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NuScale Update for NASEO

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Chief Operating Officer, Chief Nuclear Officer

Acknowledgement and Disclaimer

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The Global Reality

Energy is essential to human development.
1.1 billion people still live without any access to electricity.

Source: International Energy Agency (IEA)

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The Global Reality

By 2025, half of the world's population will be living in **water-stressed** areas.

Source: World Health Organization (WHO)

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The Global Reality

More than **1 billion** metric tons of food
is lost or wasted each year for lack of cooling.

Source: Food and Agriculture Organization (FAO)

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The Global Reality

Air pollution in developing economies routinely **exceed** U.S. standards.

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The Global Reality

Image source: Eco: Logic

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Innovation and ingenuity for a new day of energy

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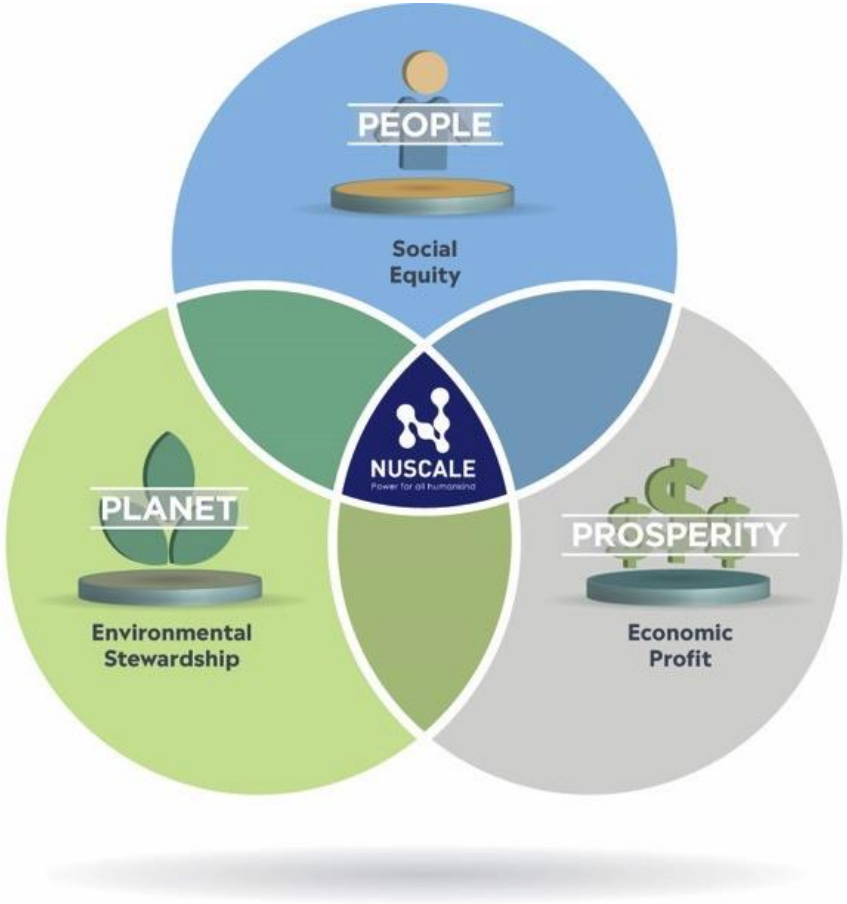
Commitment to People, Planet, Prosperity



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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NuScale's 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.**

Artistic concept of the NuScale Power Plant

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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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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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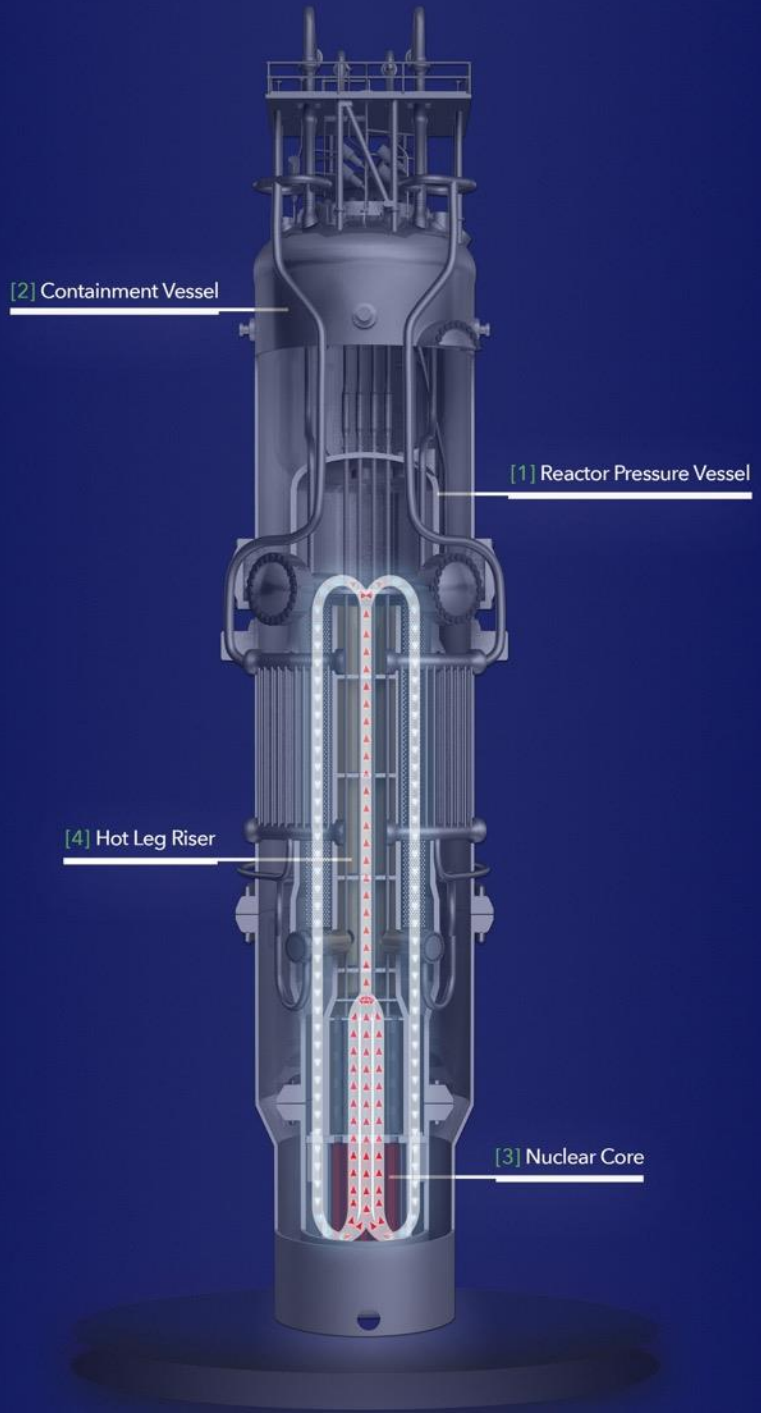

