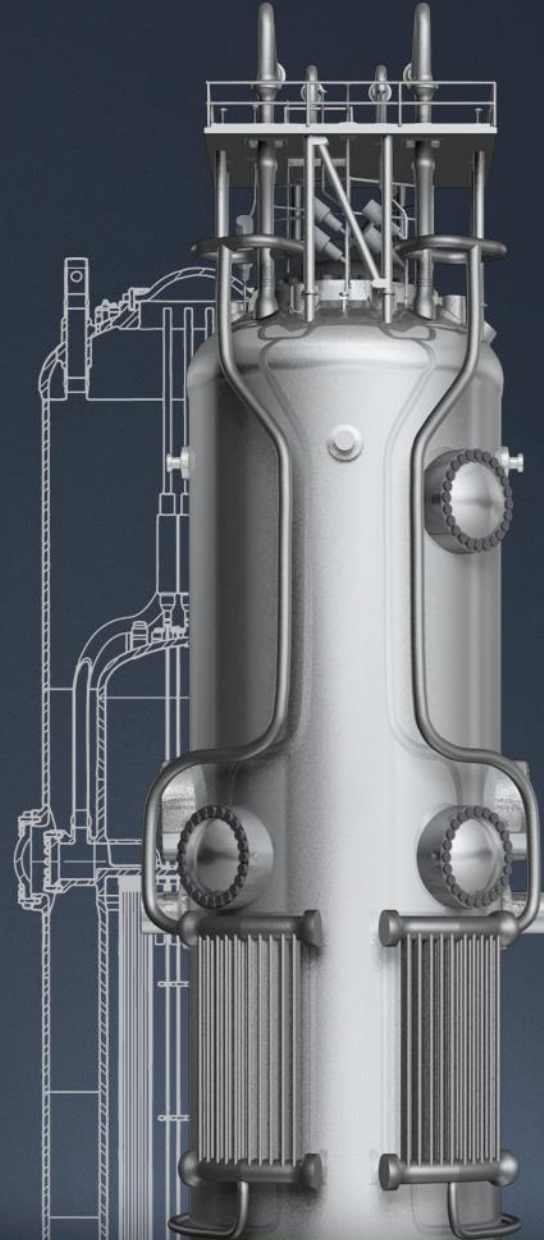




PNWER Energy Working Group
July 25, 2017

NuScale Small Modular Reactors: Advanced, Scalable, Flexible, Economic

Charles Marcinkiewicz
Director, Marketing
NuScale Power, LLC



Who is NuScale Power?

- NuScale Power was formed in 2007 to provide scalable advanced nuclear technology for the production of electricity, heat, and water to improve the quality of life for people around the world.
- Initial concepts in development and testing since the 2000 (U.S. DOE) MASLWR program.
- Fluor Corporation became primary investor in 2011.
- In 2013, NuScale wins \$217M competitively bid U.S. DOE financial assistance award.
- >350 Patents granted or pending in 20 countries.
- >800 people have worked on the project with 5 Offices in U.S. and 1 office in London.
- Design Certification Application was completed in December 2016 and accepted for U.S. NRC review in March 2017.

Today, NuScale Power is the premier developer of SMR nuclear technology in the U.S. and heading to commercialization.



