The NuScale SMR
Benefits, Myths and Prognosis

Dr. Paul Lorenzini

Co-Founder, CEO (retired)

November 19, 2014

Nonproprietary

NuScale Power™

NuScale Power Update

- NuScale technology in development and design since 2000 (DOE) MASLWR program.
- Electrically-heated 1/3-scale Integral test facility first operational in 2003
- Company formed in 2007
- Began NRC design certification (DC) pre-application project in April 2008
- Twelve-reactor simulated control room operational in May 2012 for Human Factors Engineering development
- DOE announces FOA win in 2013 and Cooperative Agreement signed May 2014
- New Office opening in Charlotte, NC
- 115 Patents Granted or Pending, U.S. and Internationally
- ~350 FTE's currently on project, ~$200MM spent project life-to-date

NuScale Engineering Offices Corvallis

One-third scale Test Facility

NuScale Control Room Simulator

NUSCALE POWER™

FLUOR® - an American Company

- Acquired majority interest in NuScale in October 2011
- A global, publicly traded engineering, procurement, construction, companies
- #110 in the FORTUNE 500 in 2013
- More than 1,000 projects annually, serving more than 600 clients in 66 countries
- More than 43,000 employees worldwide
- Offices in more than 28 countries on 6 continents
- Over 100 years of experience

Fluor Corporate Headquarters
Dallas, Texas

Revenue	$27.6 billion
New awards	$27.1 billion
Backlog	$38.2 billion

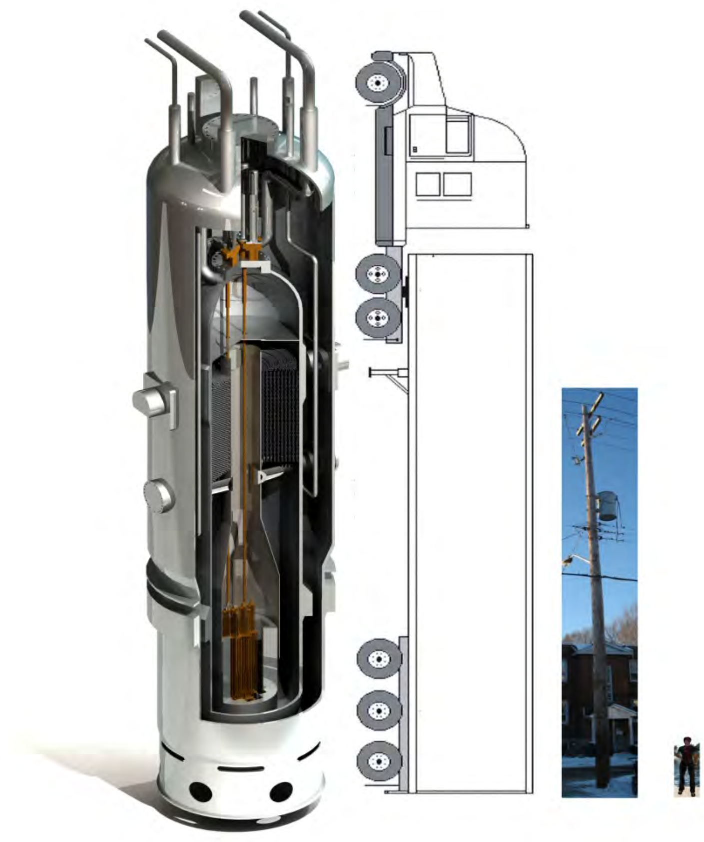
Investment Grade Credit Ratings:

S&P	A-
Moody’s	A3
Fitch	A-

NUSCALE POWER™

Why the NuScale SMR?

- Factory construction exploits 8-3-1 rule
- Modularity lowers financial risks
- Simplicity lowers unit costs
- Significantly enhanced safety
- Technology risks minimized by
    - Using Proven technology
    - Integral test facilities