Core Technology: NuScale Power Module

- 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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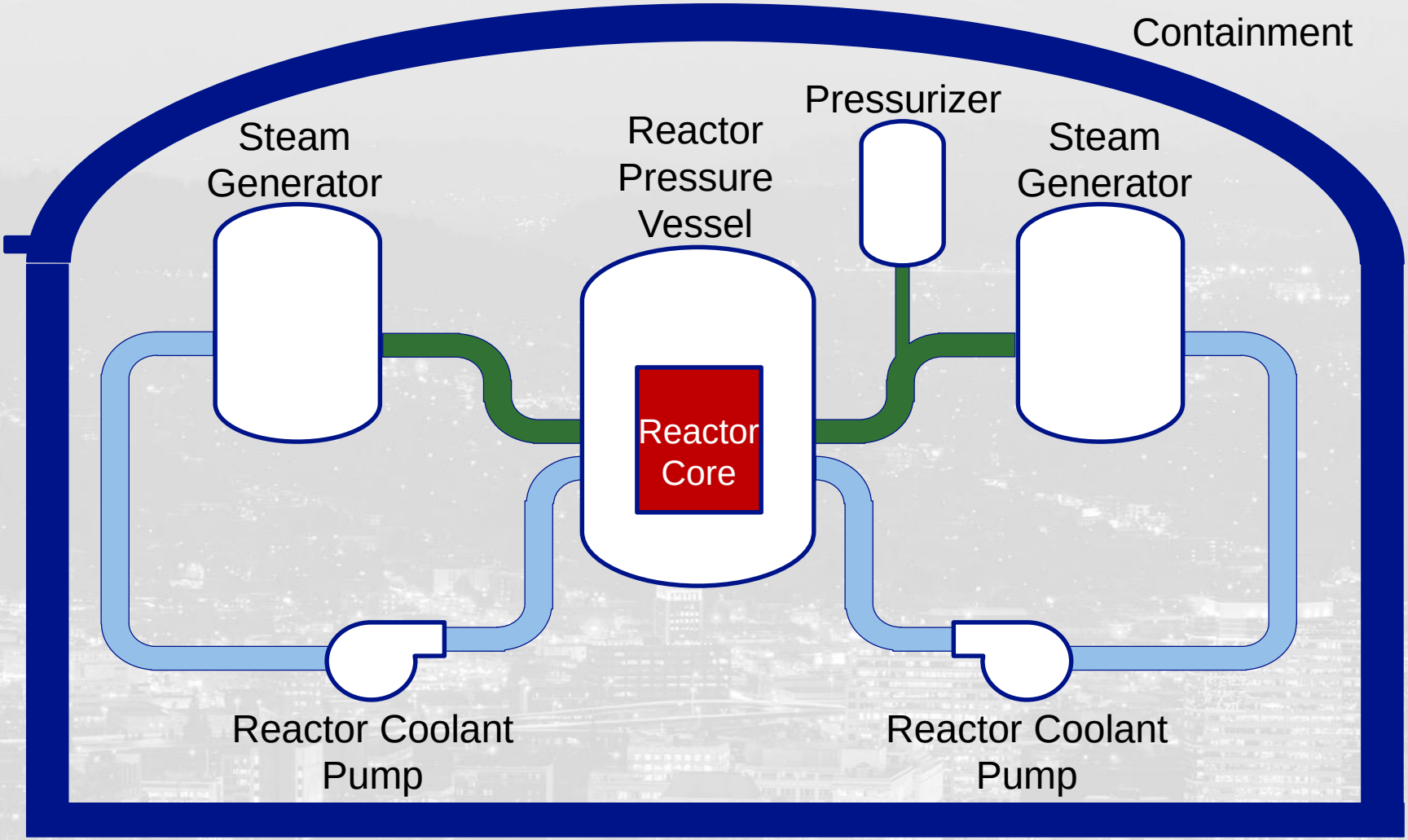
Typical Pressurized Water Reactor



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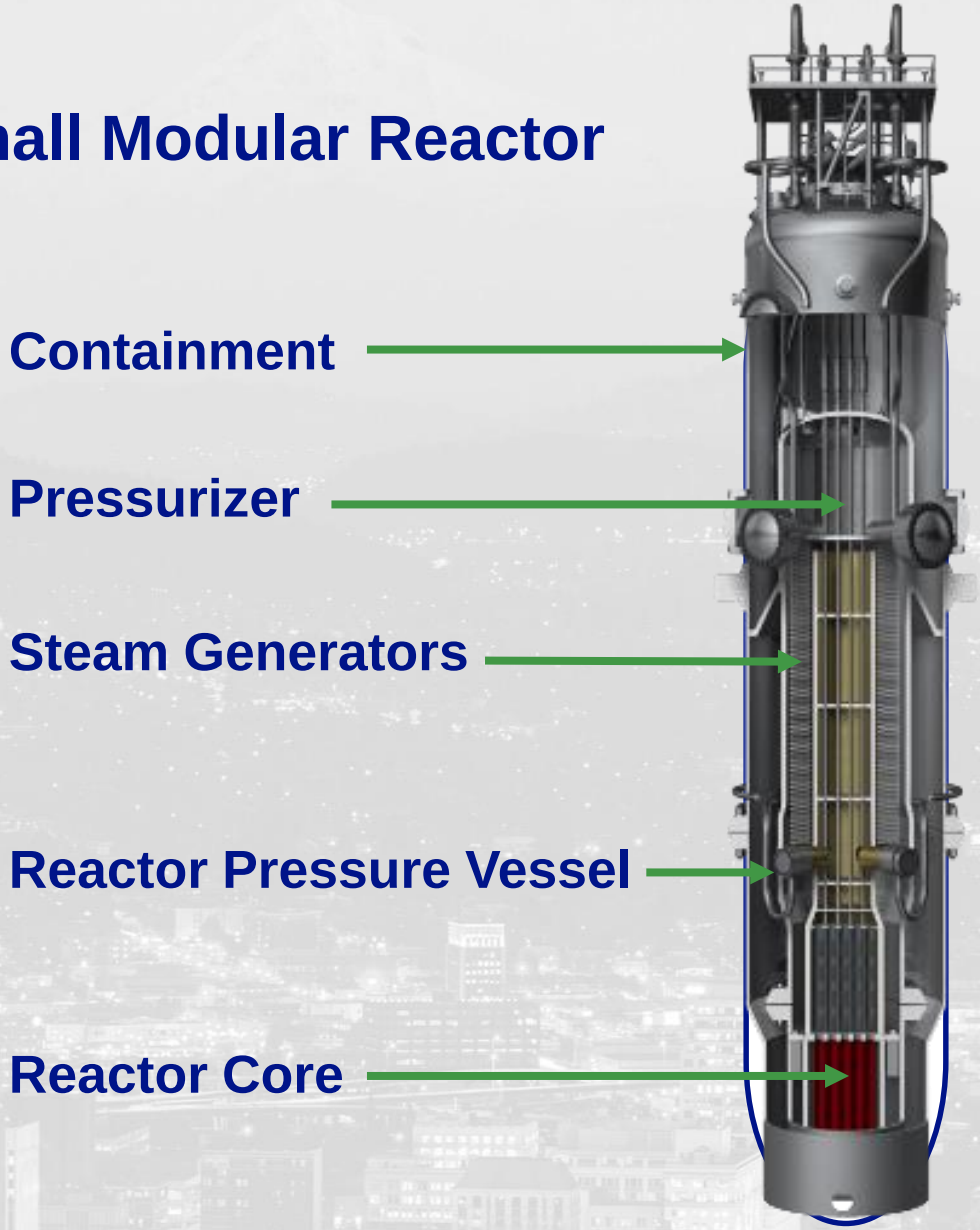
NuScale Small Modular Reactor



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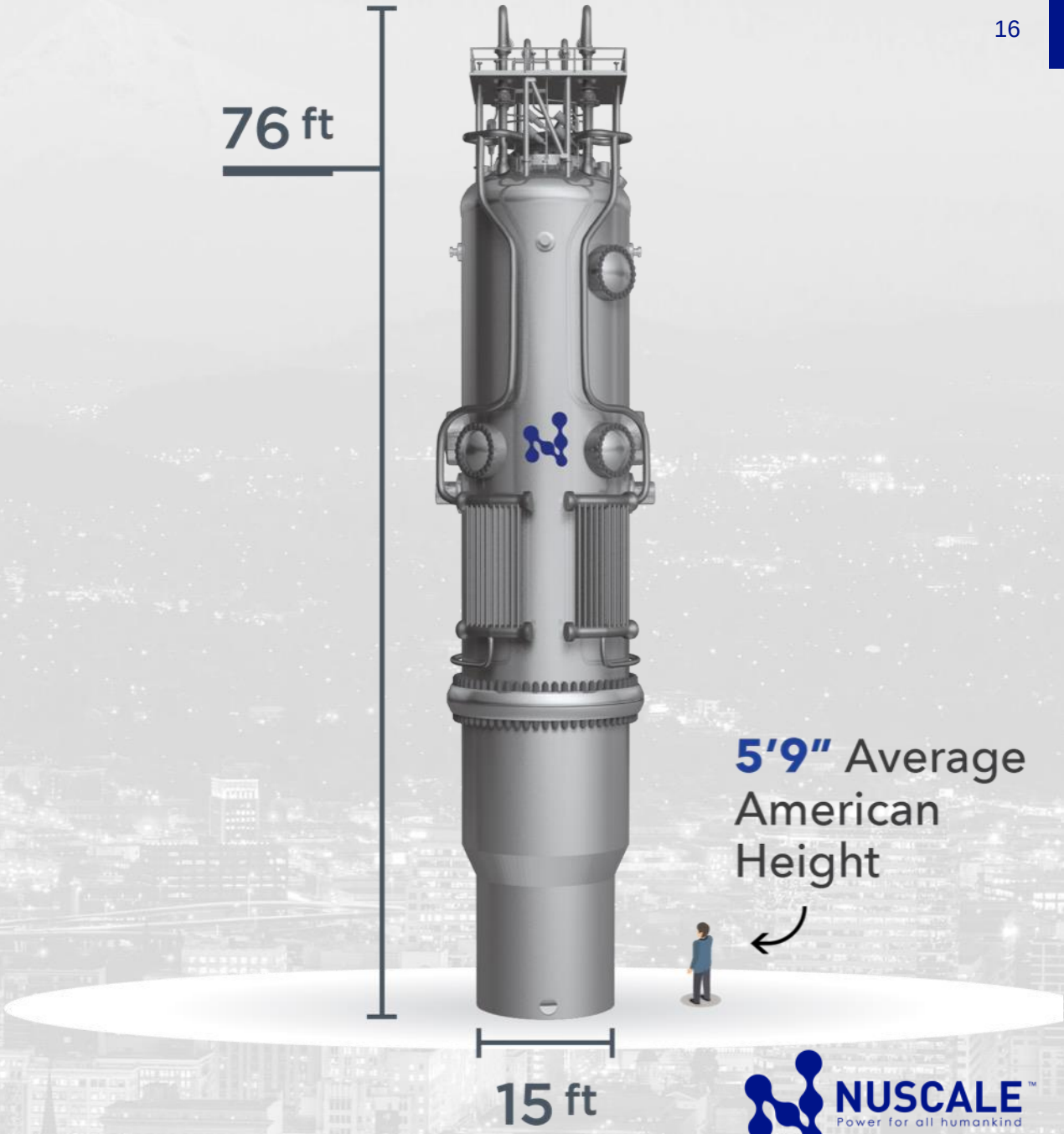
Dimensions



