NuScale Power™

February 27th 2018

A Promising Innovation in Nuclear Energy

The 7th Round-Table for Studying Energy Situations, Next-Generation Technologies and Innovation for Decarbonization ②

José N. Reyes, Jr.
Chief Technology Officer and Co-founder

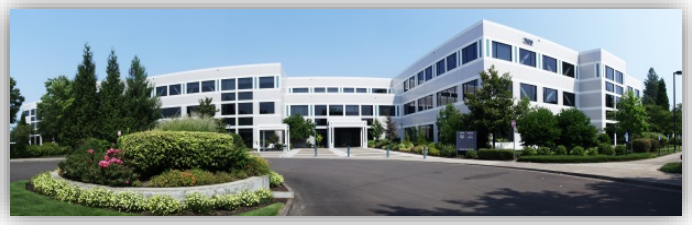
John Hopkins
Chief Executive Officer

Outline

- SMR Design Overview
  - Comparison to Conventional Nuclear Plants
- A New Level of Safety and Resiliency
- Economy, Financing, and Global Market
- Multiple Applications and Integration with Renewables
- Regulatory Communications and Approvals
- First NuScale SMR plant and Financing
- National Infrastructure for SMR deployment

Who is NuScale Power?

- NuScale Power was formed in 2007 for the sole purpose of completing the design and commercializing a small modular reactor – the NuScale Power Module™
- Initial concepts had been in development and testing since the 2000 (U.S. DOE) MASLWR program
- Fluor became lead investor in 2011
- In 2013, NuScale won $226M in matching funds in a competitive U.S. DOE Funding Opportunity
- >400 patents granted or pending in 20 countries
- >800 people have worked on the project with 6 offices in U.S. and 1 office in London
- First-ever Design Certification Application was completed in December 2016 and accepted for U.S. NRC review in March 2017
- Over US$700MM total investment to date



NuScale Engineering Offices Corvallis

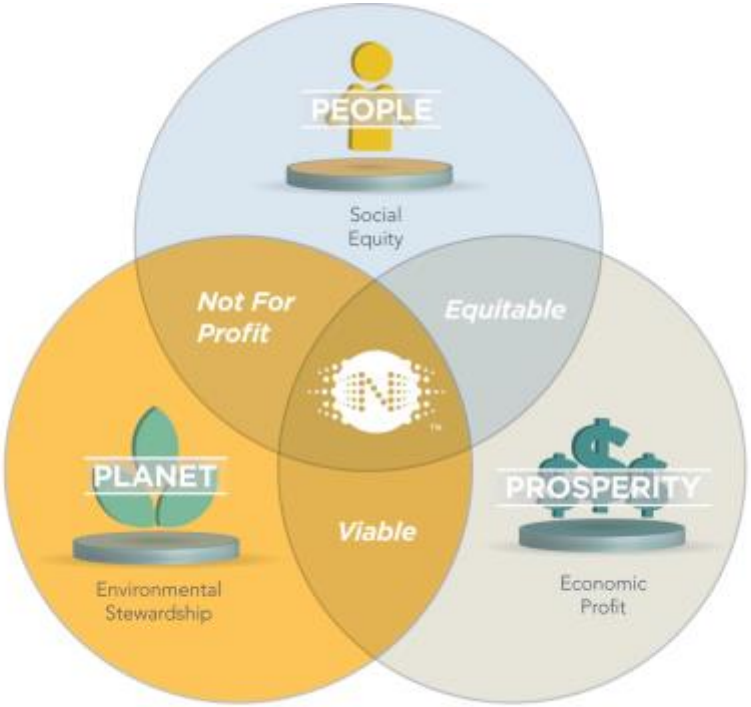
One-third scale NIST-1 Test Facility

NuScale Control Room Simulator

NuScale Power™

NuScale Value System

- NuScale Power is a Company built on Three Bottom Lines:



"NuScale Power, a viable business for people, planet, and prosperity"

- MISSION - NuScale Power will provide scalable advanced nuclear technology for the production of electricity, heat, and water to improve the quality of life for people around the world.

Why NuScale SMR for De-carbonization?

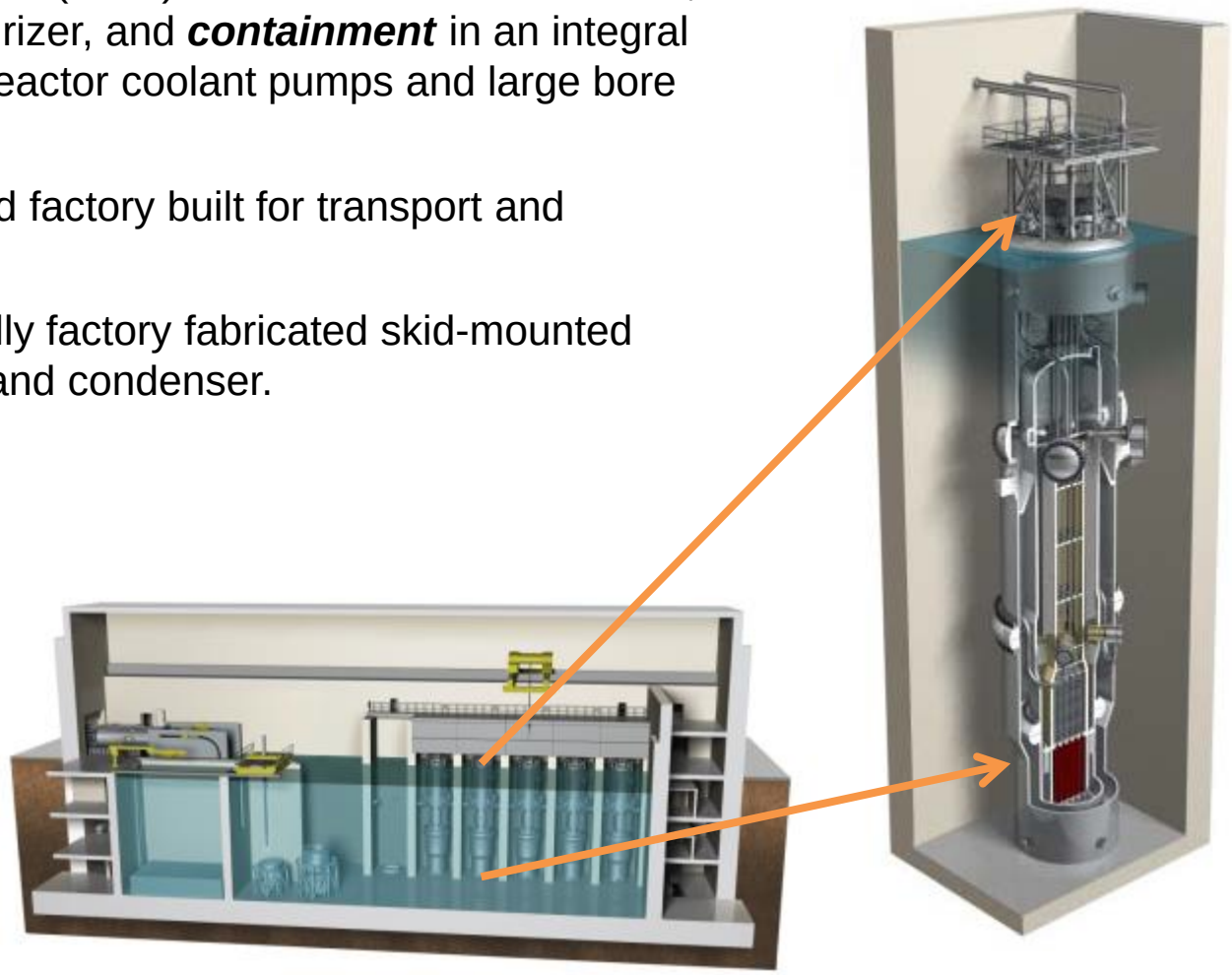
- *NuScale SMR offers:*
  - *Stable carbon-free power with small land usage for 600 MWe plant (0.14 km^2 inside the fence; <0.3 km^2 total)*
  - *Air-cooled condenser option for locating plants away from seaside.*
  - *Incremental power to match load growth*
  - *Integrates well with renewables*
  - *Reduced Capital costs and LCOE compared to large NPP*
  - *Multiple commercial applications so it can decarbonize more than just electricity production – including process heat for industrial applications and desalinization of water.*

NuScale SMR Design Overview

What is a NuScale Power Module?

Scalable design allows for 1 to 12 NPMs

- A NuScale Power Module™ (NPM) includes the reactor vessel, steam generators, pressurizer, and ***containment*** in an integral package that eliminates reactor coolant pumps and large bore piping (no LB-LOCA).
- Each NPM is 50 MWe and factory built for transport and installation.
- Each NPM has its own fully factory fabricated skid-mounted steam turbine-generator and condenser.
- Each NPM is installed below-grade in a seismically robust, steel-lined, concrete pool.
- NPMs can be incrementally added to match load growth - up to 12 NPMs for 600 MWe gross (~570 net) total output.