NuScale Engineering Offices Corvallis



One-third scale NIST-1 Test Facility



NuScale Control Room Simulator

Blazing the Trail to Commercialization



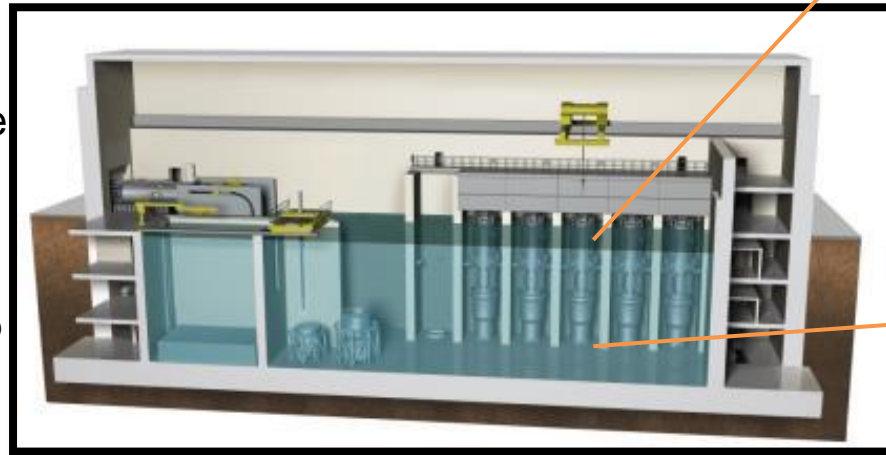
Design Certification Application Completed 12/31/16

- Pre-application accomplishments
 - >130 meetings
 - >45,000 NRC billable hours (~\$11MM)
 - 15 NRC audits and inspections
 - >1,000 documents on our docket
 - September Readiness Assessment
 - 84 NRC personnel
 - 8 working days
 - Cost >\$1 Million
 - 85 docketing items identified
- 12,000 pages, 13.5 feet of bookshelf space
- 14 Topical Reports
- 2 million labor hours
- 8.5 years
- 800 people
- >50 supplier/partners
- \$505 Million



What is a NuScale Power Module?

- A NuScale Power Module (NPM) includes the **reactor vessel, steam generators, pressurizer, and containment** in an integral package.
- Each individual NPM produces 50 MWe (gross). It is fully factory fabricated and sized to be shipped to the generating facility by rail, truck or barge.
- The NPM design is simple eliminating reactor coolant pumps and large bore piping (no LB-LOCA) as well as 13 other systems and related components needed to protect the core in large conventional reactors.
- Each NPM has a dedicated 50MWe Power Conversion System (Turbine-Generator) – No Single Shaft Failure
- NPMs can be incrementally added to match load growth - up to 12 NPMs for 600 MWe gross (~570 net) total output.



Simplicity Enhances Safety

Natural Convection for Cooling

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

Seismically Robust

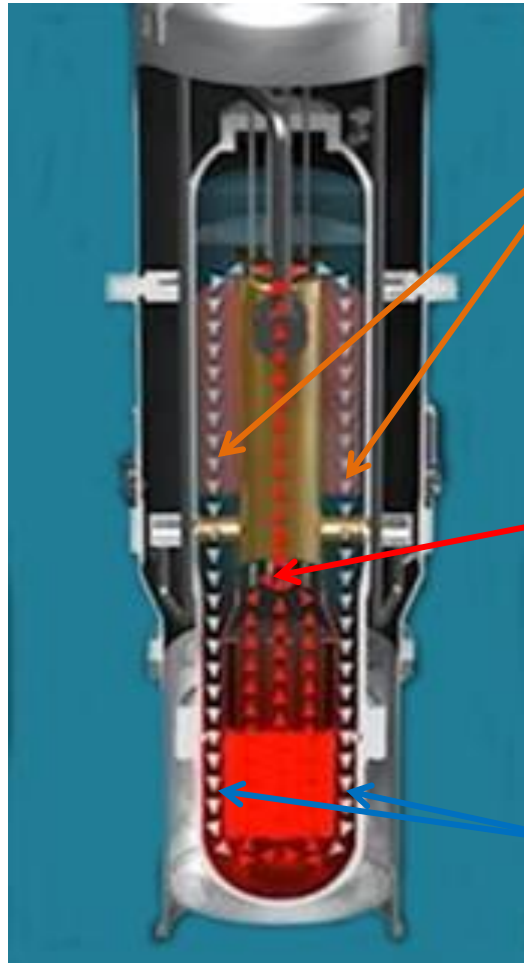
- System submerged in a below-ground pool of water in an earthquake and aircraft impact resistant building

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!