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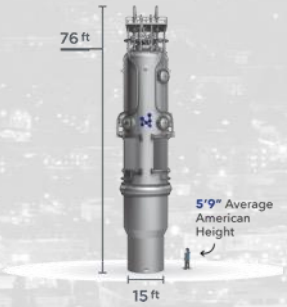
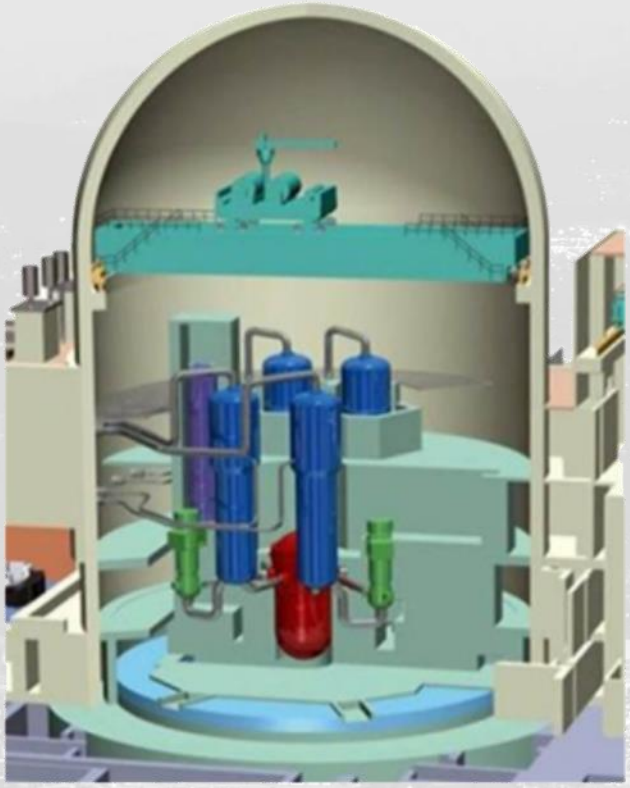
Comparison to a Large Pressurized Water Reactor (PWR)



NuScale Power Module



Typical Large PWR

Image: U.S. Nuclear Regulatory Commission

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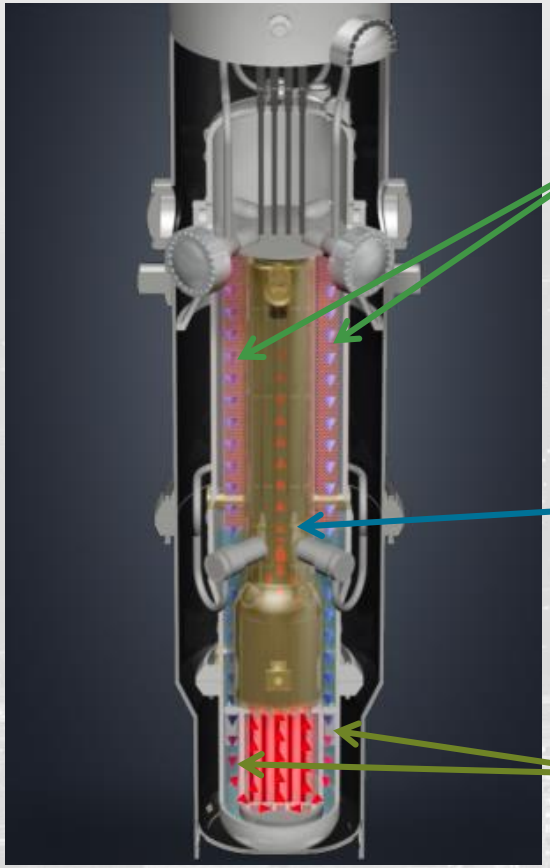
Simplicity Enhances Safety

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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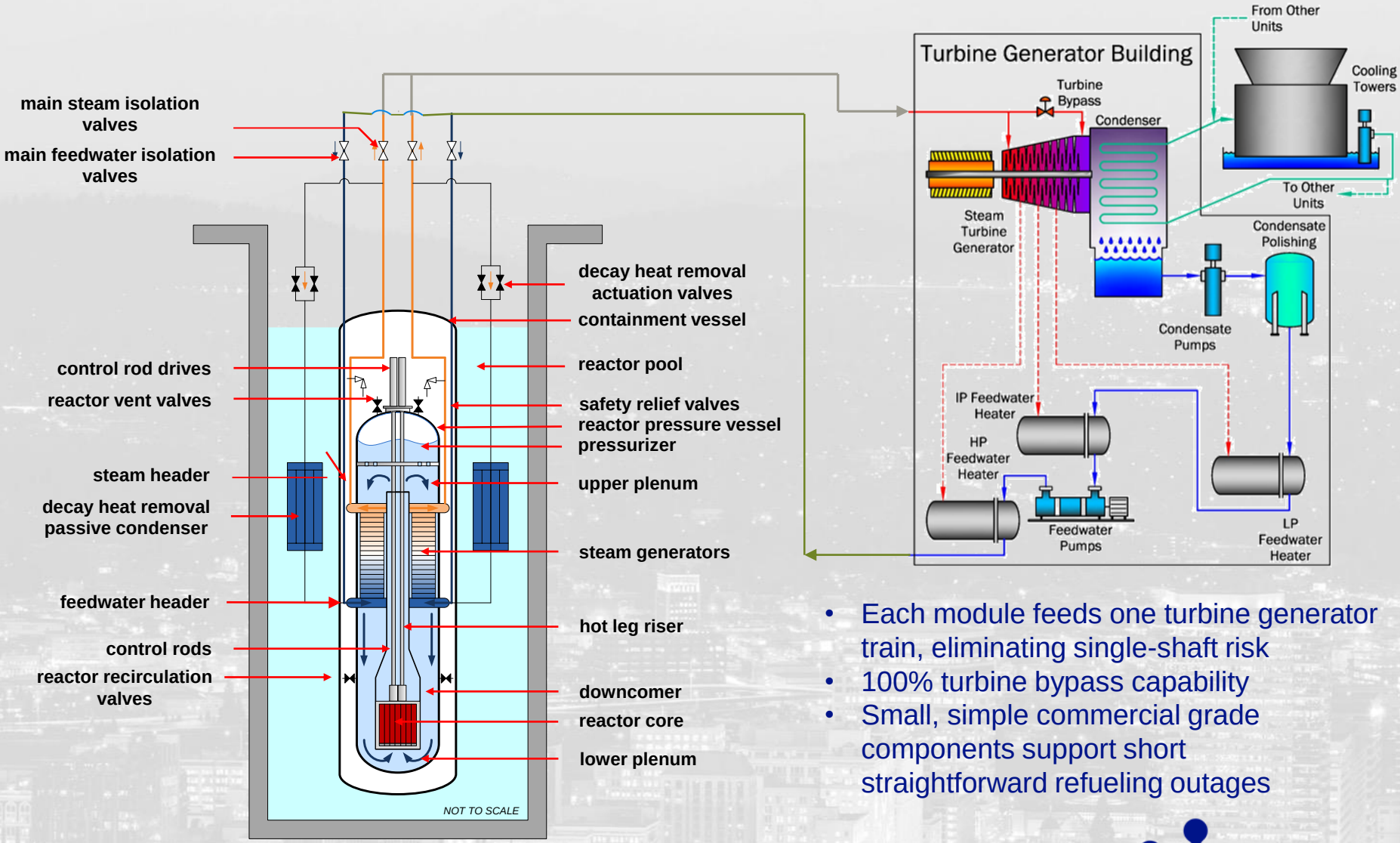
NuScale Power Train



- Each module feeds one turbine generator train, eliminating single-shaft risk
- 100% turbine bypass capability
- Small, simple commercial grade components support short straightforward refueling outages

