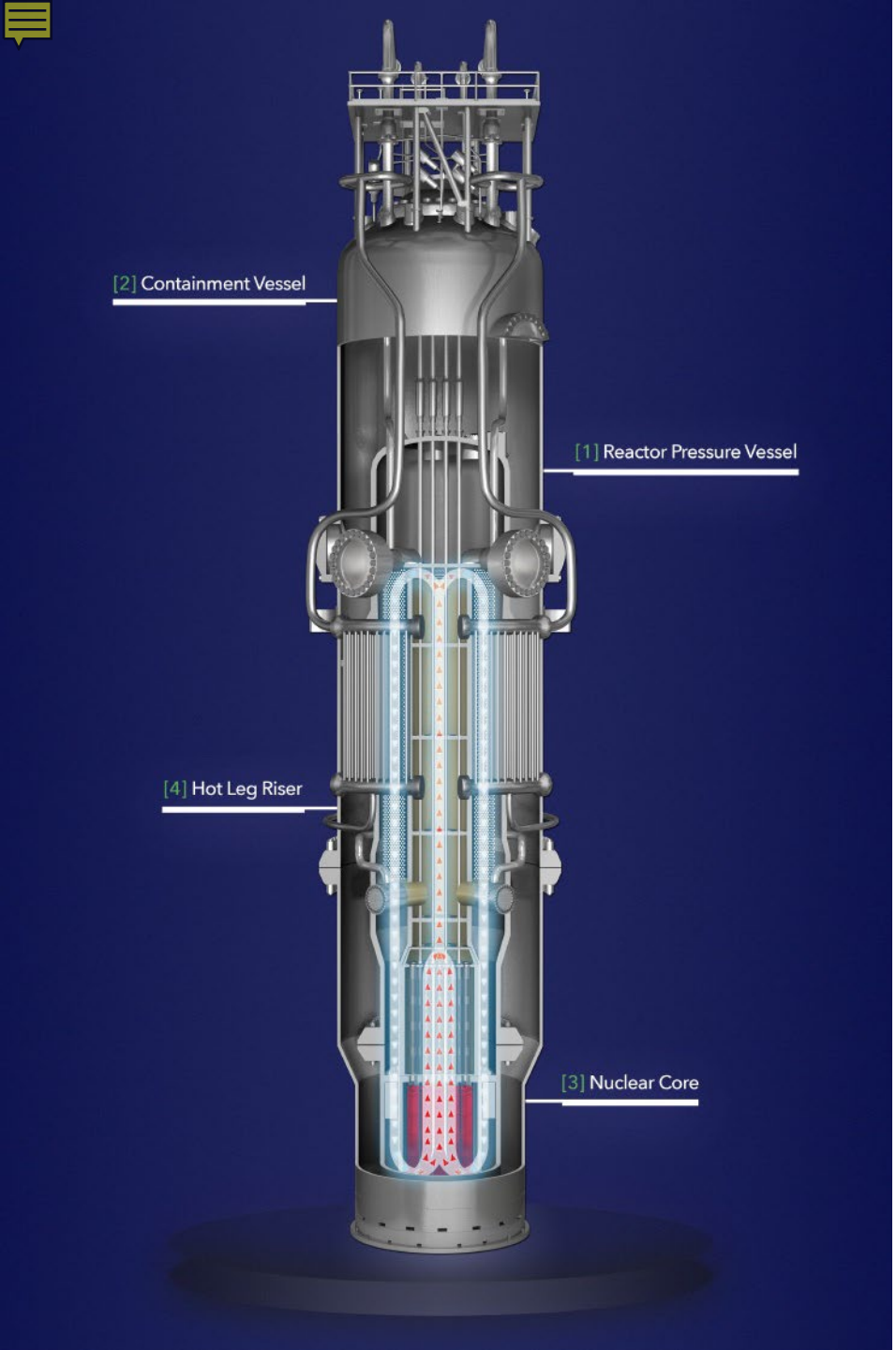

Core Technology: NuScale Power Module™

- 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