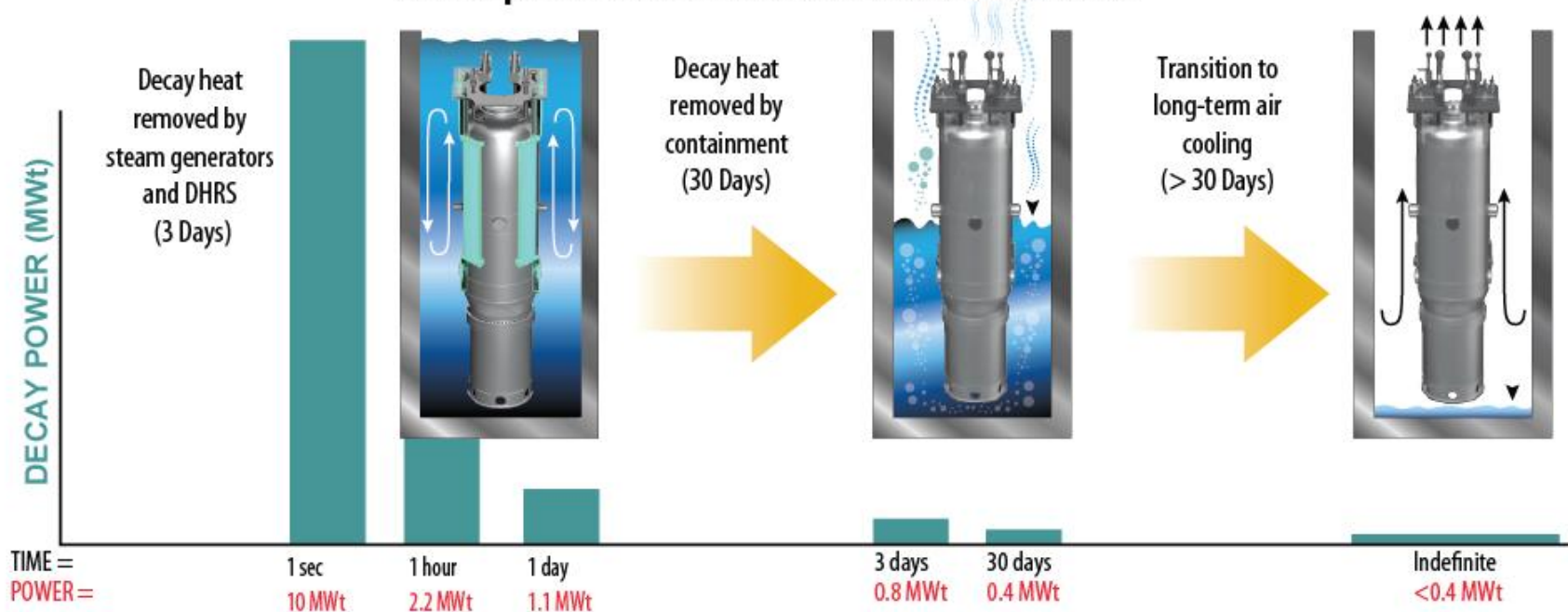
Water volume to thermal power ratio is four times larger than typical PWR!

Innovative Advancements to Reactor Safety

Station blackout response - stable long-term cooling under all conditions.
Nuclear fuel cooled indefinitely without pumps, power, or additional water.



No Pumps • No External Power • No External Water



* Based on conservative calculations assuming all 12 modules in simultaneous upset conditions and reduced pool water inventory. 30 days is a minimum.