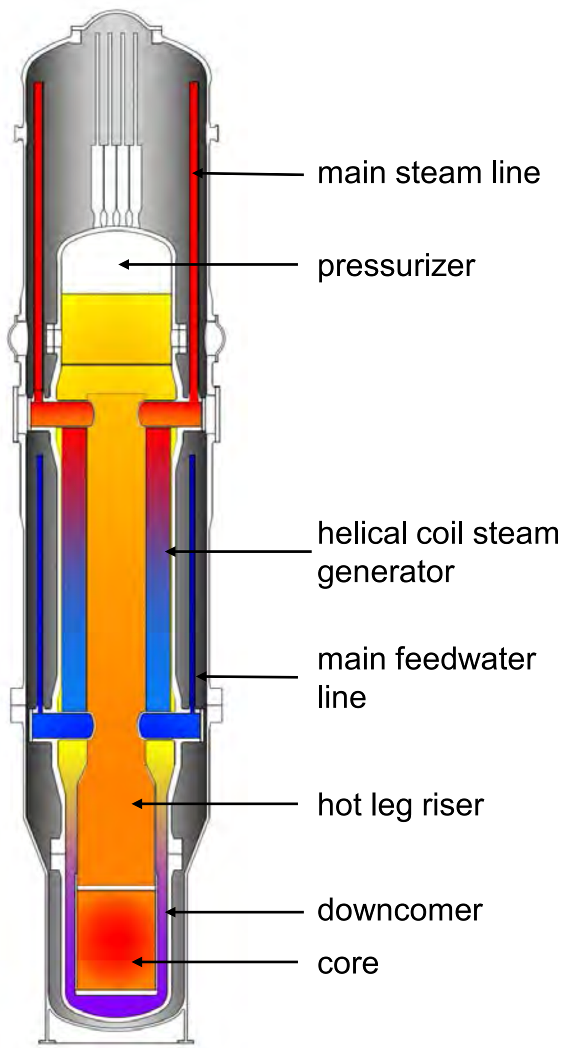


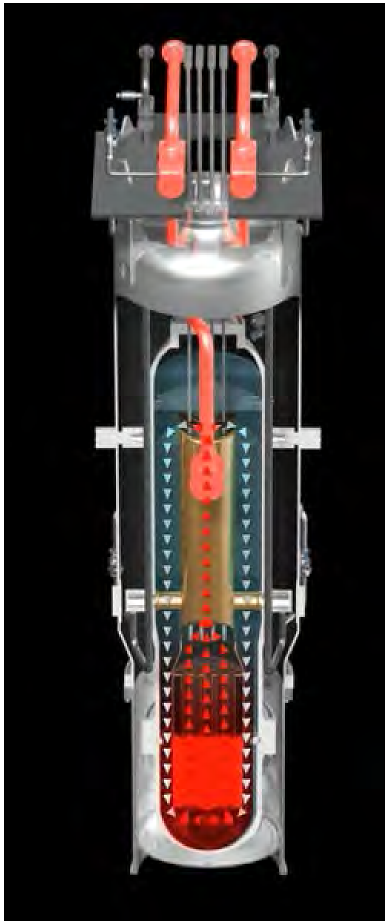
NuScale Power™

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

[Normal Operation Video]