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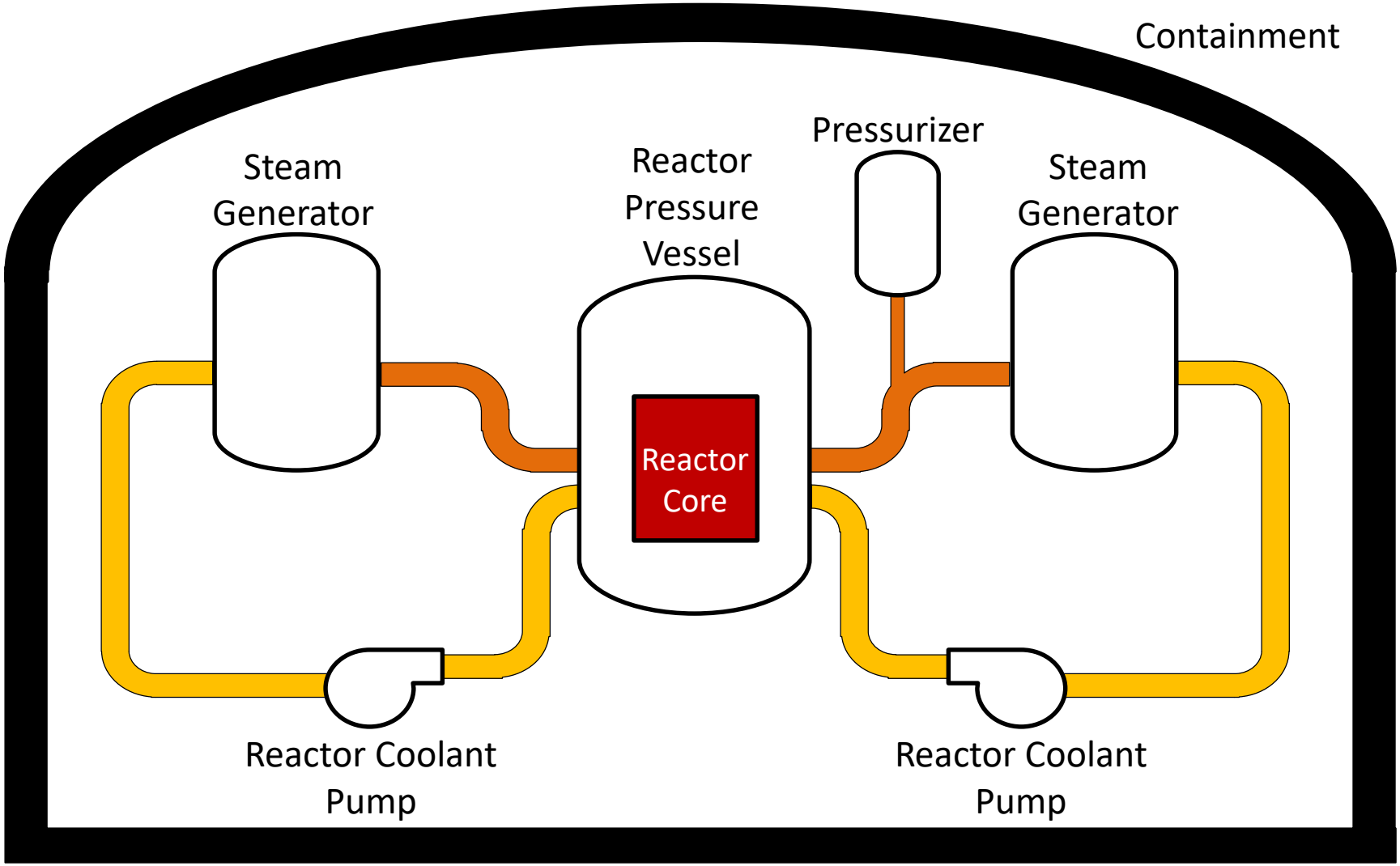
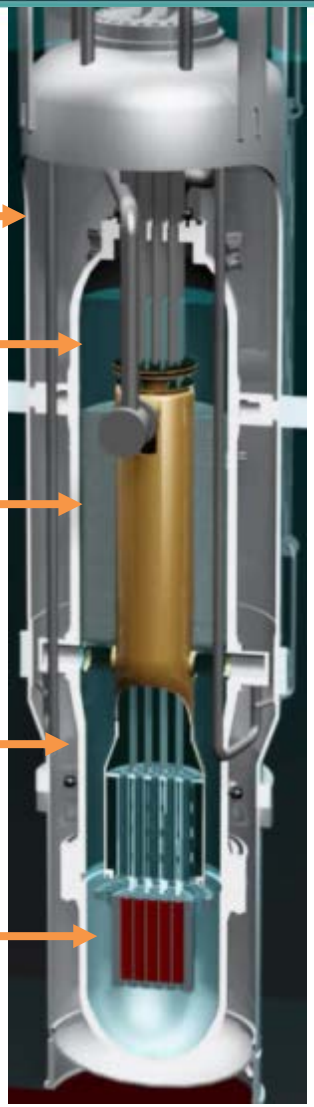
Pressurized Water Reactor Basics



NuScale Small Modular Reactor

- Containment
- Pressurizer
- Steam Generators
- Reactor Pressure Vessel (RPV)
- Reactor Core



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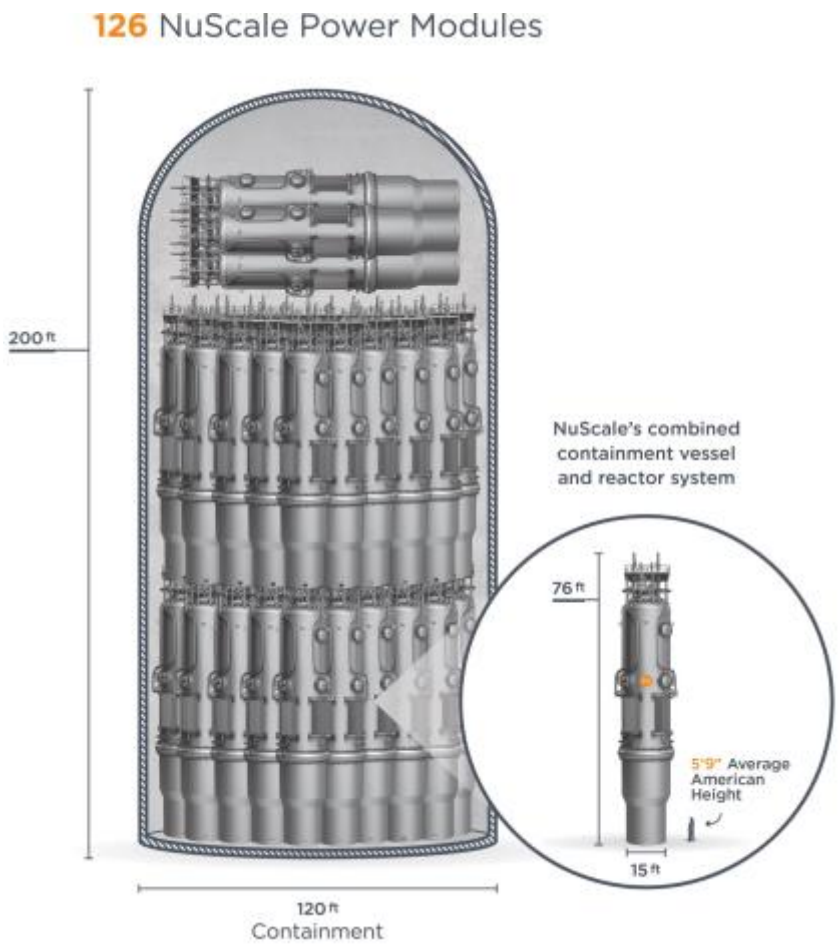
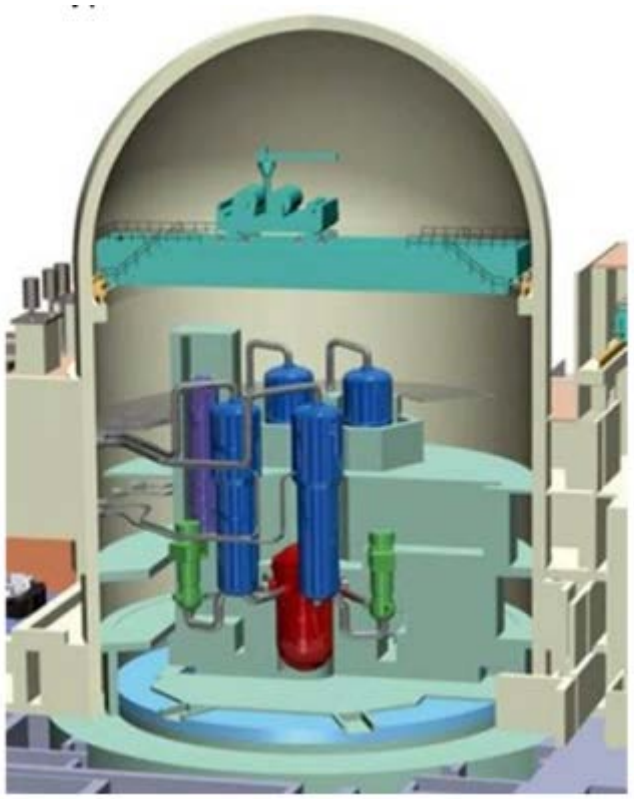
Size Comparison

Comparison size envelope of new nuclear plants currently under construction in the United States.