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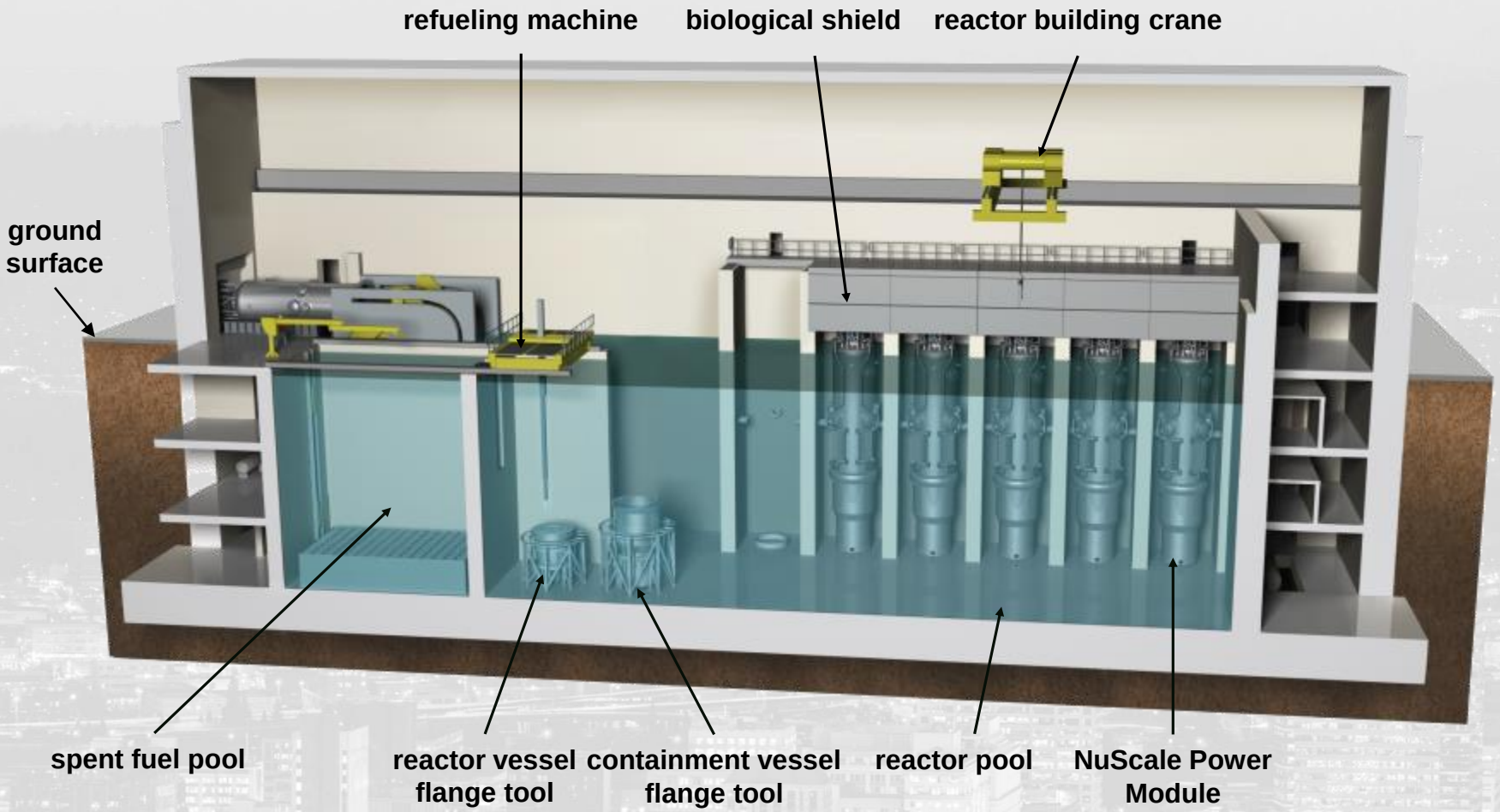
Reactor building houses NuScale Power Modules™, spent fuel pool, and reactor pool



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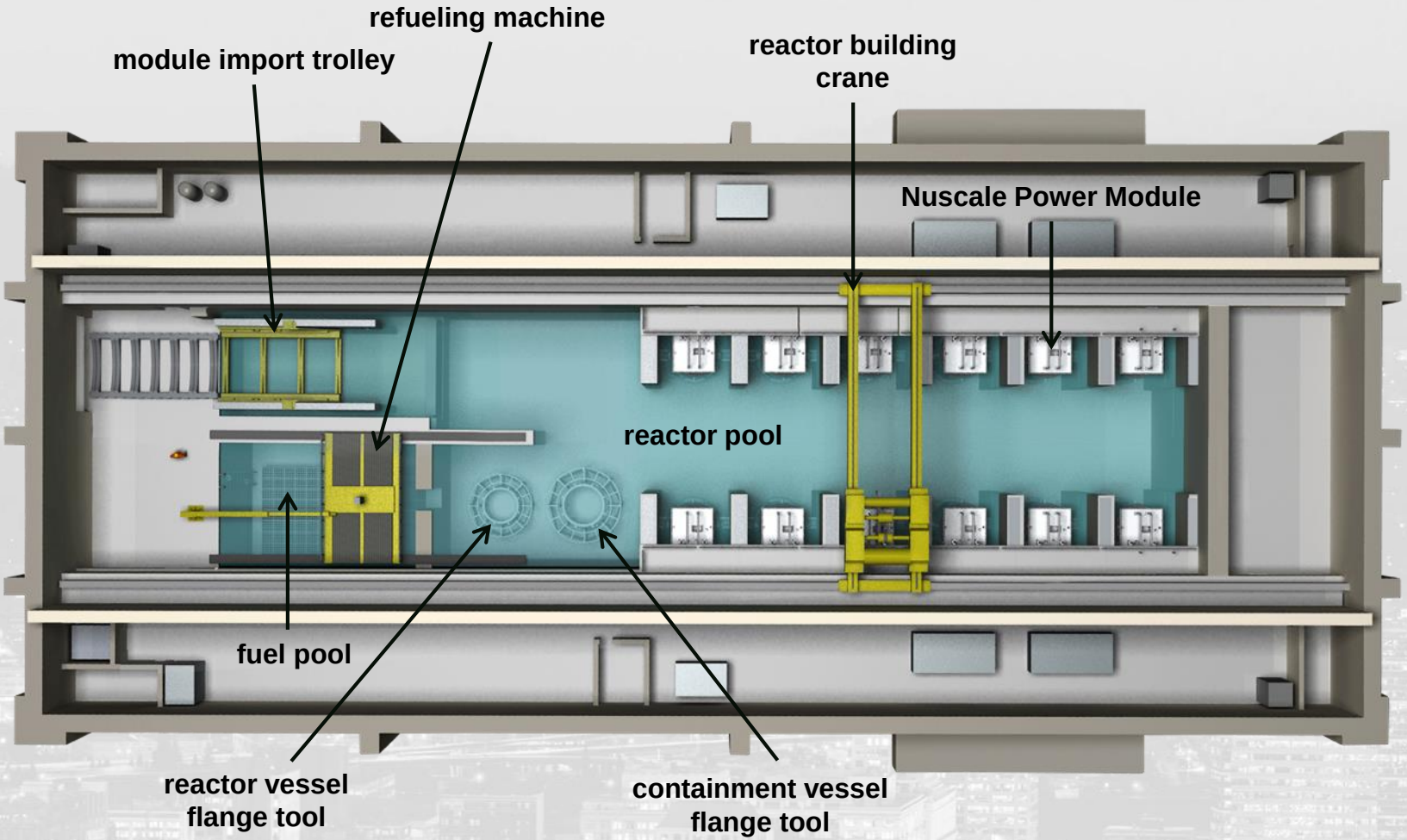
Reactor Building Overhead View