Lowering Costs of Nuclear Power

- **Small, Modular, and Scalable Approach:**
 - Streamline reactor fabrication in a factory
 - Transport modules to plants around the world
 - Reduce on-site construction burden
 - Add modules as energy demand increases
 - Flexible operation to match energy demand
 - Flexible uses for electricity, heat, and water

- **Lower up-front cost and lower operating cost as compared to large light-water nuclear reactors**

Flexible - More than Baseload Electricity Generation

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

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



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

1-Module dedicated to UAMPS 57.6 MW wind farm



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

6-Module Plant for Emission Free Hydrogen Production



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

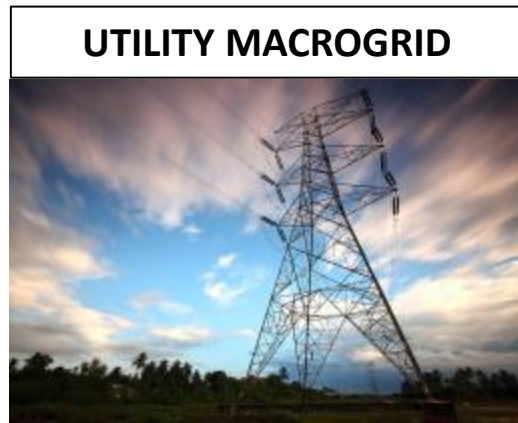
8-Module Plant can produce 50 Mgal/d (190K m³/d) of clean water plus 350 MWe



Reliable Power for Mission Critical Facilities (NuScale)

12-Module Plant coupled to a 100 MWe Mission Critical Facility

Reliability for Critical Infrastructure



**470 MWe (net)
> 95% Capacity**



- Connection to a micro-grid, island mode capability, and the ability for 100% turbine bypass allows a NuScale plant to assure 100MWe net power at 99.99% (“Four 9s”) reliability over a 60 year lifetime
- Using highly robust power modules and a multi-module plant design can provide clean, abundant and highly reliable power to those utility customers who require it
- Working to provide “Five 9s” reliability
- The design, development and operation of the NuScale safety I&C systems is consistent with the NIST 2014 Cyber-security Framework.

**DEDICATED
MICROGRID
100 MWe (net)
> 99.99% Availability**



Load Following Capability

- NuScale includes unique capabilities for following electric load requirements as they vary with customer demand and rapid output variations from renewables: NuFollow™
- There are three means to change power output from a NuScale facility:
 - **Dispatchable modules** – taking one or more reactors offline for extended periods of low grid demand or sustained wind output
 - **Power Maneuverability** – adjusting reactor power for one or more modules.
Meets EPRI URD Rev 13
 - 24 hour load cycle 100%→20%→100%
 - Ramp Rate 40% per hour
 - Step Change 20% in 10 minutes
 - **Turbine Bypass** – bypassing turbine steam to the condenser (short time frames)
- **Successfully demonstrated integration with actual generating performance of Horse Butte wind farm in Idaho!**