Typical Pressurized Water Reactor



*Source: NRC

*Source: U.S. NRC

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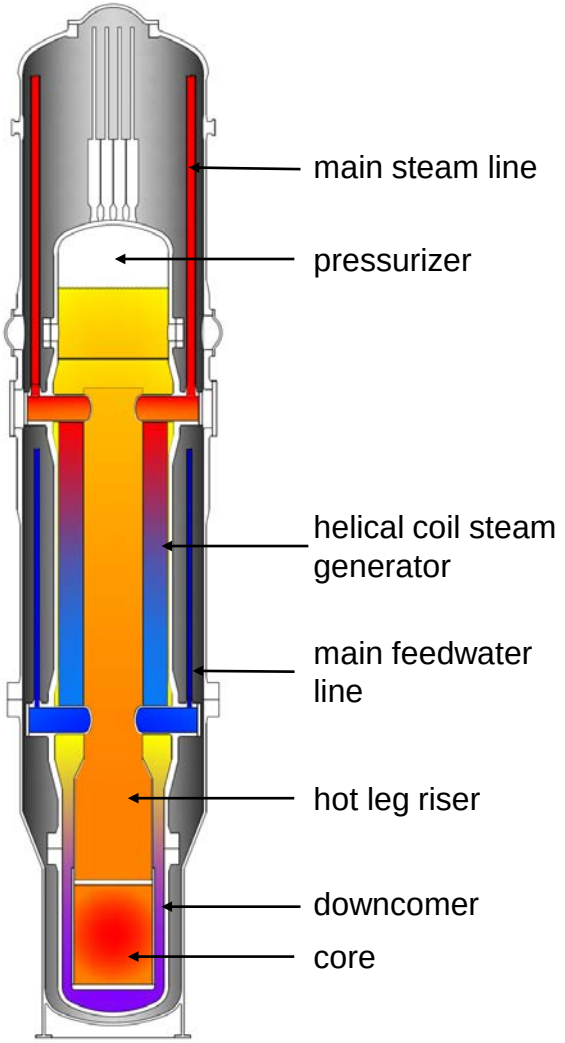
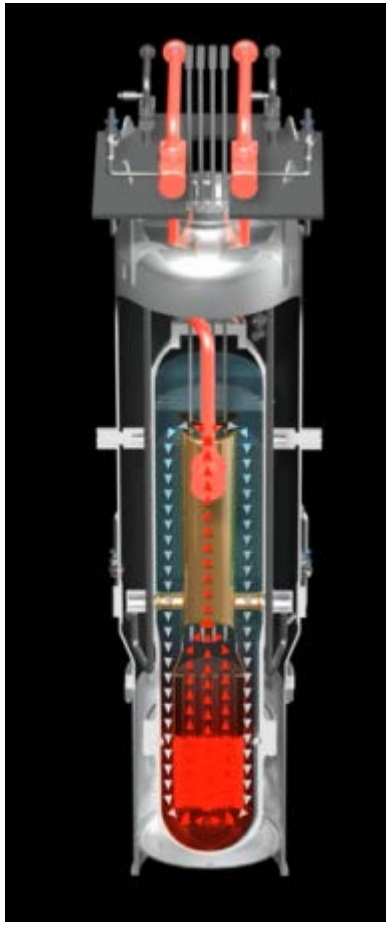
Normal Operation

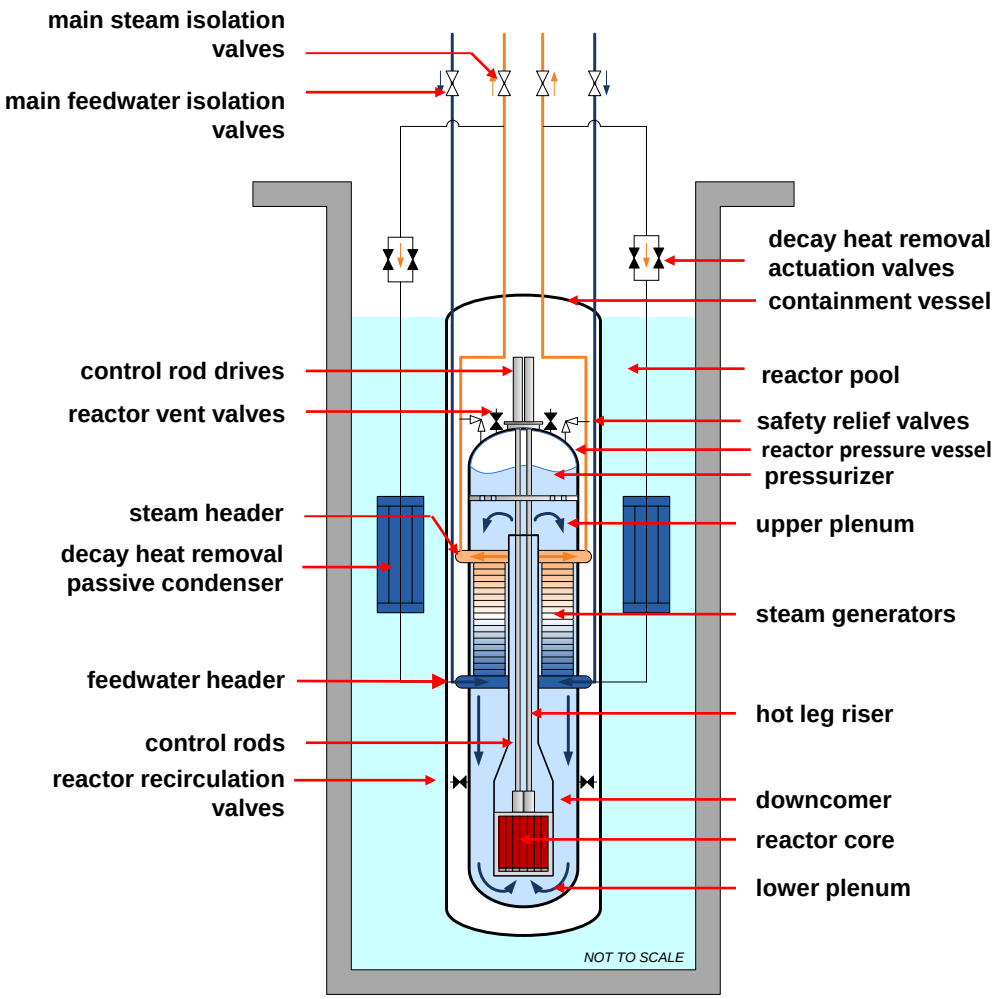
- Primary side
  - natural circulation
  - integral pressurizer
  - No Reactor Coolant Pumps
- Secondary side
  - feedwater plenums
  - two helical steam generators with large surface area per volume to maximize thermal efficiency
  - steam plenums

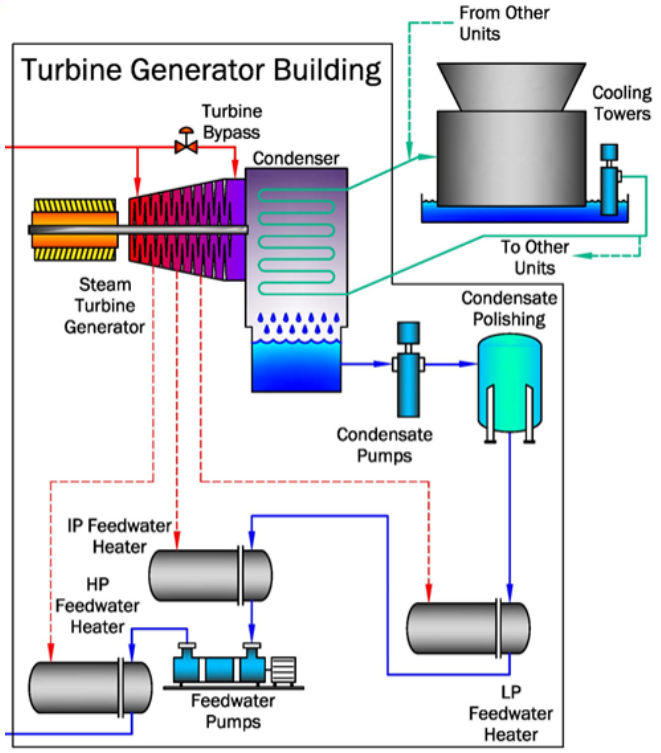




primary coolant flow path

NuScale Power Train (Video)