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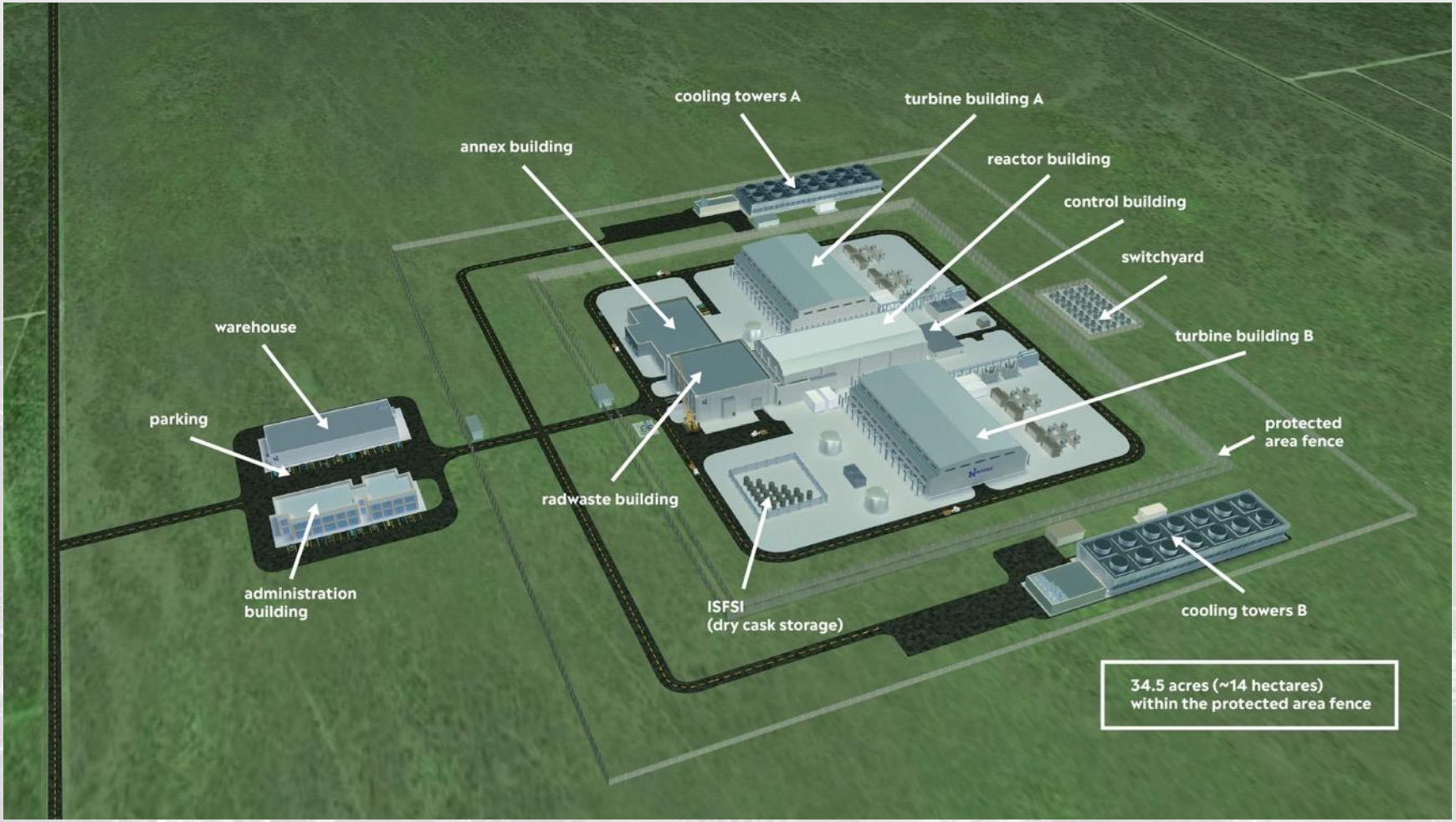
Detailed Plant Site Layout



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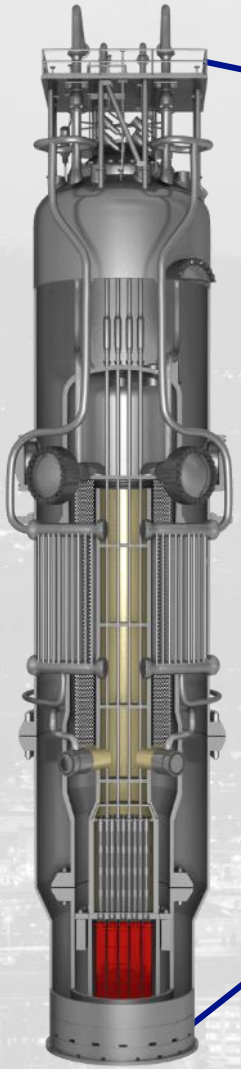
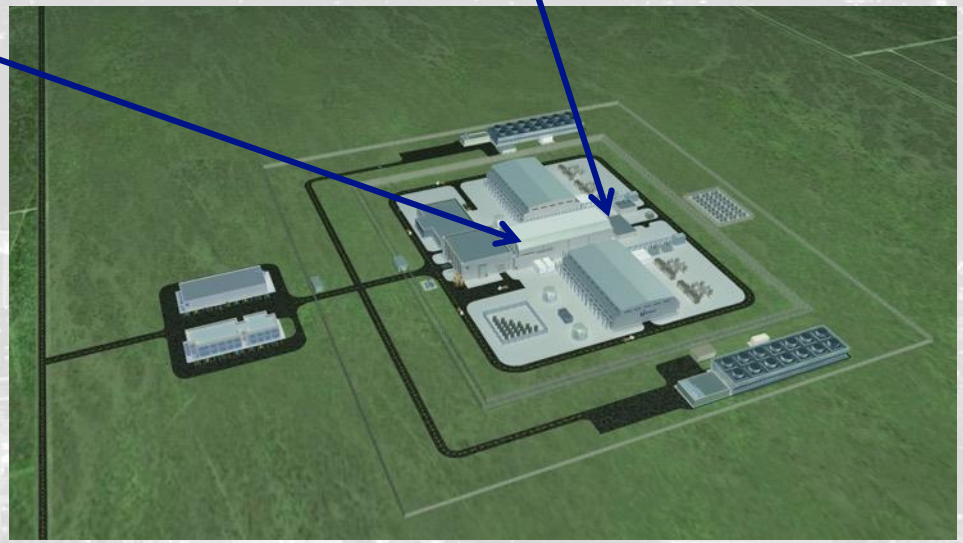
NuScale Plant Site Overview





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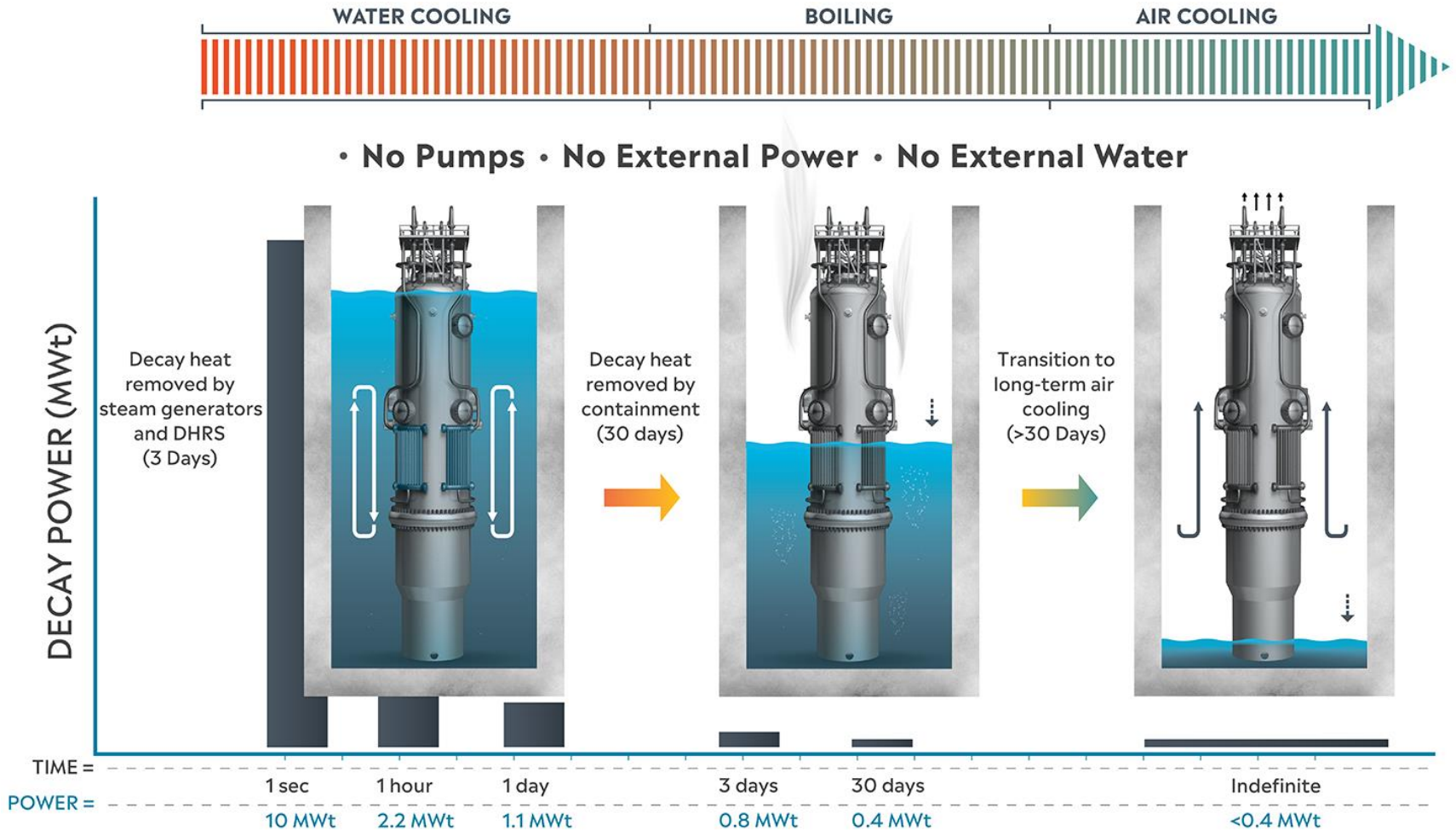
Innovative Advancements to Reactor Safety