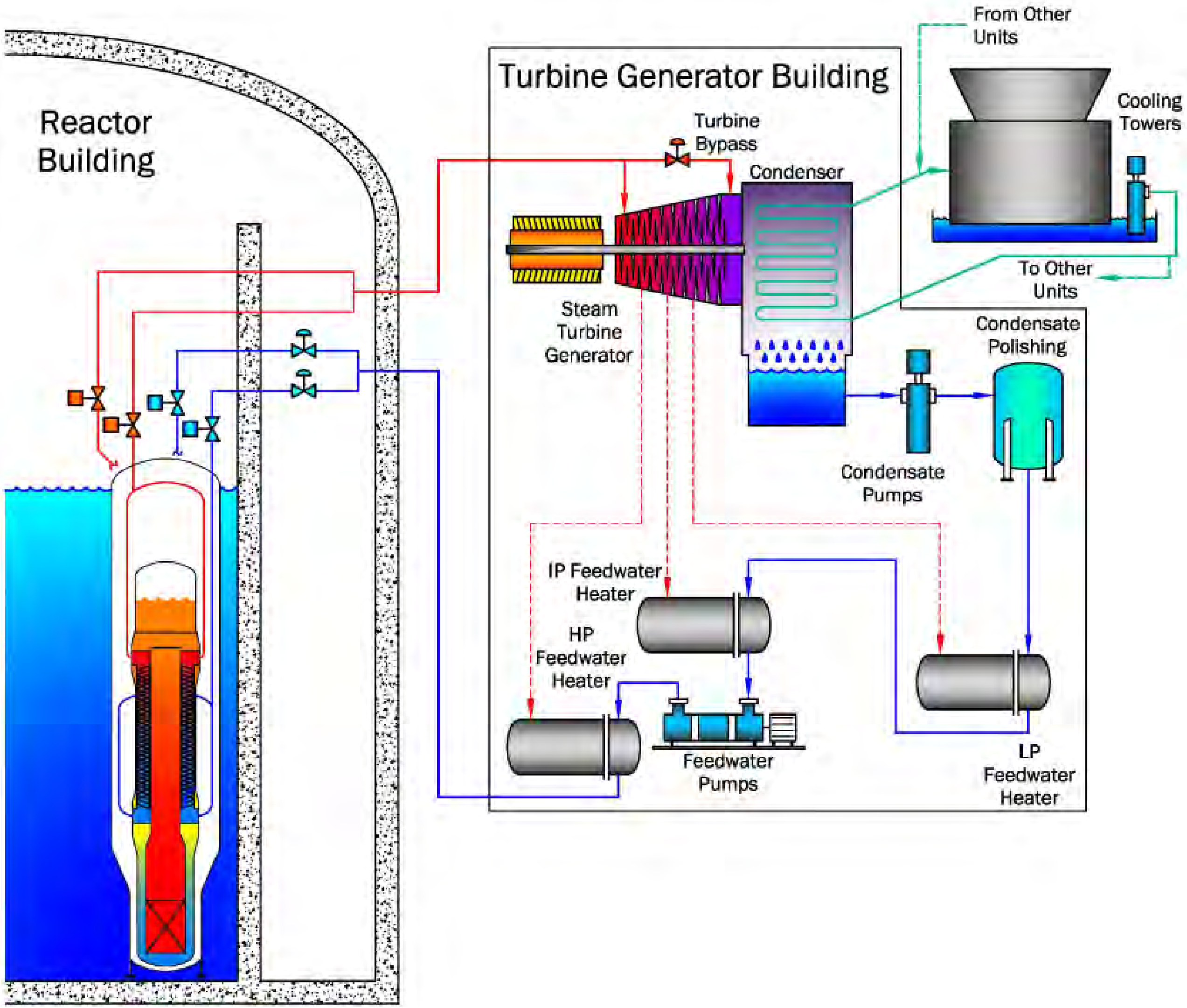




primary coolant flow path

NUSCALE POWER™

Power Conversion System

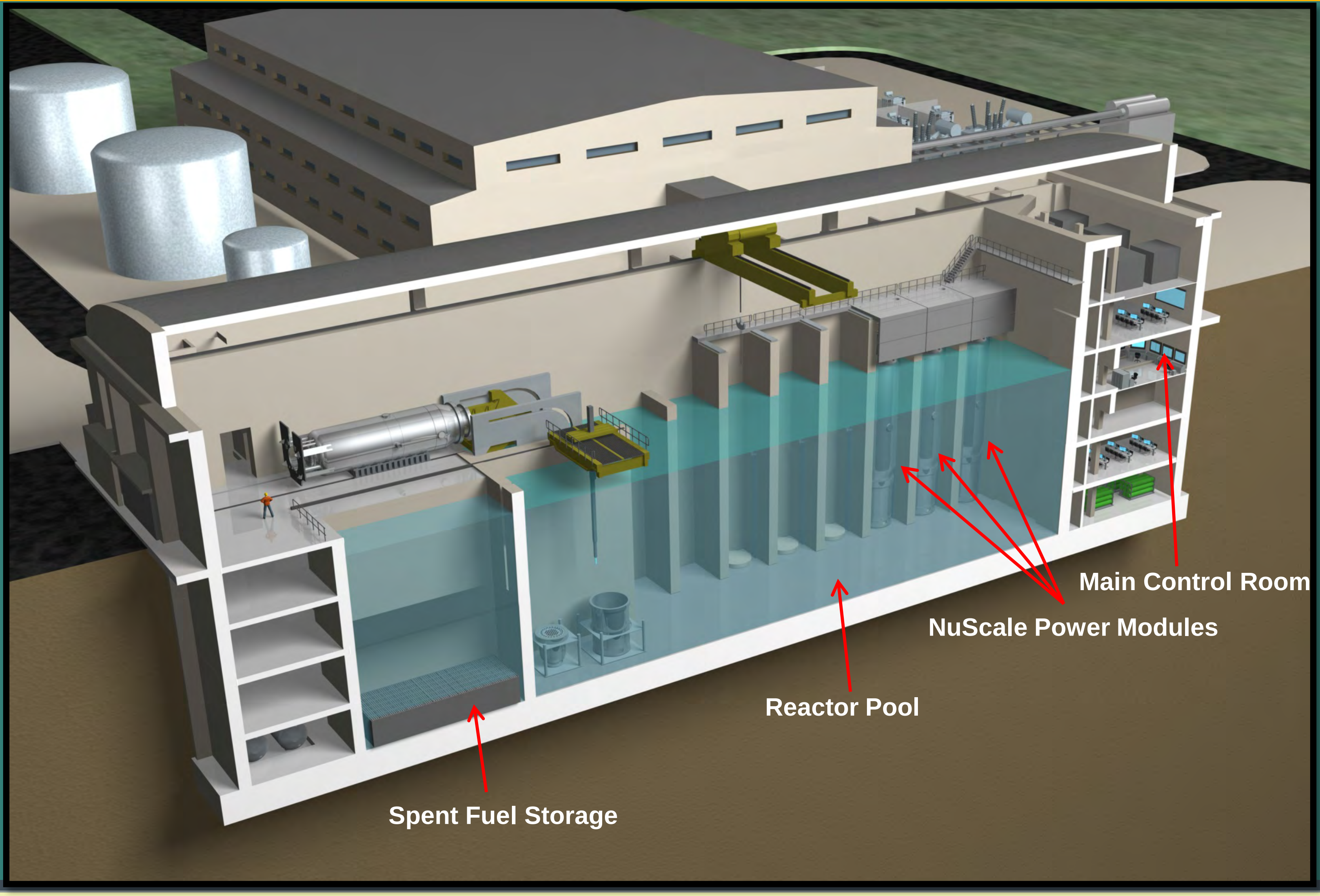


Key Features:

- One turbine generator (45MWe) per unit
- Shared cooling towers and circulating water system (per 6 units)
- 100% turbine bypass capability
- Reactor building and pool water add barriers to limit potential accident releases