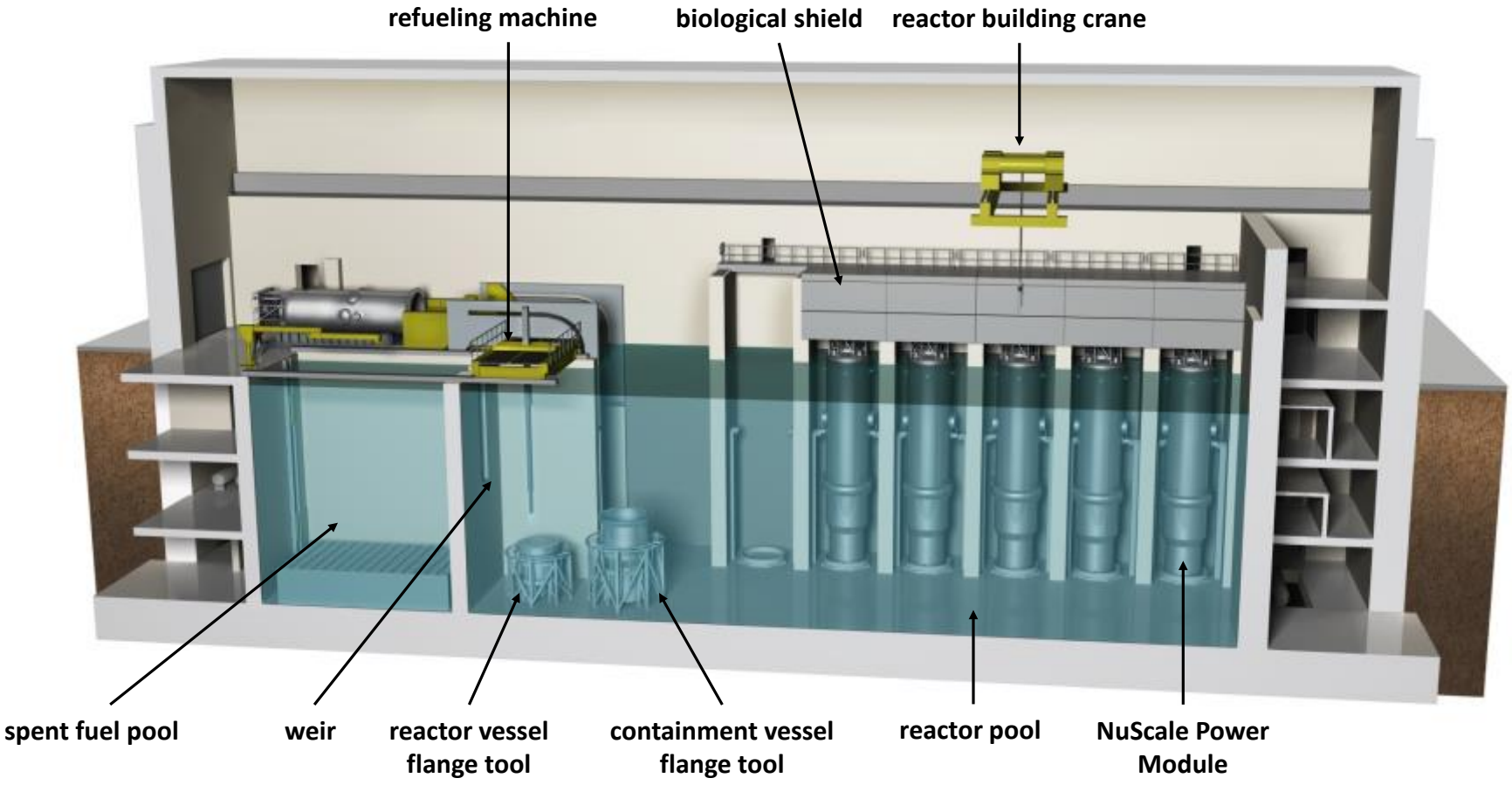




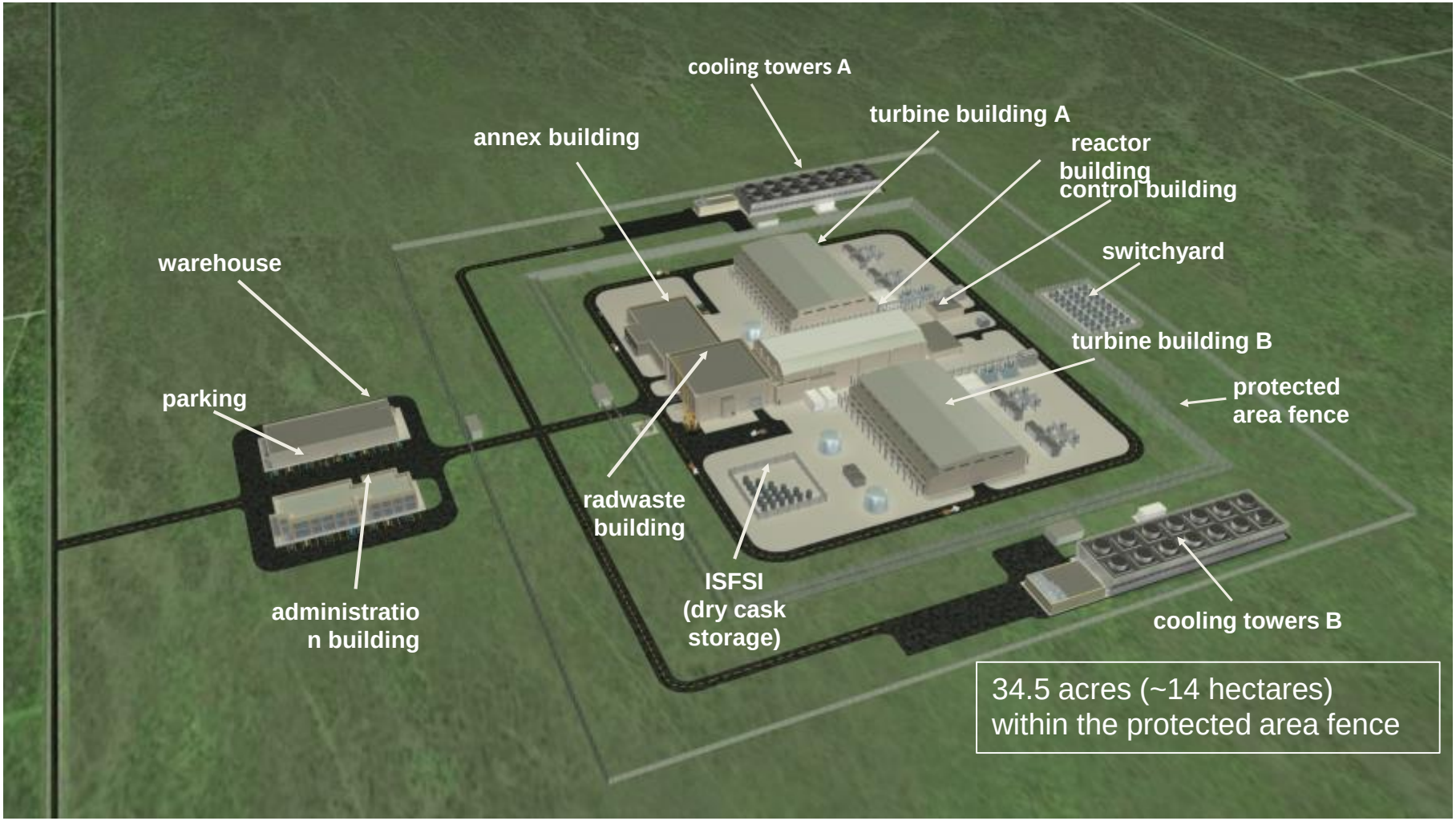
- Each NuScale power module feeds one turbine generator train eliminating single-shaft risk
- 100% turbine bypass capability
- Generator is totally enclosed water to air cooled (no hydrogen cooling required)
- Small, simple components support short, simple refueling outages

Reactor Building Cross-Section

Reactor building houses NuScale power modules, spent fuel pool, and reactor pool



Site Overview



A New Level of Safety and Resiliency

Simplicity Enhances Safety

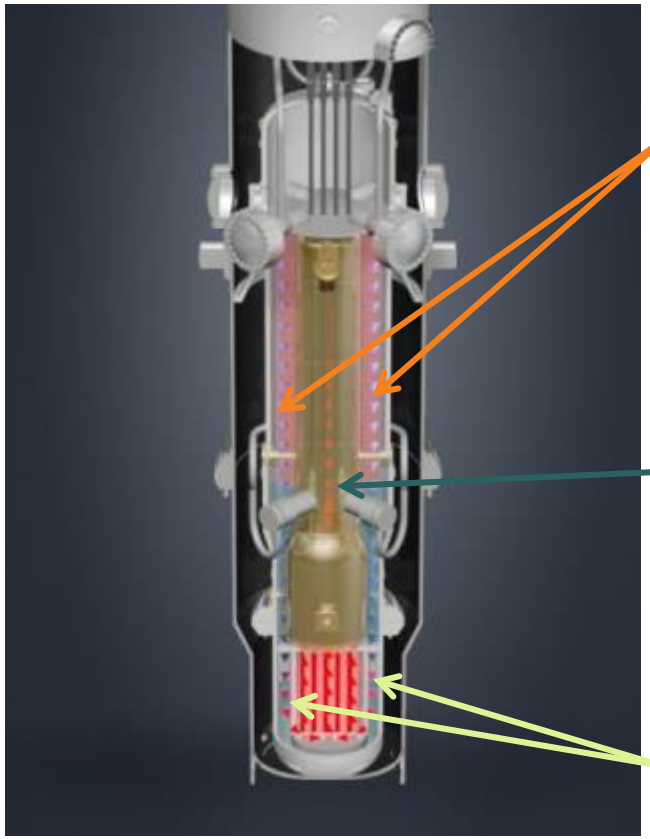
Second-to-none safety case – site boundary Emergency Planning Zone capable

Natural Convection for Cooling
- Passively safe, driven by gravity, natural circulation over the fuel
- No pumps, no emergency generators

Seismically Robust
- System submerged in a below-ground 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 **– heat is transferred through the walls of the tubes in the steam generator, heating the water (secondary coolant) inside them to turn it to steam. Primary water cools.**

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

Gravity **– colder (denser) primary coolant "falls" to bottom of reactor pressure vessel, cycle continues**

Steel containment has *>10 times pressure rating of a typical PWR.*
Water volume to thermal power ratio is *four times larger than typical PWR.*

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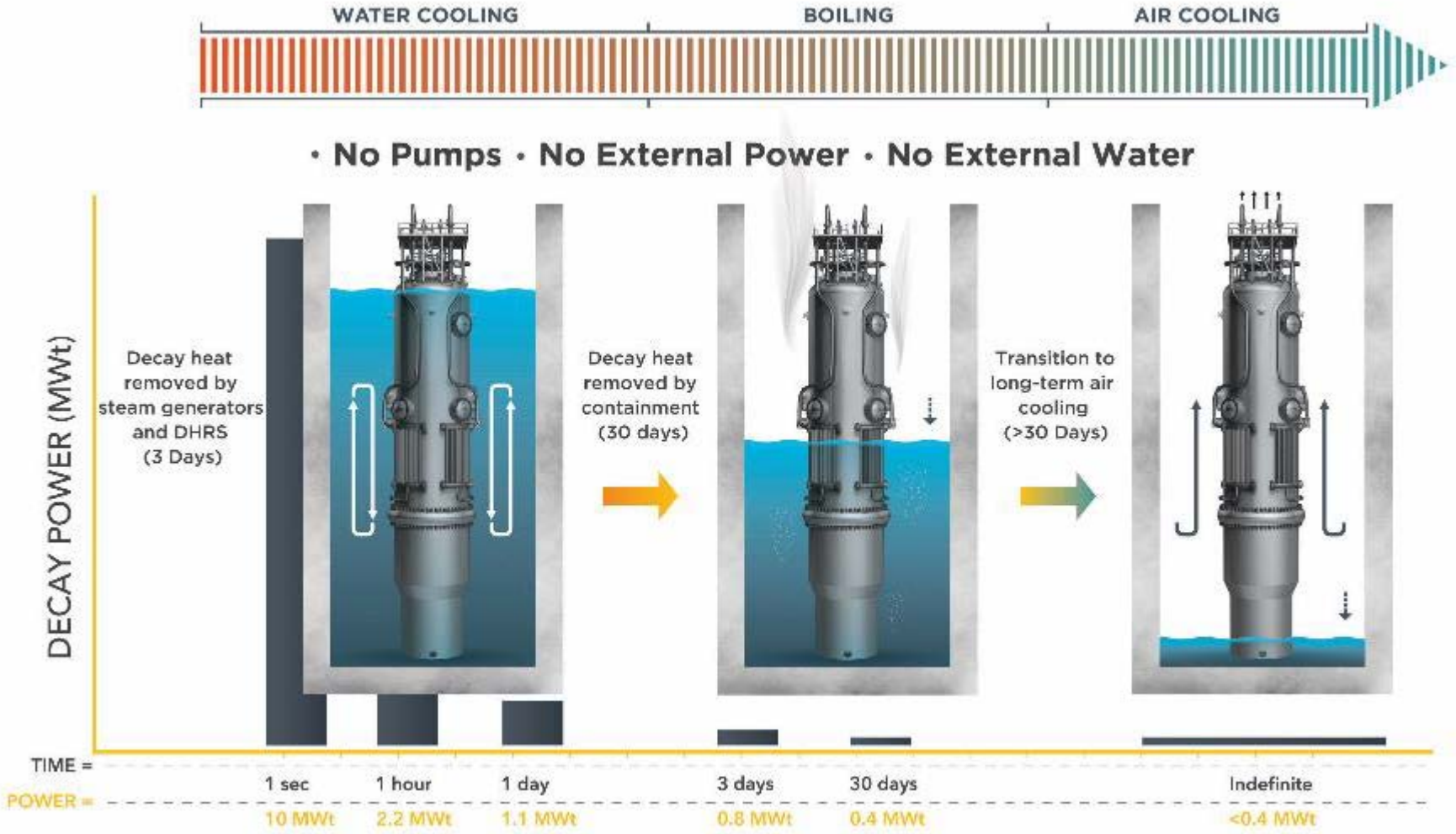
Innovative Advancements to Reactor Safety