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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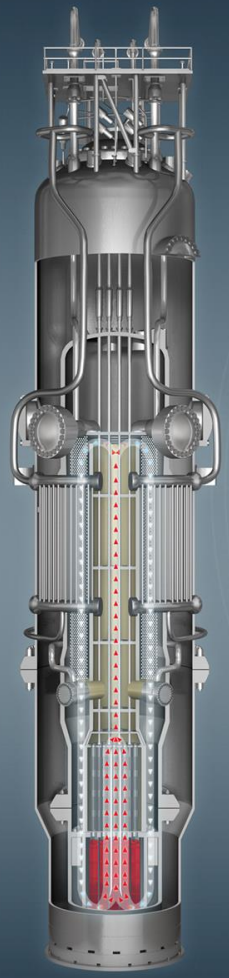
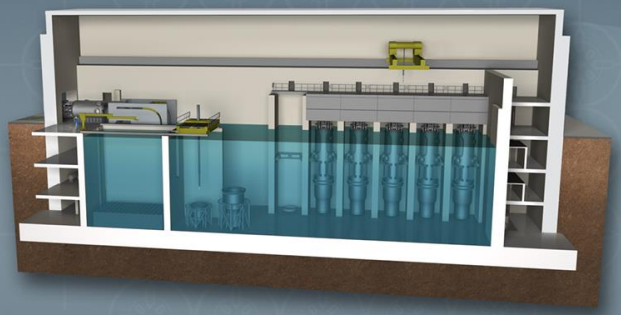
A New Approach to Construction and Operation



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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Technology Validation

- **NuScale Integral System Test (NIST-1)** facility located at Oregon State University in Corvallis, Oregon
- **Critical Heat Flux** testing at Stern Laboratories in Hamilton, Ontario Canada
- **Helical Coil Steam Generator** testing at SIET SpA in Piacenza, Italy
- **Fuels testing** at AREVA's Richland Test Facility (RTF) in Richland, Washington
- **Critical Heat Flux** testing at AREVA's KATHY loop in Karlstein, Germany
- **Control Rod Assembly (CRA)** drop / shaft alignment testing at AREVA's KOPRA facility in Erlangen, Germany
- **Steam Generator** Flow Induced Vibration (FIV) testing at AREVA's PETER Loop in Erlangen, Germany
- **Control Rod Assembly Guide Tube (CRAGT)** FIV at AREVA's MAGALY facility in Le Creusot, France

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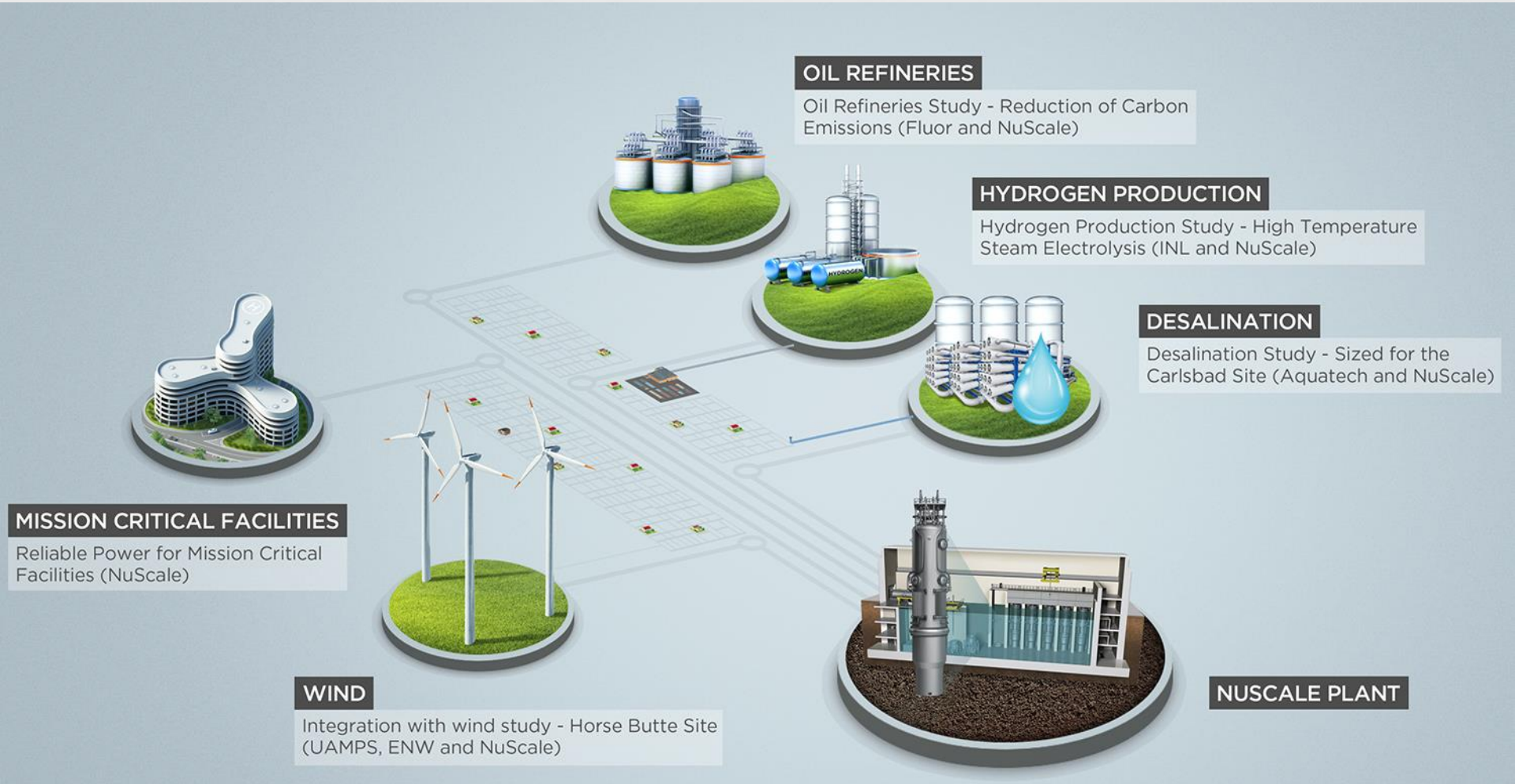
Beyond Baseload: NuScale Diverse Energy Platform



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

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Clean Air & Environment

- Nuclear energy produces **no harmful emissions** during operation and all wastes are accounted for and managed during the entire life cycle of the plant and incorporated into the cost.
- When energy sources are evaluated over their entire life cycle, from mining of materials and fuel, to construction, and eventual decommissioning and waste storage – **nuclear energy has one of the lowest carbon footprints** – lower than solar PV and about the same as wind.
- NuScale's operational flexibility can **enable more renewables on the grid** and help decarbonize industrial and transportation sectors – making the transition to a clean energy system faster.