NuScale Power™

Reactor Building

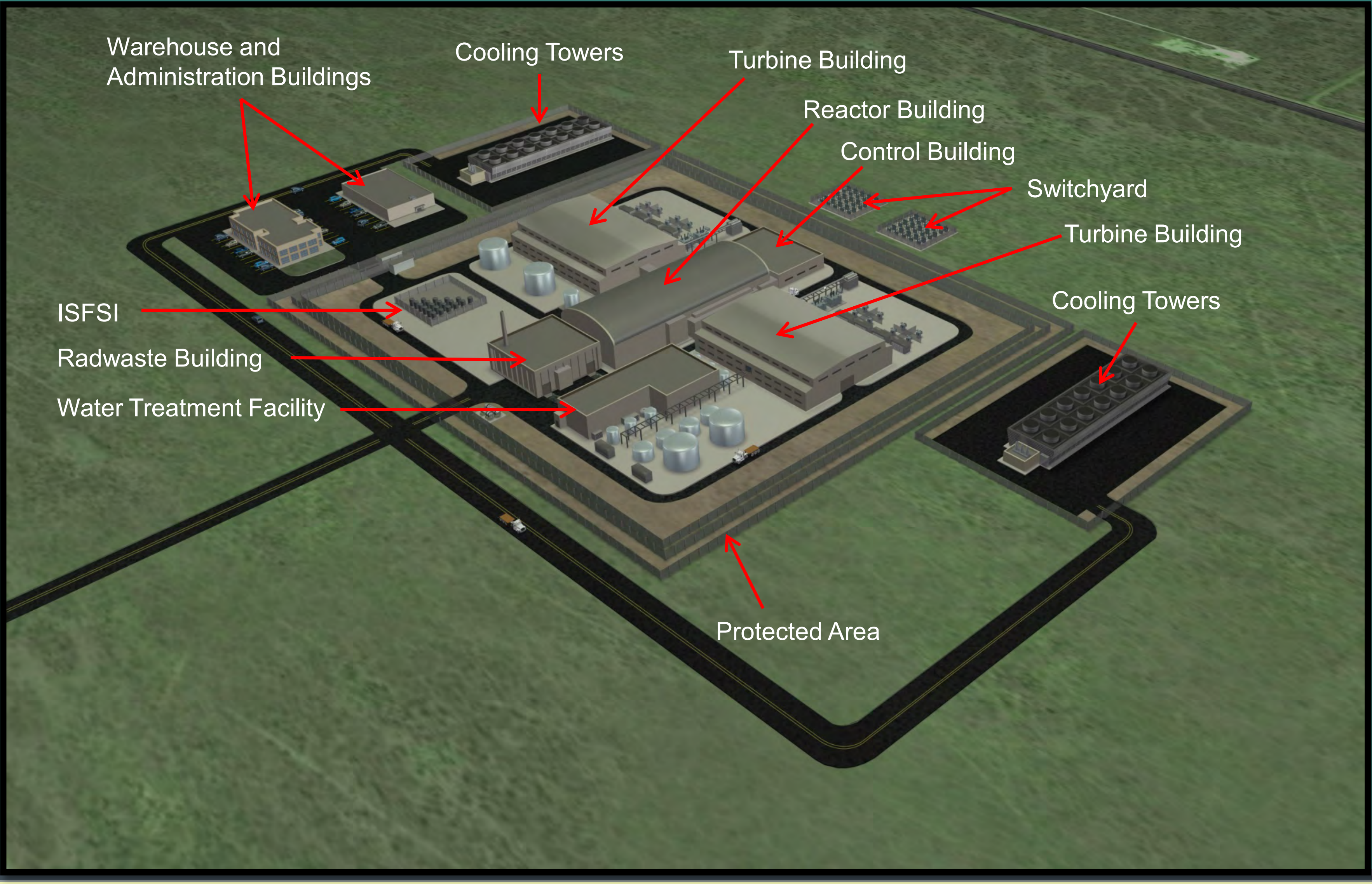


NuScale Power™

Plant Overview for a 12 module installation

Overall Plant	
• Net Electrical Output	>540 MWe
• Thermal Efficiency	>30%
• Number of Power Generation Units	12
• Nominal Plant Capacity Factor	> 95%
• Site Water Usage	14,000 gpm (peak withdrawal, wet cooling towers)
• Protected Area Size	~40 acres
Power Generation Unit	
• Number of Reactors	One
• Reactor Thermal, Electric Rating	160 Mwt, 45 Mwe
• Steam Generator Number and Type	Two independent bundles Vertical helical tube
• Steam Cycle	Regenerative Rankine, superheated

Site Layout

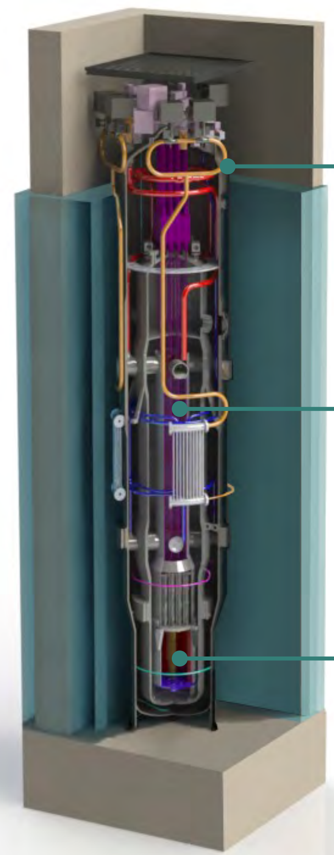


Nonproprietary

Simplicity Enhances Safety

All safety equipment needed to protect the core is shown on this picture

- Natural Convection for Cooling
  - Passively safe, driven by gravity, natural circulation of water over the fuel
  - No pumps, no need for emergency generators
- Seismically Robust
  - System submerged in a below-ground pool of water in an earthquake resistant building
  - Reactor pool attenuates ground motion and dissipates energy
- 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