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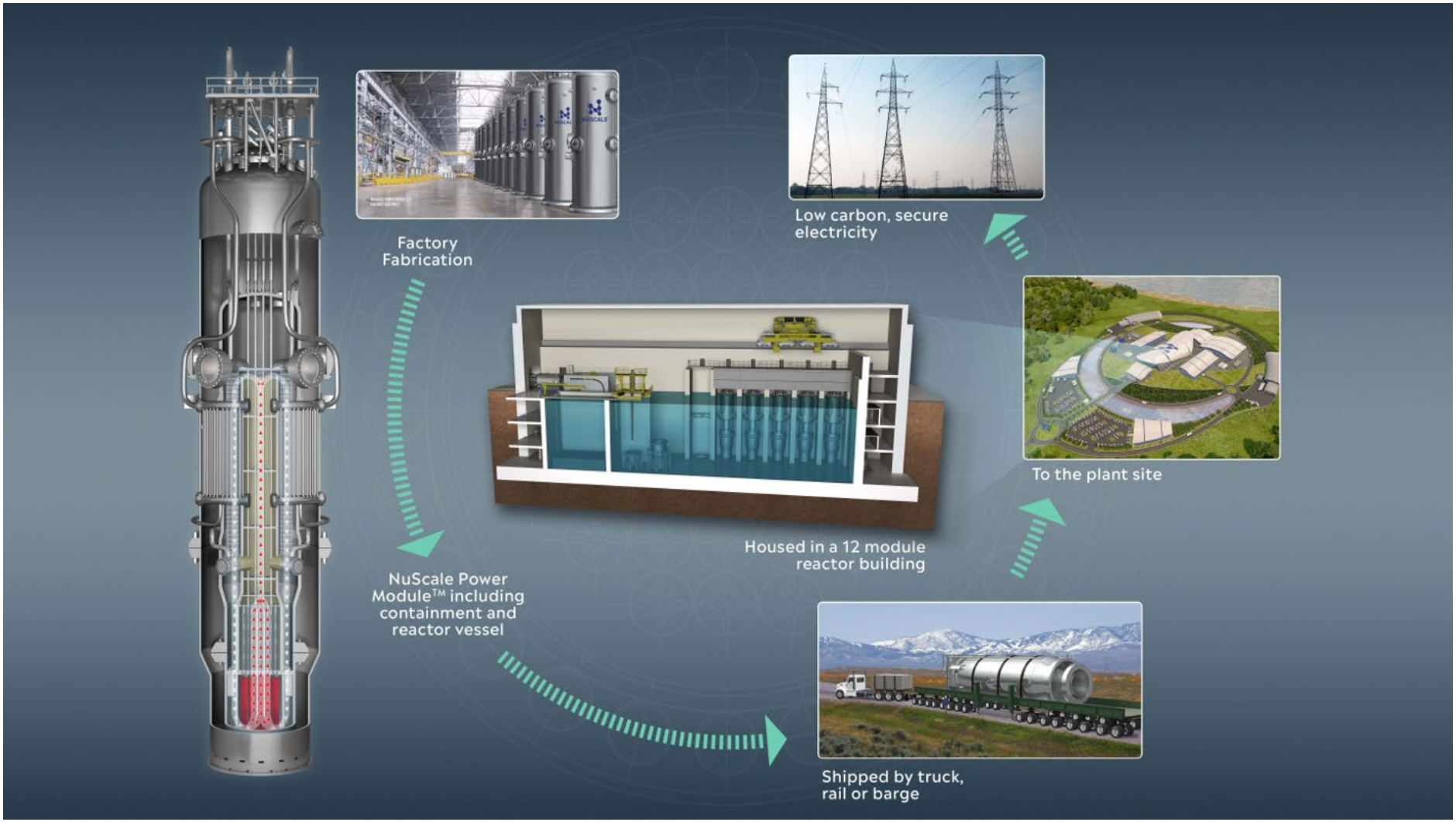
A New Approach to Construction and Operation