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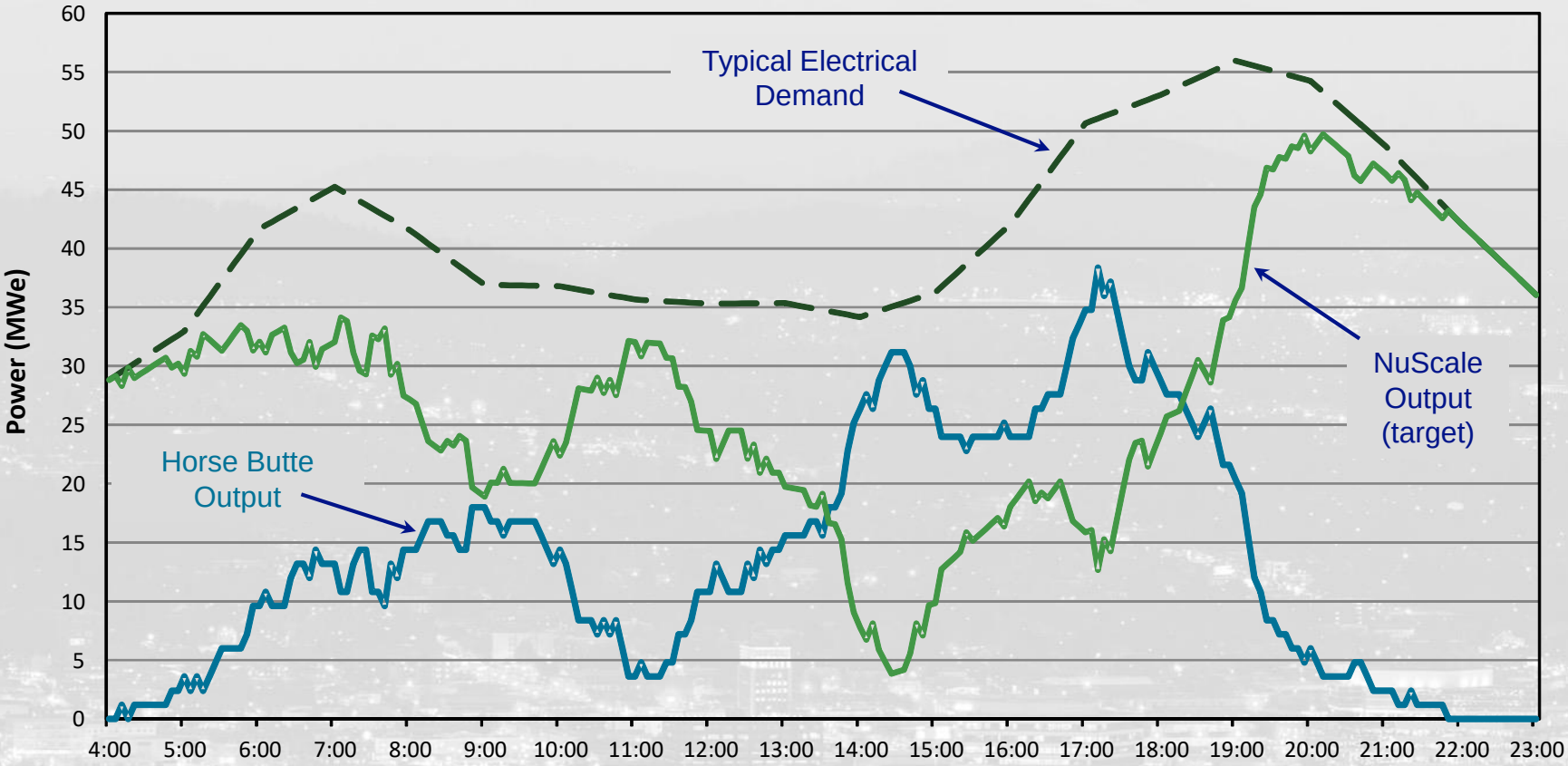
Load-Following with Wind



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

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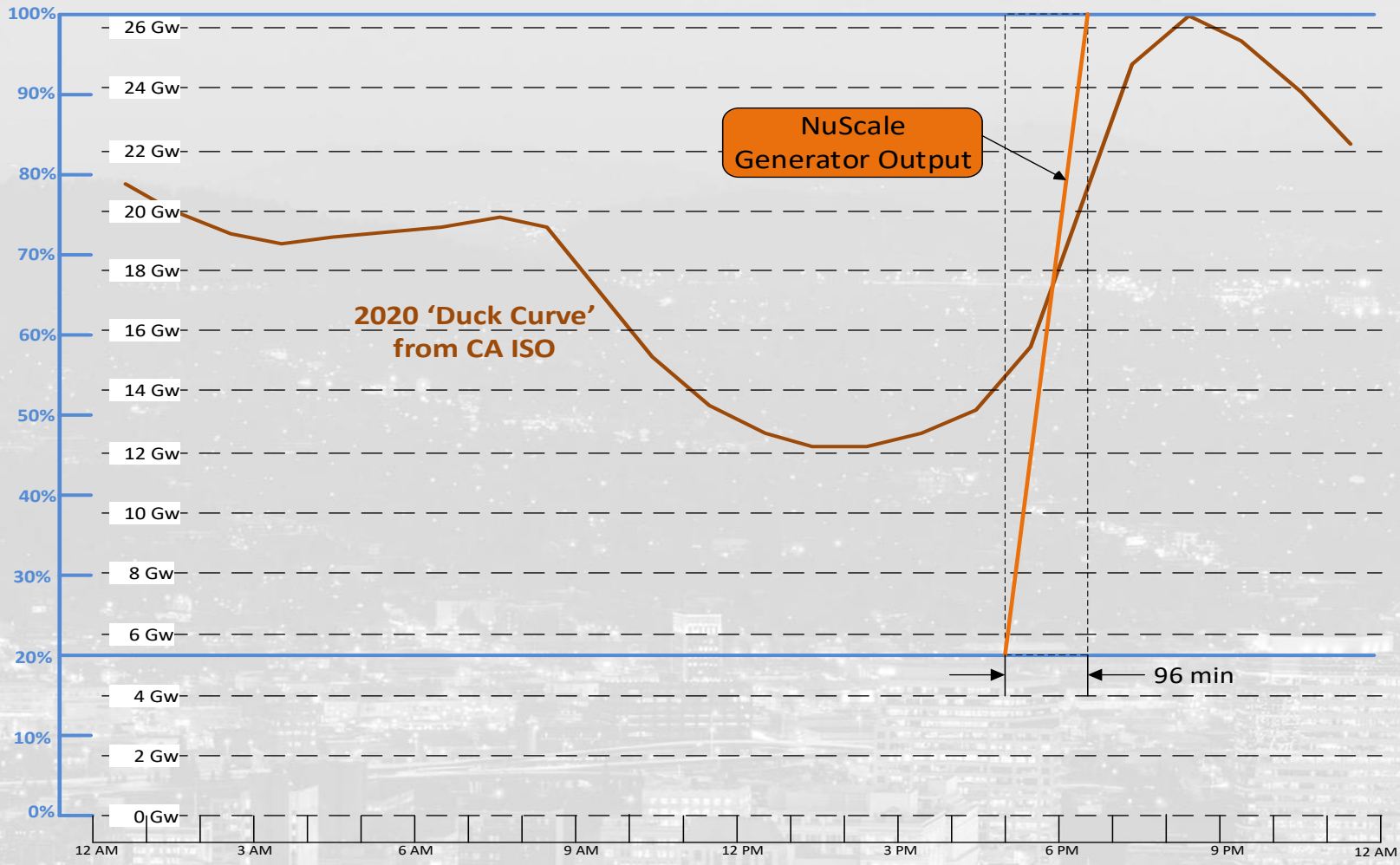
NuScale and the 2020 California “Duck Curve”



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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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Reliable Power for Mission Critical Facilities

UTILITY MACROGRID

684 MWe (net)
> 95% Capacity

- 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
- Using highly robust power modules and a multi-module plant design can provide **clean, abundant, and highly reliable power** to customers
- Working with utilities and customers to achieve “Five 9s”

NuScale 12-Module Plant

DEDICATED MICROGRID
120 MWe (net)
> 99.95% Availability

MISSION CRITICAL FACILITY

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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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Used Fuel Management at NuScale Plant

- NuScale reactor building and plant design incorporates a proven safe, secure, and effective used fuel management system
- **Stainless steel lined concrete pool holds used fuel for at least 10 years under 60 feet of water.**
- The used fuel is protected both by the ground and the **Seismic Category 1 reinforced concrete reactor building** designed to withstand an aircraft impact, and a variety of natural and man-made phenomena.