Local Economic Impacts of a NuScale Plant

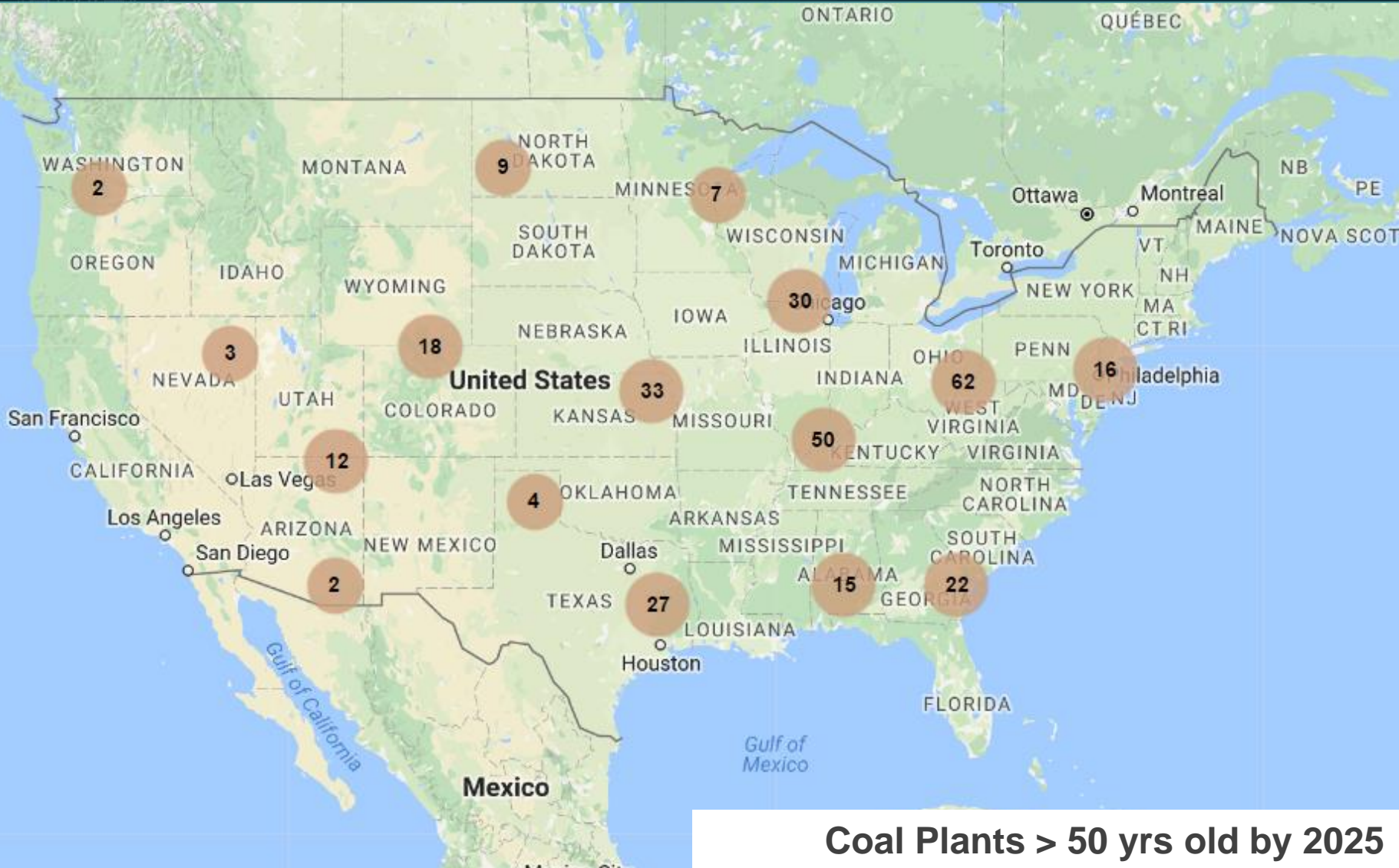
- Project will create ~1000 construction jobs at peak, for duration of 2-3 years
- Indirect economic benefits and associated job multipliers
- Full-time plant employment ~360 at average U.S. salaries \$85K
- Indirect economic benefits
- 12,000+ manufacturing jobs in NuScale supply chain
- Reliable power for development of local resources



Potential Manufacturing Locations



Potential Construction Locations



Coal Plants > 50 yrs old by 2025

Operation

Plant Staffing for Typical Baseload Power Plants

	Coal	Natural Gas Combined Cycle	NuScale Power Plant
Plant Employees (per 600 MWe)	146	24	365
Average Annual Wage for Staff	\$71,800	\$75,130	\$89,940

Jobs by educational requirement at 600 MW NuScale Power Plant

- Associates Degree, Vocation, or Military 170
- High School Diploma 110
- BS Engineering 85

➤ *Opportunity to train current coal plant workers to work at NuScale plant*

Sources: Utah Associated Municipal Power Systems (UAMPS); NuScale Power; Occupational Employment and Wages, May 2015, Bureau of Labor Statistics

Continuing Work

- Communications with the NRC and responses to RAIs
- First of a Kind Engineering Development
- Cost Reduction Initiatives and Projects
- Standard Plant Development
- Operational Procedures and Services
- Supply Chain Development
- Commercialization
 - First Customer will likely be UAMPS
 - First Plant to be located in Idaho on the Idaho National Laboratory
 - First COD – 2026
 - Discussions with multiple US utilities and foreign countries

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