Steel containment is *10 times stronger* than typical PWR

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

Reactor core has only *five percent of the fuel* of a large reactor

160 MWt NuScale Power Module

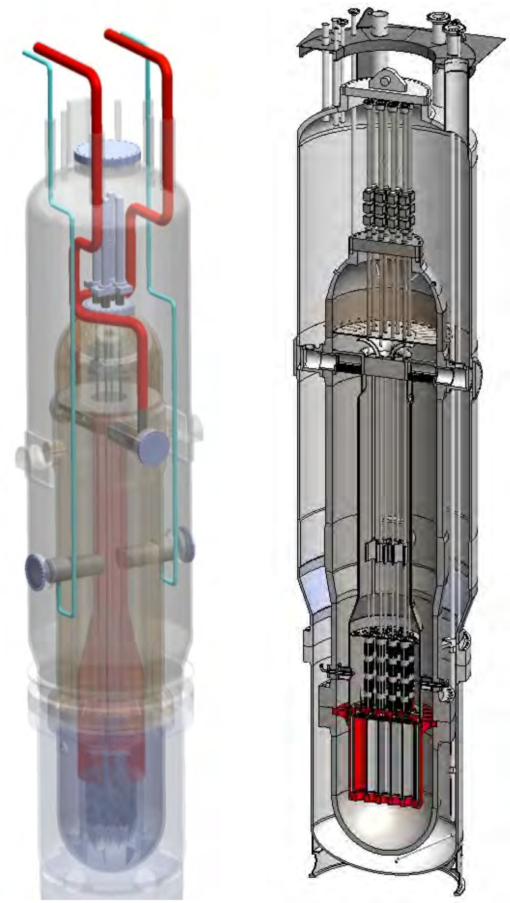
Nonproprietary

NuScale Power™

Containment Design

High Pressure Containment – Enhanced Safety

- Containment volume sized so that core does not uncover following a LOCA (prevents fuel heat-up)
- Large water pool keeps containment shell cool and promotes efficient post-LOCA steam condensation
- Insulating vacuum
  - significantly reduces heat transfer during normal operation
  - requires no insulation on reactor vessel. Eliminates sump screen blockage issue (GSI-191)
  - improves LOCA steam condensation rates by eliminating air
  - prevents combustible hydrogen mixture in the unlikely event of a severe accident (i.e., little or no oxygen)
  - reduces corrosion and humidity problems inside containment