*Nuclear fuel cooled indefinitely without Computer/Operator Action, AC/DC Power, or additional water**



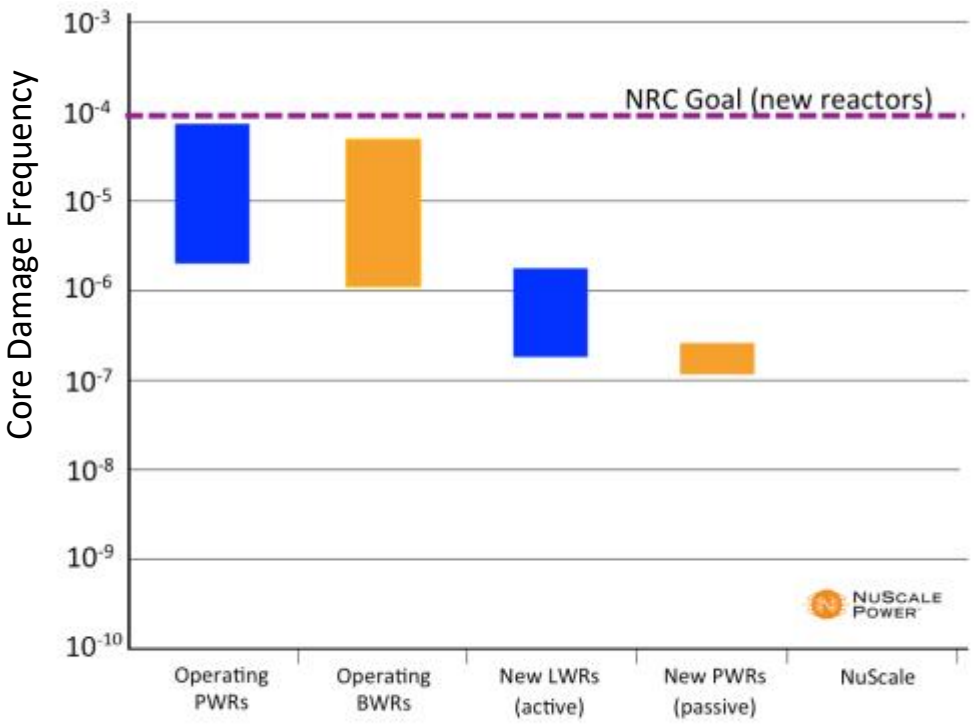
- ***30 days is a minimum based on very conservative estimates for all 12 modules.***

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

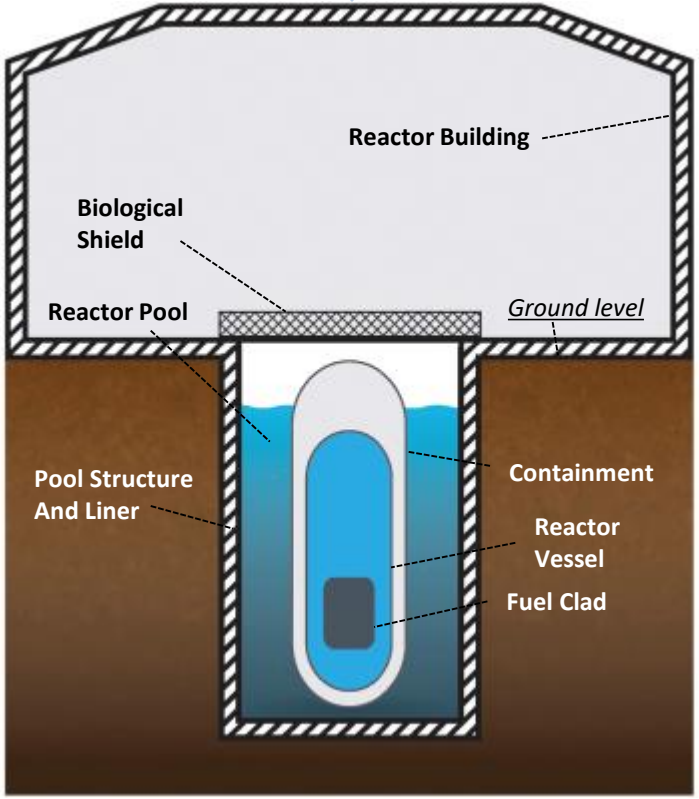
NuScale Power™

Reducing Plant Risk

Risk = (frequency of failure) X (consequences)



Probability of core damage due to NuScale reactor equipment failures is ***<1 in 1,000,000,000 years***



Four additional barriers to release of radioactivity from a NuScale plant.

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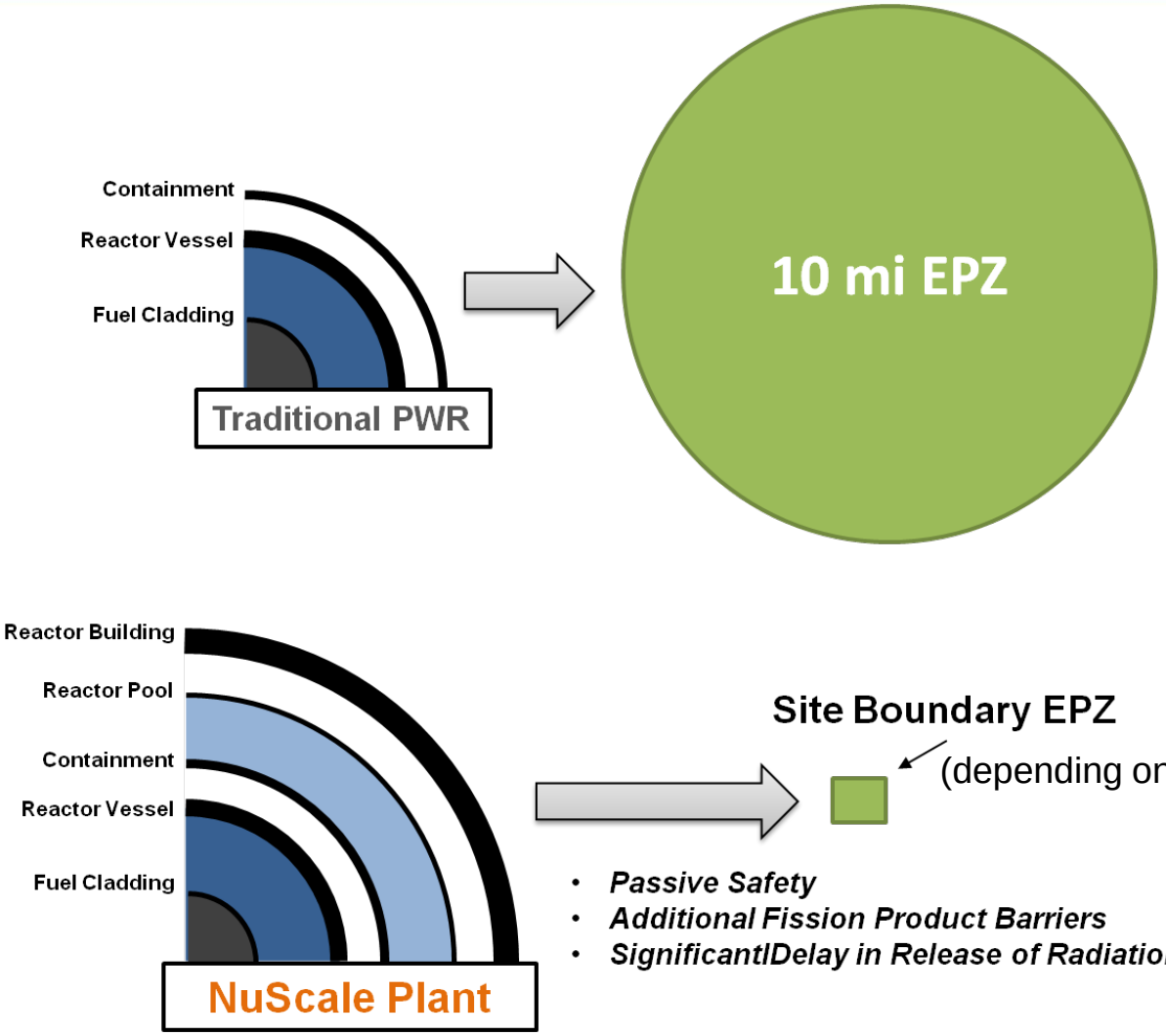
Smaller Emergency Planning Zone (EPZ) Due to Enhanced Safety