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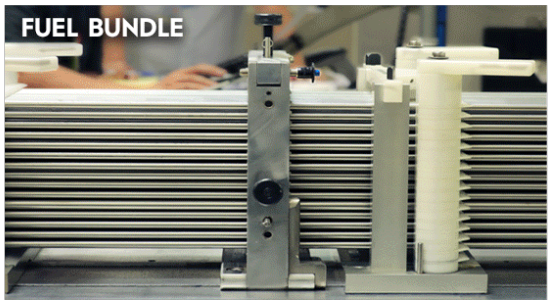
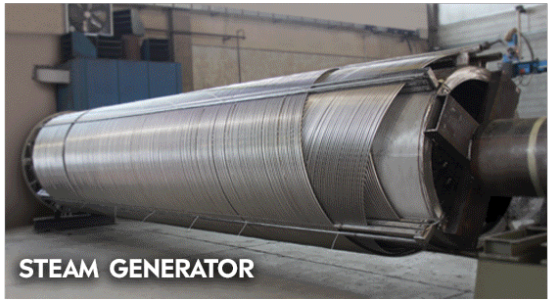
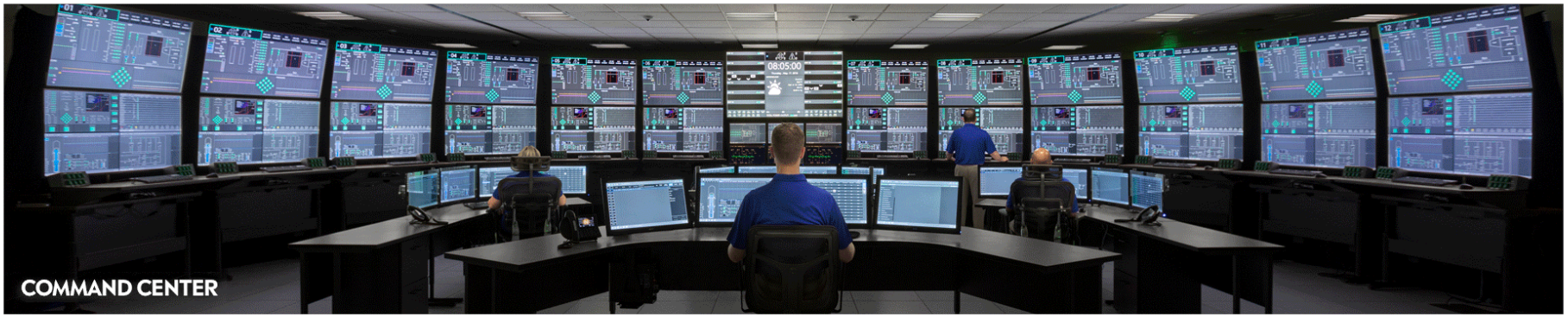
Manufacturing and Testing of Hardware







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Features that Enhance NuScale Plant Reliability and Resilience

- NuScale has incorporated multiple design features th work independently or in conjunction to provide new levels of plant reliability and resilience.
  - Black-start capability
  - Island Mode
  - 100% Steam Bypass
  - Robust I&C Voting Technology
  - No Reactor Coolant Pumps
  - Simple FW System Design
  - Simple Turbine-Generator Design
  - Robust Electrical Distribution

NuScale Safety Approach is Foundational to Plant Resilience

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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

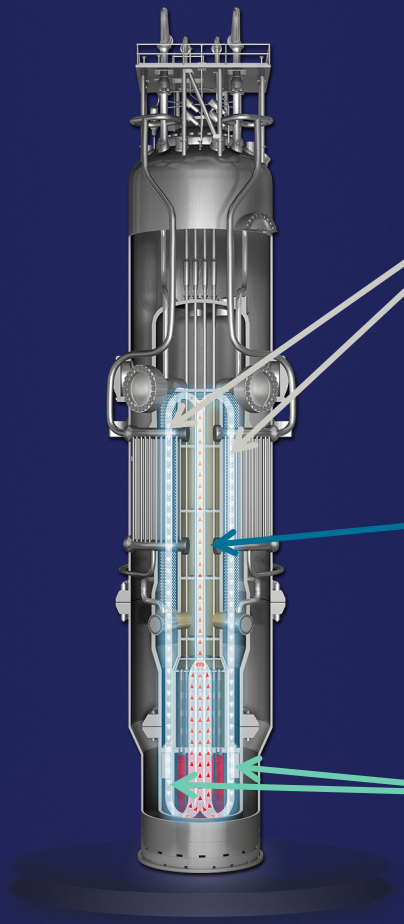
- System submerged in a below-grade pool of water in an earthquake and aircraft impact resistant building.