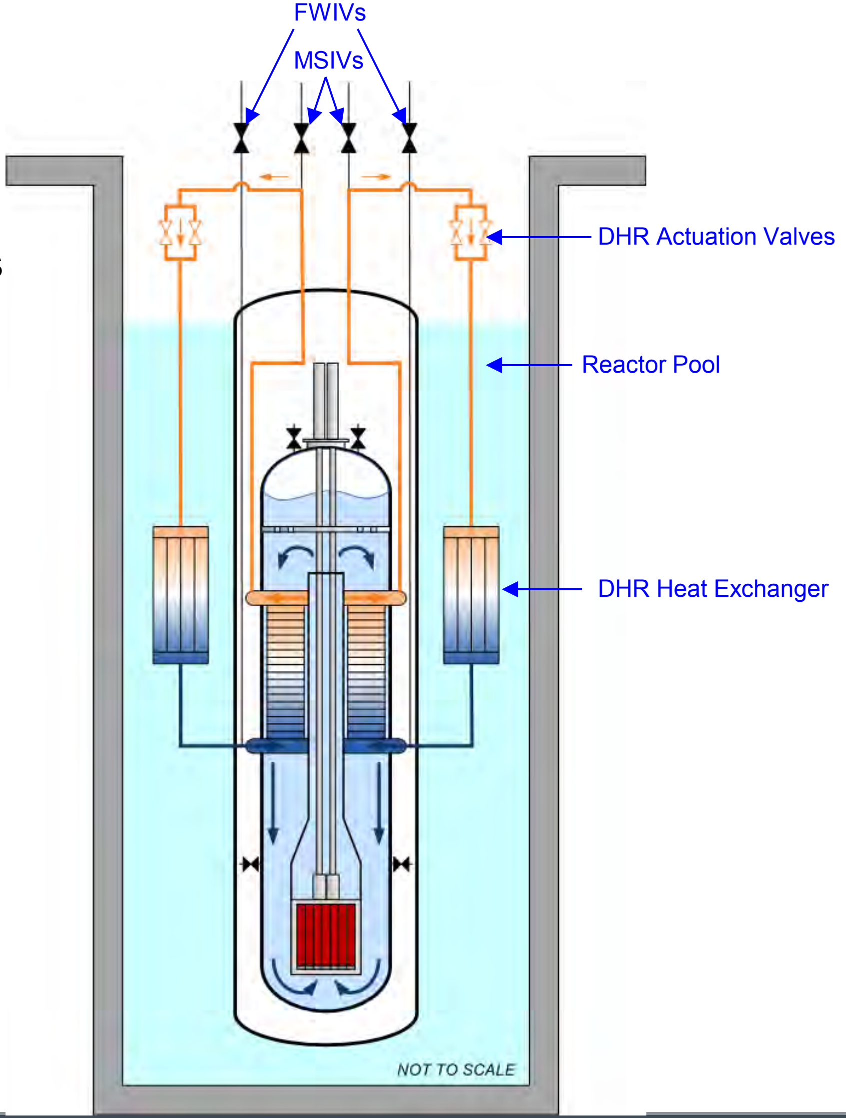
NuScale Power™

Decay Heat Removal System

The DHR system is composed of:

- DHR actuation valves
- DHR heat exchangers
- Main steam and feedwater isolation valves
- Ultimate heat sink (reactor pool)

Two 100% redundant trains



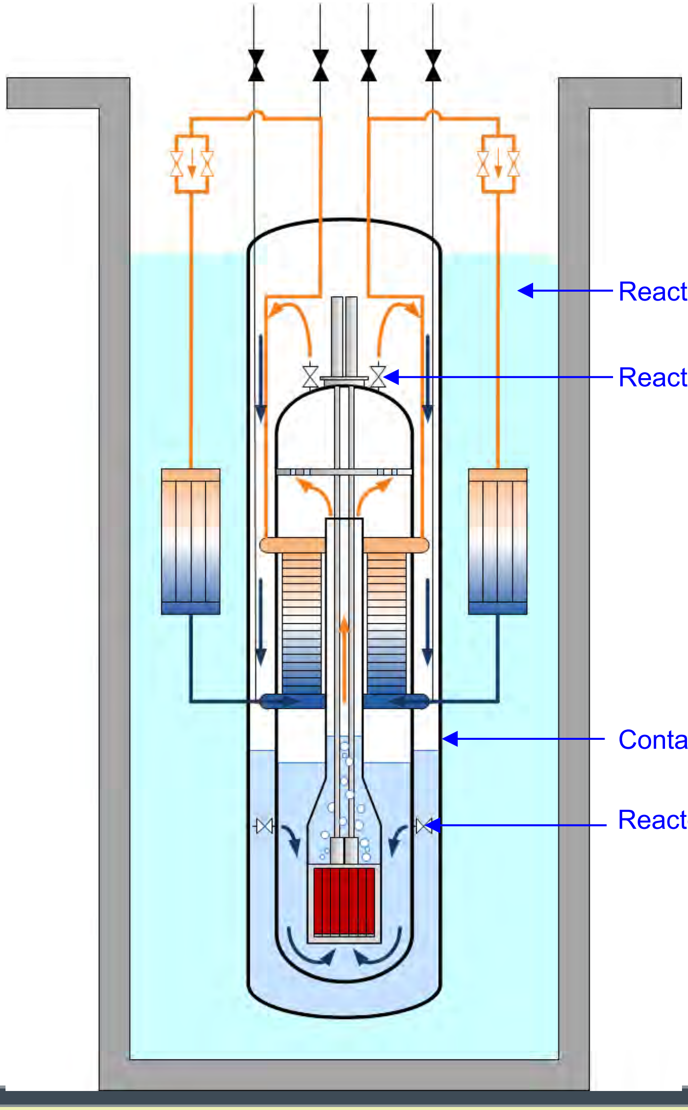
[DHR System Video]

Emergency Core Cooling System

The ECC system is composed of:

- Two reactor vent valves
- Two reactor recirculation valves
- Containment vessel
- Containment isolation valves
- Ultimate heat sink (reactor pool)