NEI Press Release
(September 7, 2017)

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News & Media

Home > News & Media > News > News Archives > 2017 > TVA Demonstrates Site Boundary EPZ Possible for SMRs

TVA Demonstrates Site Boundary EPZ Possible for SMRs

- TVA analysis adds information on Clinch River early site permit application
- Shows any accident radiological impact would be limited to within site boundary
- Analysis provides basis for exemption from 10-mile EPZ in regulatory breakthrough

https://www.nei.org/News-Media/News/News-Archives/2017/TVA-Demonstrates-Site-Boundary-EPZ-Possible-for-SM

NuScale Power

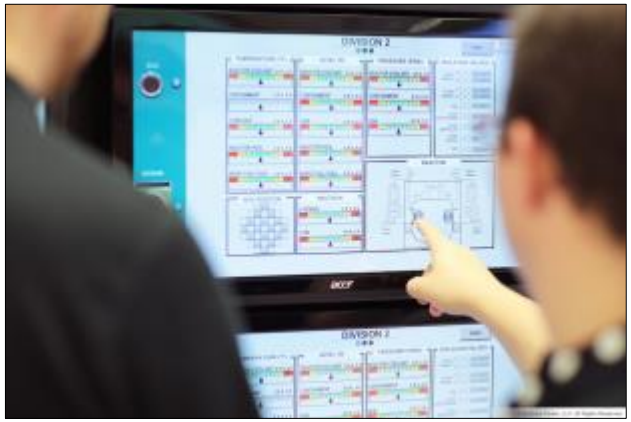
NuScale Test Programs

NuScale 12-Module Control Room Simulator, Corvallis, Oregon

A New Level of Plant Resiliency

NuScale design offers unparalleled resilience

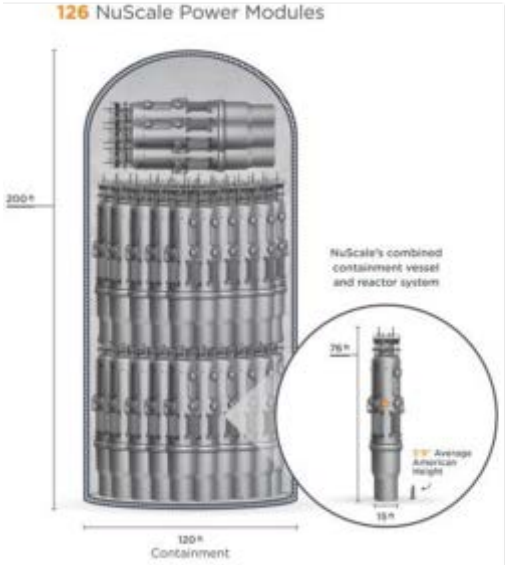
- **Loss of Offsite Power** - Single module powers entire plant. (Island mode). NuScale plant does not require operator or computer actions, AC/DC power, additional water or grid connection for safety.
- **First Responder Power** – On loss of offsite grid, all 12 modules can remain at full power or be ramped down while rejecting 100% steam to its condensers.
  - Able to provide grid power in 50 MWe increments upon grid restoration.
- **Resilience to Natural Events** – Modules and fuel pools located below grade in a Seismic Category 1 Building.
  - Can withstand a Fukushima type seismic event
  - Can withstand hurricanes, tornados, and floods
- **Resilience to Aircraft Impact** – Reactor building withstands aircraft impact as specified by NRC aircraft impact rule.
- **Cybersecurity** – NuScale Plant protection systems are non-microprocessor systems (i.e., field programmable gate arrays) and software-free and therefore not vulnerable to internet cyber-attacks.



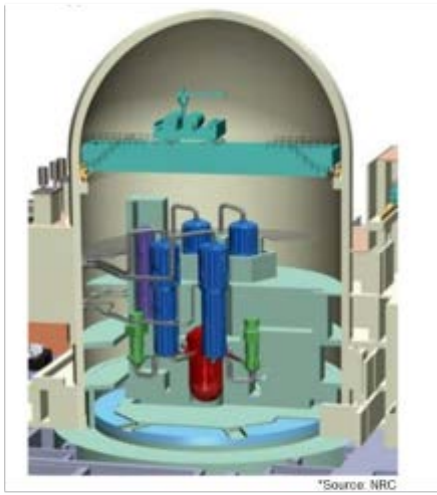
Economy and Global Market

Capturing the “Economies of Small”

Design moves field construction to factory fabrication



Typical Pressurized Water Reactor

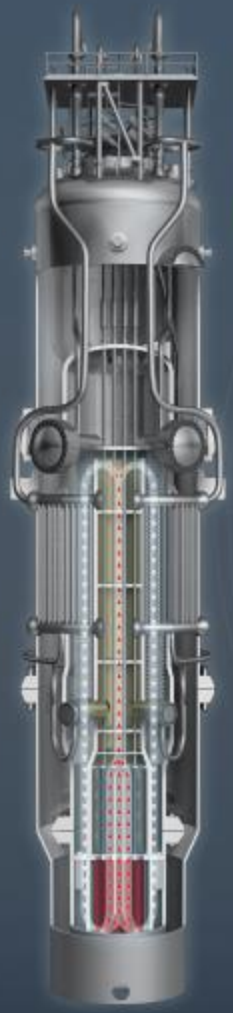


Economies of Small

Design Simplicity
Factory Fabrication
Simplified Construction
Innovative Operations

NuScale Power™

A New Approach to Construction and Operation



Factory Fabrication

Low carbon, secure electricity

To the plant site

Housed in a 12 module reactor building

NuScale Power Module™ including containment and reactor vessel

Shipped by truck, rail or barge

NuScale Power™

Economics

- Simplicity of design provides competitive levelized cost of electricity 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 LCOE - $65/MWh
- Up to 12 modules can be added to a facility incrementally, in response to load growth, reducing initial capital costs
- First module in situ can generate 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

Construction Cost Summary (U.S.)

Overall EPC Overnight Plant Costs

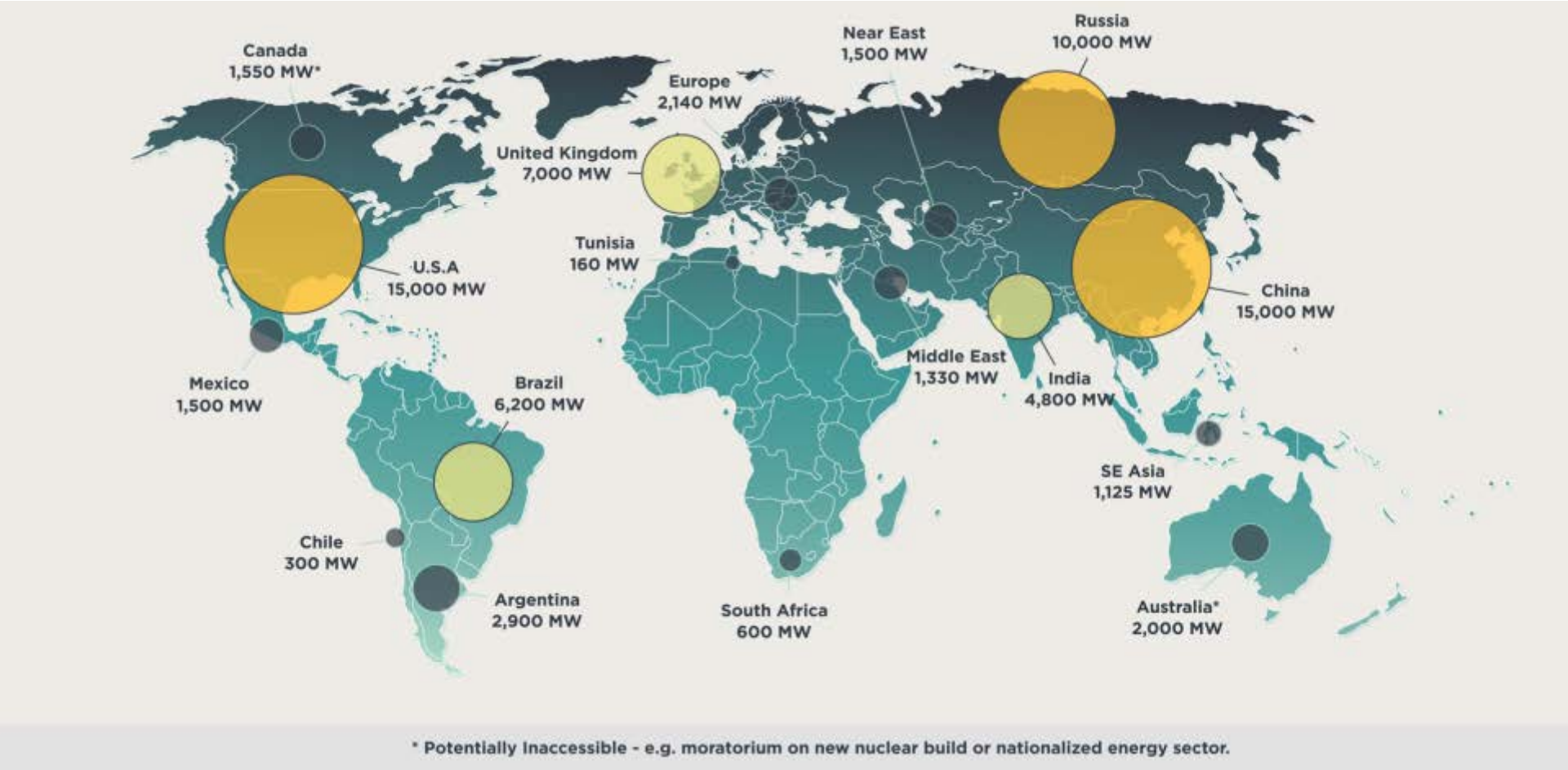
($1,000,000)