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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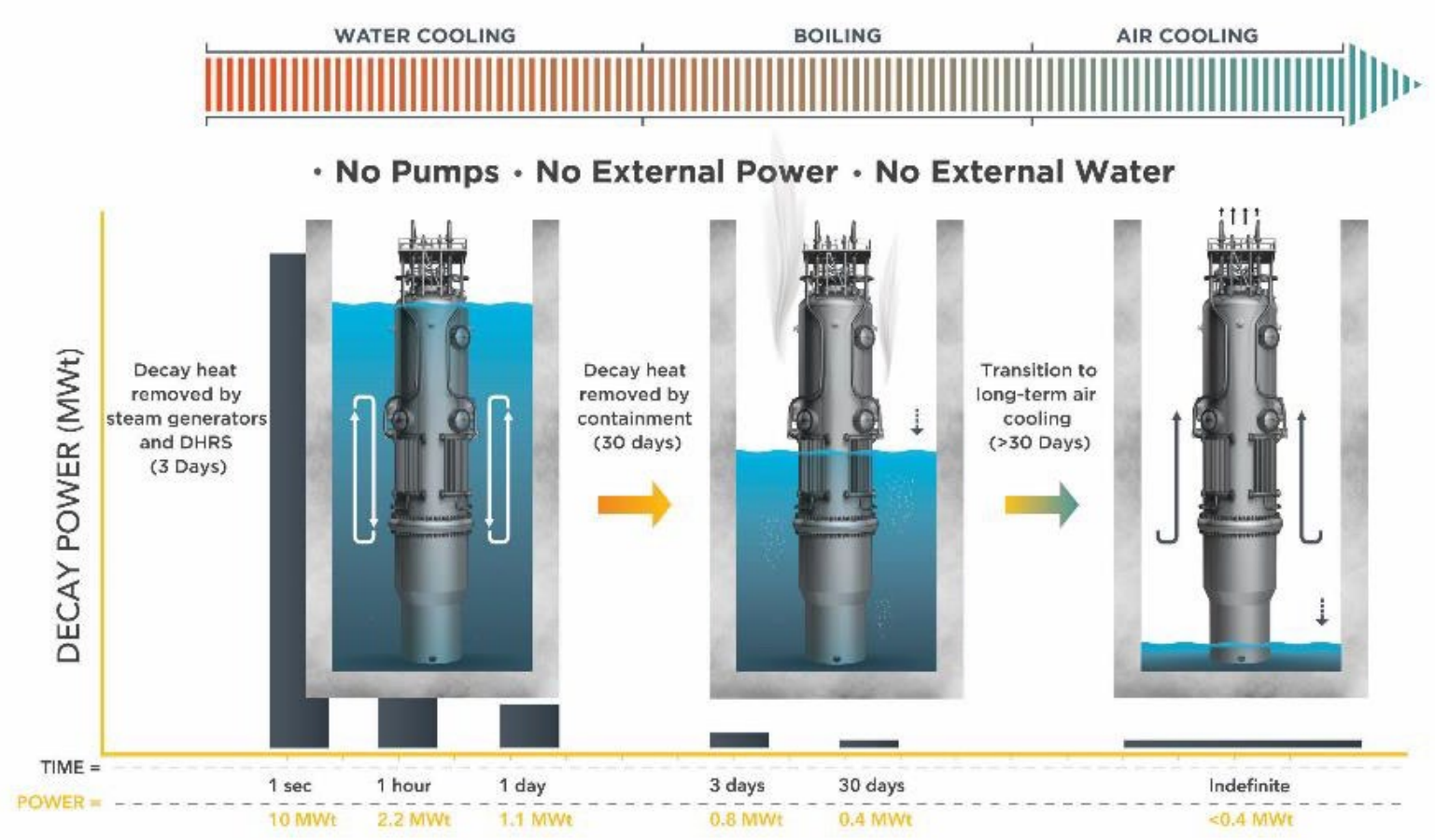
Innovative Advancements to Reactor Safety

*Nuclear fuel cooled indefinitely without AC or DC power**



**Alternate 1E power system design eliminates the need for 1E qualified batteries to perform ESFAS protective functions – Patent Pending*

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A New Level of Plant Resiliency

Climate Adaptation

Black-Start and Island Mode Following Loss of Offsite Power

A single module can be Black-Started and 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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Regulatory Approval of Innovation Related to Plant Resilience

NuScale Digital I&C Platform (HIPS) Approved by NRC (July 2017)

- The Highly Integrated Protection System (HIPS) Platform is a protection system architecture jointly developed by NuScale Power and Rock Creek Innovations. ***It uses field programmable gate array technology that is not vulnerable to internet cyber attacks.***

NRC approves NuScale Approach for no 1E Power (December 2017).