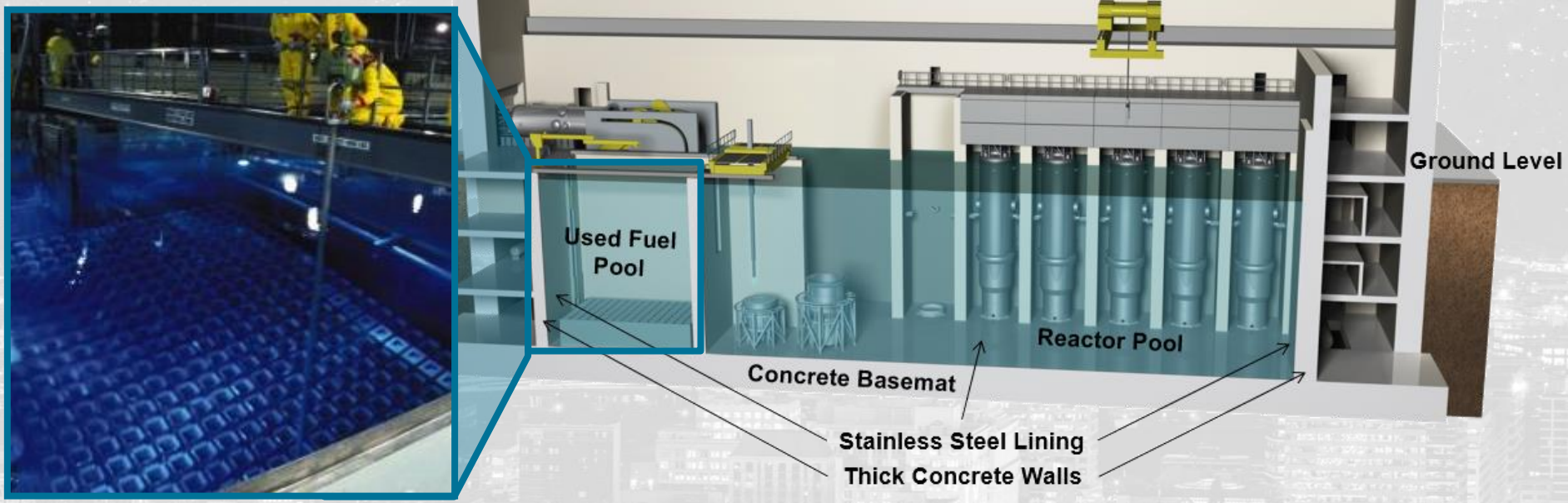

Image Credit: Nuclear Energy Institute

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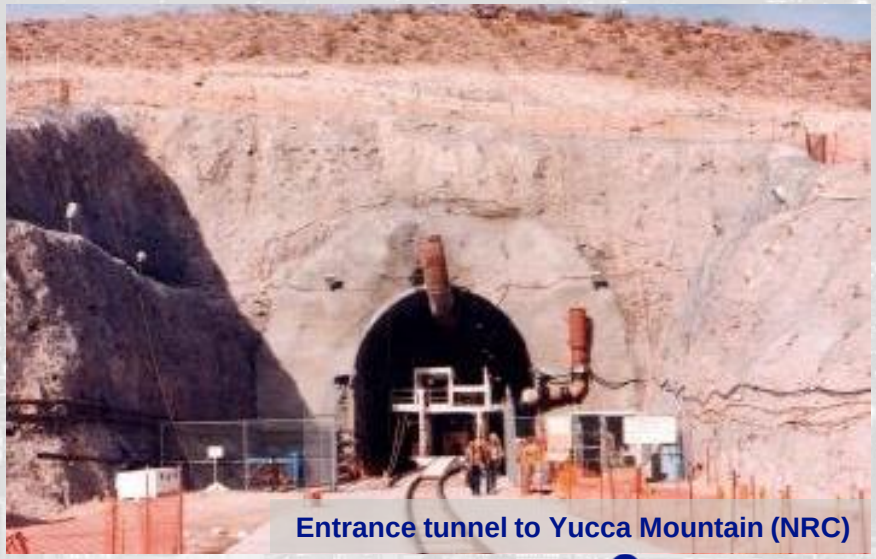
Used Fuel Storage & Disposal

- **After cooling in the spent fuel pool, used fuel is placed into certified casks – steel containers with concrete shells – on site of the plant.**
  - NRC's Waste Confidence Rule states that dry cask storage is a safe and acceptable way to store used fuel for an interim period at the plant up to 100 years.
  - NuScale's standard facility design includes an area for the dry storage of all of the spent fuel produced during the 60-year life of the plant.
- **U.S. Department of Energy (DOE) has responsibility for the final disposal of used fuel under the Nuclear Waste Policy Act.**
  - Under the Act, the generators of electricity from nuclear power plants must pay into a fund to be used for the long term disposal of this used fuel; over $35 billion is currently in the Nuclear Waste Fund.

Inspectors examining vertical dry cask storage (NRC)



Entrance tunnel to Yucca Mountain (NRC)

Sources: U.S. NRC; U.S. DOE; Nuclear Energy Institute

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Used Fuel Recycling – A better option?

- Recycling used fuel could significantly reduce the burden of mining and disposing of spent fuel, making our nuclear fuel cycle more sustainable and further reducing the already-low carbon total footprint of nuclear power

KEY FACTS

- **96% of the content of the used fuel is reusable energy**
- **Recycling used fuel:**
  - **Saves 25% of natural uranium resources**
  - **Reduces the volume of high-level waste slated for disposal in a repository by 75%**
  - **Reduces the waste's toxicity by about 90%**

- Recycled fuel and mixed uranium-plutonium oxide (MOX) fuel are suitable for use in the NuScale SMR
- Recycling has been in successful use in several markets, such as France, for decades
  - Some new advanced designs will utilize this used fuel in its reactors as a means to reduce the overall quantity

Sources: Framatome, Third Way

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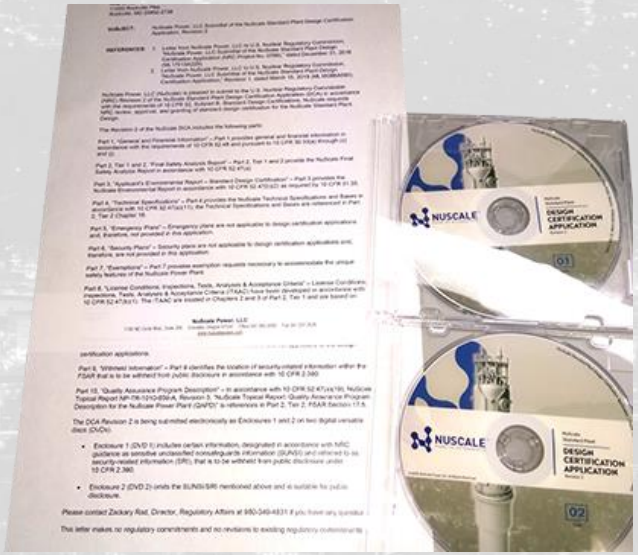
First SMR to Undergo Licensing in the U.S.

- 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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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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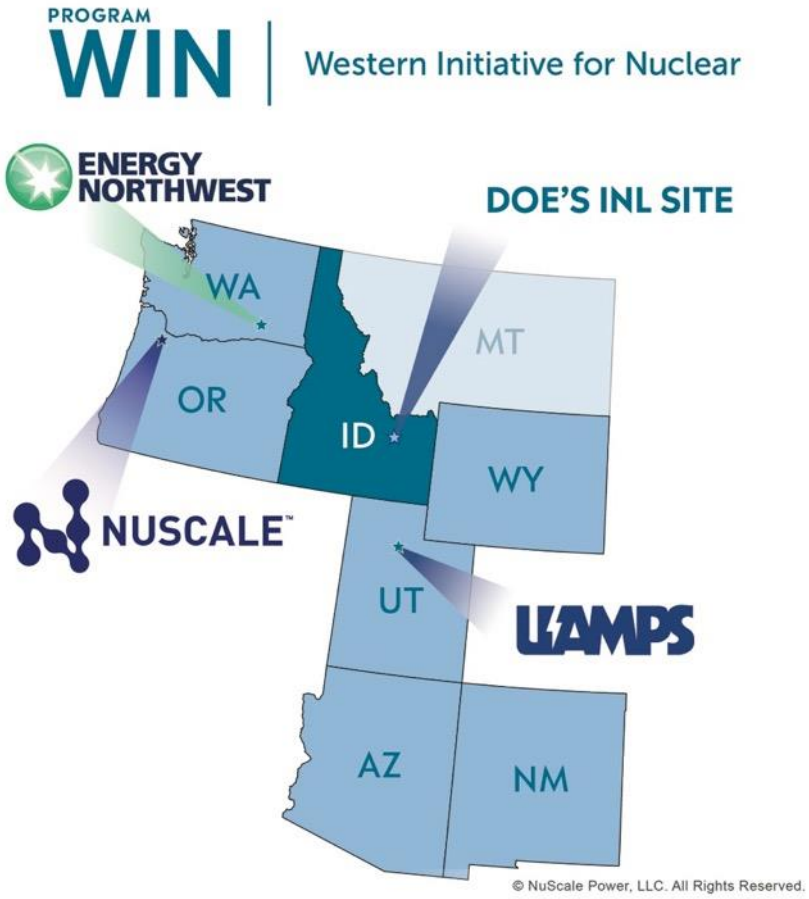
Industry Interest and Support

- Positive attributes of a flexible, carbon-free baseload generating technology scaled for customer needs bringing significant market enthusiasm
- NuScale has engaged with multiple utilities and other end users to potentially deploy NuScale SMR technology domestically and internationally
- To support engagement with the domestic utility market, NuScale created the NuScale Advisory Board (“NuAB”) in 2008, which initially had 8 members
  - Over 29 companies have participated in NuAB since its inception
  - NuAB meets about two times a year to contribute to design discussions that will meet their operational needs

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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Economics

- **Simplicity of design provides competitive levelized cost of electricity (LCOE) compared to other low carbon options**
  - First plant target LCOE - $65/MWh
  - 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**
  - ~$4,300/KW compared to more than $9,000/KW for recent large nuclear plant projects in Georgia and South Carolina
  - Overnight capital cost substantially improved in regions of the world where construction labor costs are considerably lower than in the U.S.
- **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 factory fabrication

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