ITEM	2014 Dollars
Power Modules (FOAK Cost plus Fee, Transportation, & Site Assembly)	$ 848
Home Office Engineering and Support	$ 144
Site Infrastructure	$ 60
Nuclear Island (RXB, RWB, MCR)	$ 538
Turbine Island (2 buildings with 6 turbines each)	$ 350
Balance of Plant (annex, cooling towers, etc)	$ 225
Distributables (Temp. Bldgs., Field Staff, Const. Equip., etc.)	$ 545
Other Costs	$ 185
Total Overnight Price	**$ 2,895**

$ 5,078 per kWe net

International SMR Market Potential

- UK NNL* calculated the potential SMR market to be approximately 65-85GW by 2035, 55-75 GW excluding Russia; this is 1100 – 1500 NuScale Power Modules

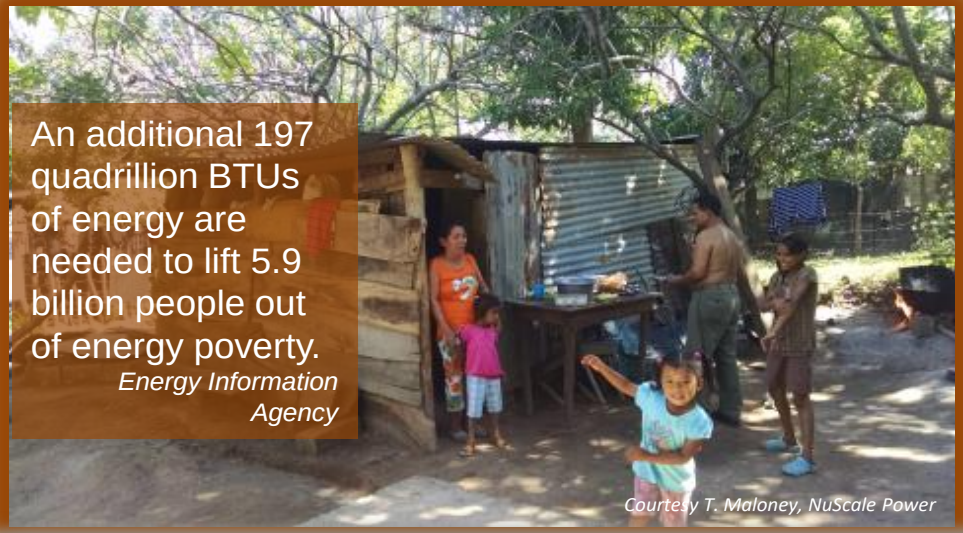


**UK National Nuclear Laboratory "SMR Feasibility Study", December 2014*

Multiple Applications and Integration with Renewables

New Applications - Expanding the Role of Nuclear Energy

Part of the Solution - Environmental Protection, Energy Security and Economic Growth



An additional 197 quadrillion BTUs of energy are needed to lift 5.9 billion people out of energy poverty.

Energy Information Agency

Courtesy T. Maloney, NuScale Power

783 million people do not have access to clean water. More than 300 million people around the world rely on desalinated water for some of their daily needs.

World Health Organization

Courtesy R. Temple, NuScale Power

Outdoor air pollution contributes to the deaths of an estimated 5.5 million people globally every year, or about 15,000 people a day, -

2016 Global Burden of Disease Project.

More than 1 billion metric tons of food is lost or wasted each year - decaying in fields or farms before harvest or while it's being transported.

World Resources Institute UNEP

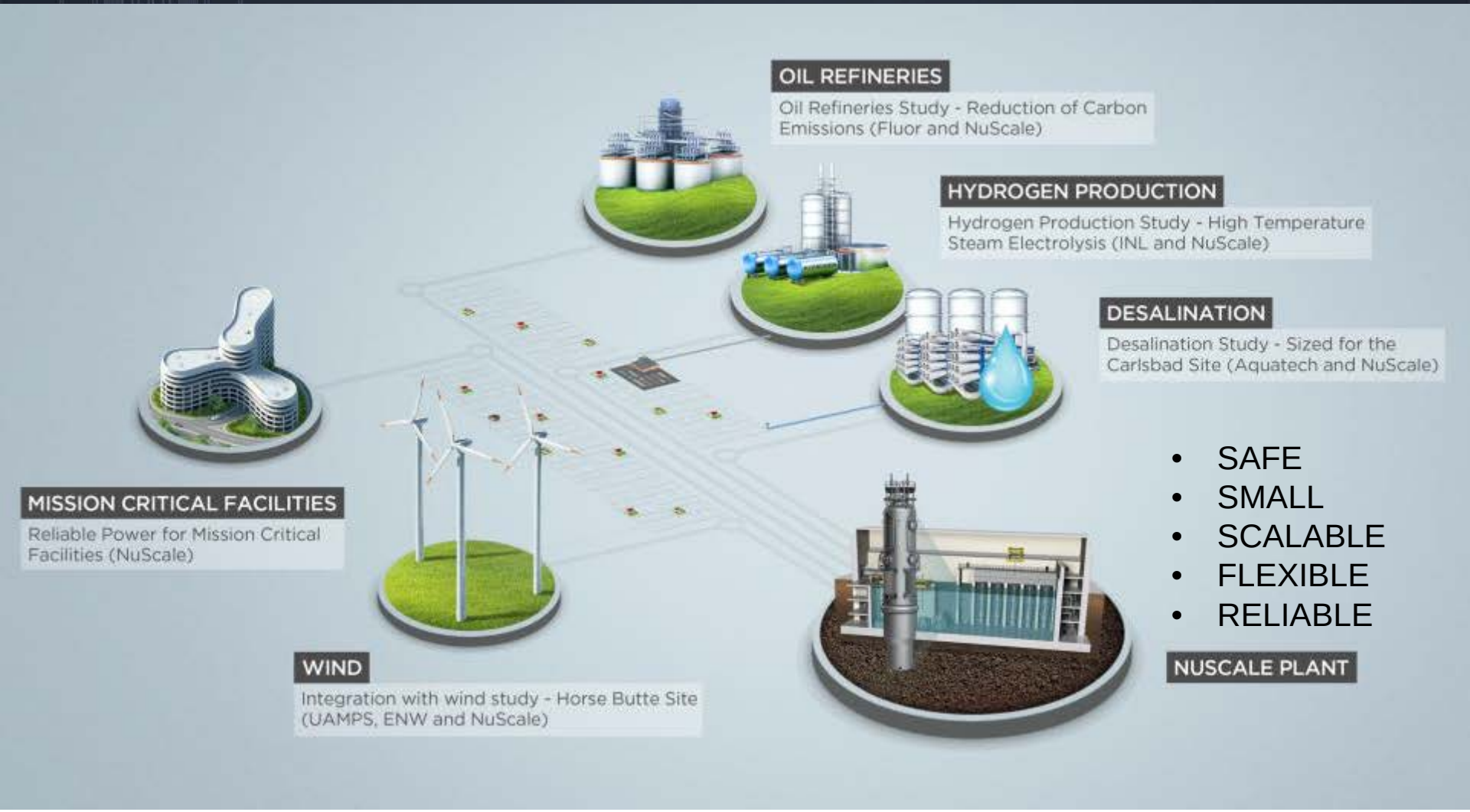
NUSCALE POWER™

NuScale – Part of the Global Solution

MISSION - NuScale Power will provide scalable advanced nuclear technology for the production of electricity, heat, and water to improve the quality of life for people around the world.

- NuScale has completed 5 studies with partners on different applications of the NuScale Power Modules that relate to the mission of the company:
  - Clean Water - Desalination
  - Clean Transportation Fuel – Hydrogen Production
  - Clean Air - Reduction of Carbon Emissions at Oil Refineries
  - Clean Energy - Facilitating Growth of Renewables – Load Following
  - Reliable Power – Protecting Critical Infrastructure

NuScale Diverse Energy Platform (NuDEP) Initiative

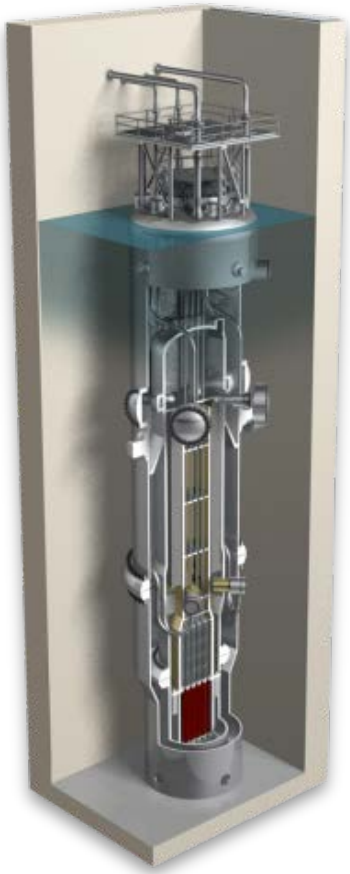


NuScale Diverse Energy Platform (Part 1)

Oil Refineries Study - Reduction of Carbon Emissions
(Fluor and NuScale)

10-Module Plant coupled to a 250,000 barrels/d refinery

"NuScale Energy Supply for Oil Recovery and Refining Applications," Proceedings of the 2014 International Congress on Advances in Nuclear Power Plants (ICAPP 2014), Charlotte, NC, USA, April 6-9, 2014.
This study explores how nuclear power can support oil recovery and refining operations. Concluded that electricity and heat provided by a single NuScale plant can reduce the carbon emission footprint of a large oil refinery by nearly 40%.