- This novel safety design approach eliminates the need for class 1E power, the regulatory standard set for the design of safety-related nuclear power plant electrical systems, which are currently required of all nuclear plants in the U.S. ***Supports NuScale objective of providing dedicated "off-grid" power for mission critical facilities***.

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Reliable Power for Mission Critical Facilities

UTILITY MACROGRID

687 MWe (net)
> 95% Capacity

NuScale 12-Module Plant

DEDICATED MICROGRID
120 MWe (net)
> 99.95% Availability

MISSION CRITICAL FACILITY

- Connection to a micro-grid, island mode capability, and the ability for 100% turbine bypass allows a 720 MWe (gross) NuScale plant to assure **120 MWe net power at 99.95% reliability over a 60 year lifetime**
  - 60 MWe at 99.98% availability
- Joint study with TVA demonstrated six-9s availability (99.9999%) at power levels between 50-100 MWe when including all power sources supporting a mission critical subgrid.

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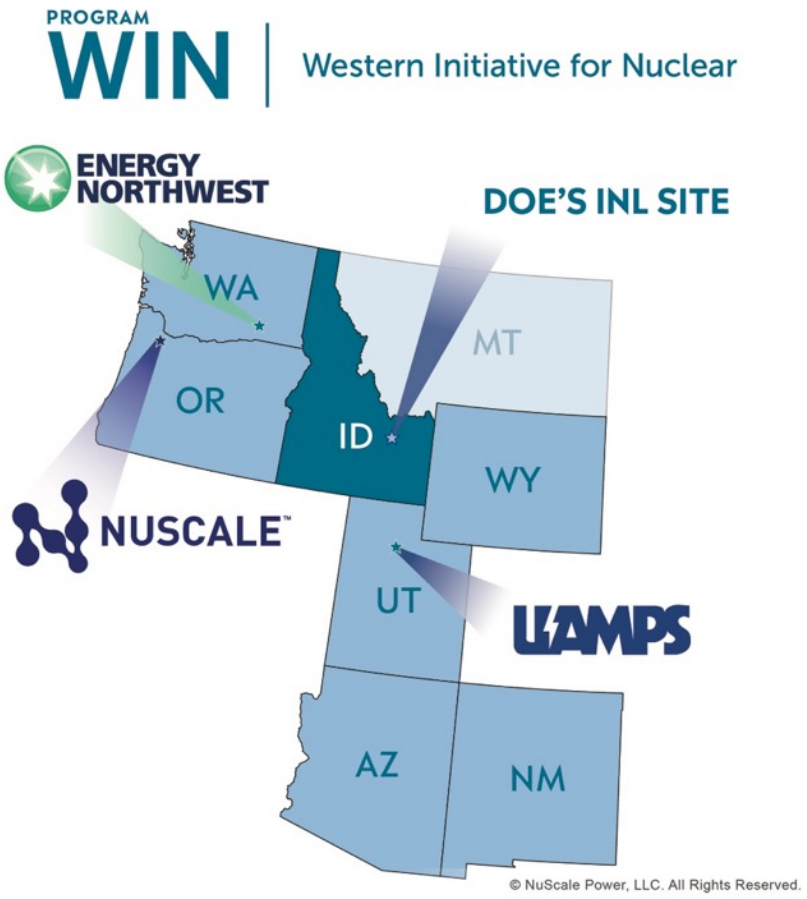
First Deployment: UAMPS Carbon Free Power Project



- 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 $63.3 million in matching funds to perform site selection, secure site and water, and prepare combined operating license application to NRC and advance the site specific design.

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A New Level of Plant Resiliency

- **Island Mode/Loss of Offsite Power**
- **Black-Start Capability**
- **First Responder Power**
- **Resilience to Natural Events**
- **Resilience to Aircraft Impact**
- **Cybersecurity**
- **Long-Term Power for Mission Critical Facilities**
- **High Altitude Electromagnetic Pulse (EMP) and Geomagnetic Storms**


NuFuel HTP2 Testing

One-third scale NIST-1 Test Facility


NuScale Control Room Simulator

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The Future of Energy is Here

Fuel Assembly Bundle

One-third Scale NIST-2 Test Facility

NuScale Control Room Simulator

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