Hydrogen Production Study – High-Temperature Steam Electrolysis
(INL and NuScale)

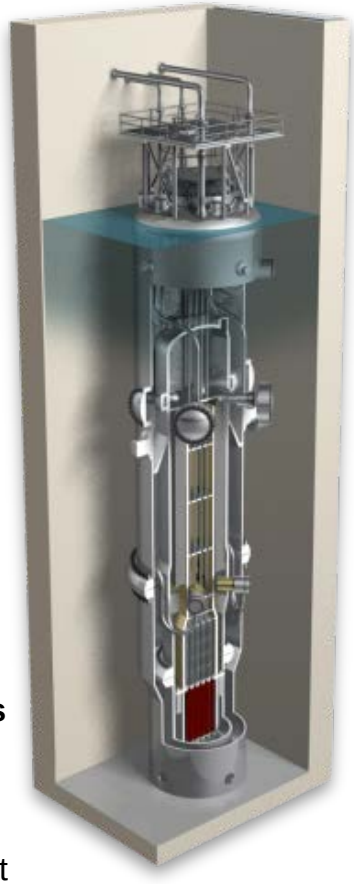
6-Module Plant for Emission Free Hydrogen Production

"Extending Nuclear Energy to Non-Electrical Applications," Proceedings of the 19th Pacific Basin Nuclear Conference (PBNC 2014), Vancouver, B.C., Canada, August 24-28, 2014.
This paper provides a review of several studies demonstrating the flexibilities of the NuScale design for supporting non-traditional applications, including oil refining, water desalination, hydrogen production, and integration with renewable energy sources.

NuScale Diverse Energy Platform (Part 2)

Integration with Wind Study - Horse Butte Site
(UAMPS, ENW and NuScale)

1-Module dedicated to UAMPS 57.6 MW wind farm



Desalination Study – Sized for the Carlsbad Site
(Aquatech and NuScale)

8-Module Plant can produce 50 Mgal/d (190K m^3/d) of clean water plus 350 MWe

"Can Nuclear Power and Renewables be Friends?" Proceedings of the International Congress on Advances in Nuclear Power Plants (ICAPP 2015), Nice, France, May 3-6, 2015.

This paper evaluated options for using a NuScale plant to compensate for variable output from a specific wind farm while meeting electrical demand. It demonstrated the flexibilities integral to a NuScale plant for load-following operations.

"NuScale small modular reactor for co-generation of electricity and water," *Desalination*, 340, 84-93 (May 2014).

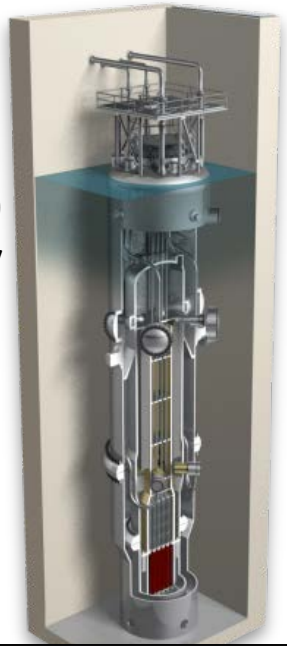
This publication was a detailed study of coupling a NuScale plant with several water desalination technologies. It demonstrated that a single NuScale plant coupled to a reverse osmosis desalination plant can produce sufficient clean water and electricity to support a community of 300,000 people.

NuScale Diverse Energy Platform (Part 3)

Reliability for Critical Infrastructure

UTILITY MACROGRID

470 MWe (net)
> 95% Capacity



NuScale 12-Module Plant

DEDICATED MICROGRID
100 MWe (net)
> 99.95% Availability

MISSION CRITICAL FACILITY

"Highly Reliable Nuclear Power for Mission-Critical Applications," Proceedings of the International Congress on Advances in Nuclear Power Plants (ICAPP 2016), San Francisco, CA, April 17-20, 2016.

This paper describes the study conducted to determine the reliability of power afforded by the independent and redundant power configuration of a NuScale plant. It determined that up to 100 MWe can be provided to a dedicated microgrid with 99.95% availability over the entire 60-year lifetime of the plant. **"Island Mode**" capable.

NuScale Power

Regulatory Communications and Approvals

Reducing Licensing Risk

- Design Certification Application (DCA) completed at end of 2016.
- DCA accepted for docketing in March 2017.
- >800 people have worked on the project across 5 Offices in U.S.
- *~43,000 NRC review hours, and participation in 119 Formal Meetings and in an NRC DCA Readiness Review.*
- RAI process is in full implementation
- NRC has published its review schedule

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

Regulatory Approval of Innovation

NRC Approves "No Power" aspect of Triple Crown of Safety and Digital I&C Platform

- **NuScale Digital I&C Platform (HIPS) Approved by NRC (July 2017)** -The HIPS Platform is a protection system architecture jointly developed by NuScale Power and Rock Creek Innovations. The HIPS platform is based on the fundamental I&C design principles of independence, redundancy, predictability and repeatability, and diversity and defense-in-depth. The HIPS platform is comprised of just four module types which can be interconnected to implement multiple configurations to support various types of reactor safety systems. It also uses field programmable gate array technology that is **not vulnerable to internet cyber attacks.**
- **NRC approves NuScale Approach for no 1E Power (December 2017).** NRC approved NuScale's "Safety Classification of Passive Nuclear Power Plant Electrical Systems" Licensing Topical Report, which establishes the bases of how a design can be safe without reliance on any safety-related electrical power. 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.

First NuScale SMR Plant and Financing

Industry Interest and Support

NuScale is making steady progress towards a healthy sales backlog

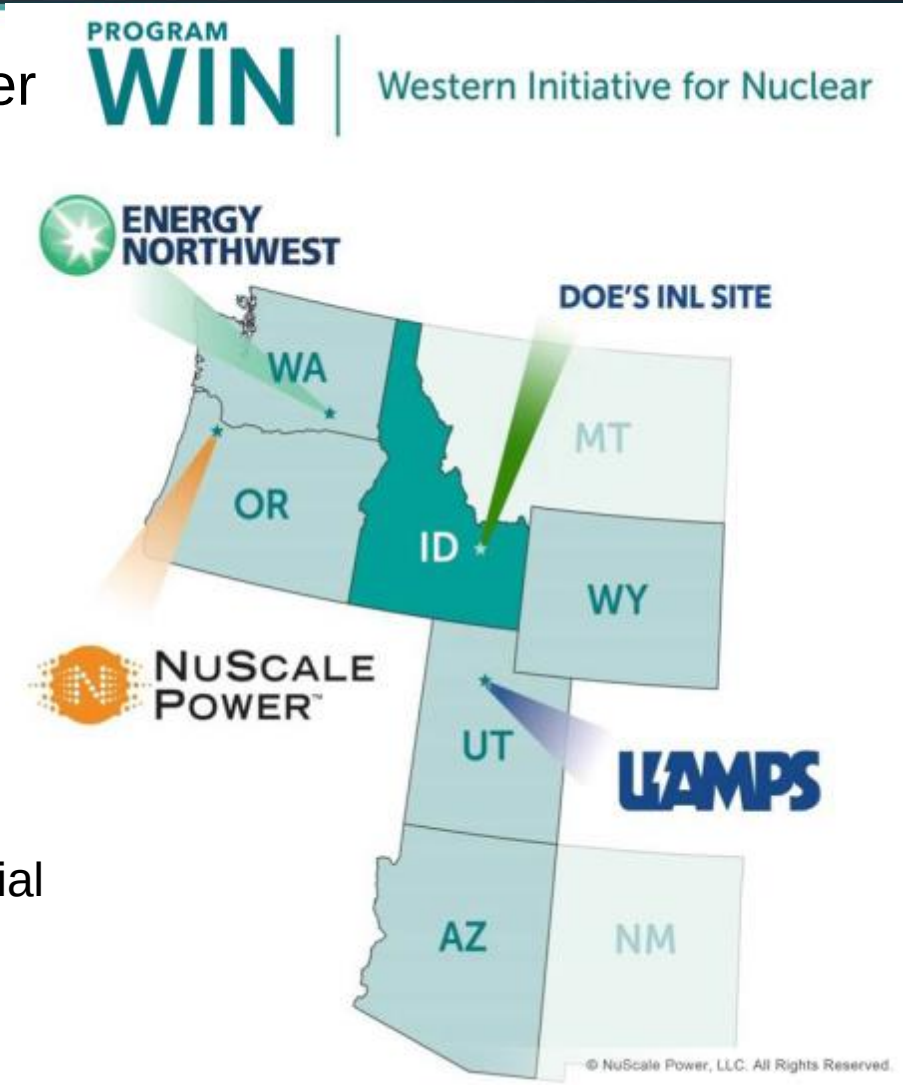
- NuScale has considerable domestic customer interest
  - NuScale has a 29 member domestic utility advisory board (“NuAB”)
- Lead deployment effort is a result of the Western Initiative for Nuclear (part of “*Program WIN”*)
  - Broad western state collaboration
  - First deployment in late 2026 in Idaho
- NuScale has a technical advisory board comprised of industry subject experts.
- Strong and increasing international customer interest in multiple markets

NuScale Advisory Board (NuAB) Members

NUSCALE POWER

NuScale First Project

- Utah Associated Municipal Power System (UAMPS) *Carbon Free Power Project (CFPP)*
  - 600 MWe (gross), 12 module plant
  - Located on the Idaho National Laboratory (INL) site
  - UAMPS as owner
  - Energy Northwest as operator
  - Fluor / NuScale as EPC
  - 2026 commercial operation
  - 35 UAMPS members to take CFPP output under power sales contracts
  - DOE awarded $16.5 million in cost sharing for project planning and initial licensing support activities



National Infrastructure for SMR Deployment

Japan is ideally positioned to implement NuScale technology in support of de-carbonization

- *Existing infrastructure for nuclear plant licensing and regulation. However, new regulations for SMRs would be needed.*
- *Existing domestic module manufacturing capability. Potentially a new SMR industry for Japan.*
- *Significant expertise in commercial nuclear power construction and operation.*
- *World class nuclear power testing and research capability at Japanese national laboratories and universities.*
- *Social acceptance requires national government commitment to nuclear energy and education of the public.*

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