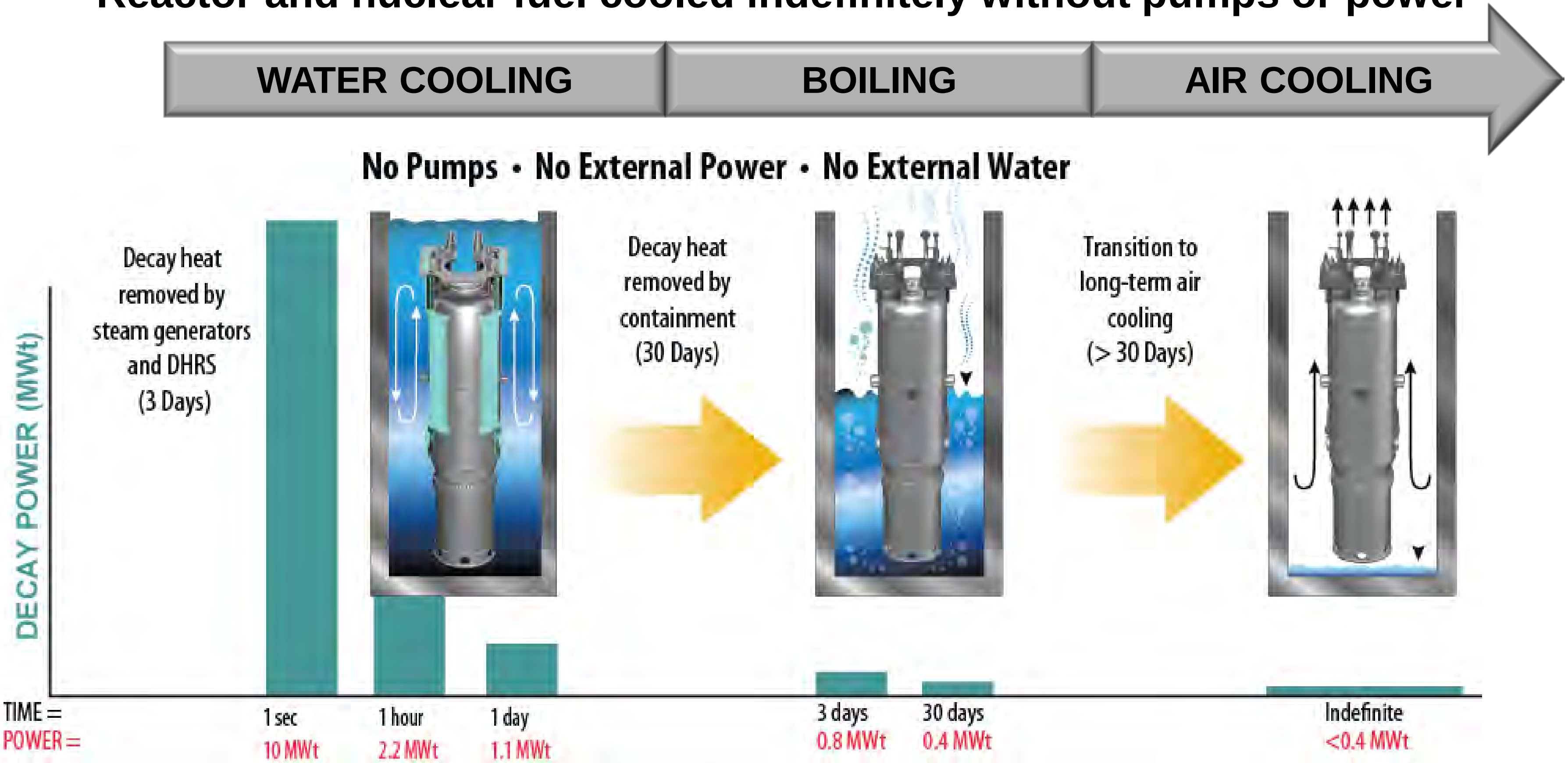
Only 1 RVV and 1 RRV needed



[ECC System Video]

Station Blackout Response

Stable Long-Term Cooling Under all Conditions
Reactor and nuclear fuel cooled indefinitely without pumps or power



** Based on conservative calculations assuming all 12 modules in simultaneous upset conditions and reduced pool water inventory*

SBO Video

NuScale Power™

Control Room Simulator

Dispelling the myths

THE ECONOMIC FAILURE OF NUCLEAR POWER AND THE DEVELOPMENT OF A LOW CARBON ELECTRICITY FUTURE:
WHY SMALL MODULAR REACTORS ARE PART OF THE PROBLEM, NOT THE SOLUTION

Mark Cooper, Ph.D.

Senior Fellow for Economic Analysis
Institute for Energy and the Environment
Vermont Law School

Small Modular Reactors

No Solution for the Cost, Safety, and Waste Problems of Nuclear Power

ieer

nstitute for Energy and
Environmental Research

PSR

HYSICIANS FOR
OCIAL RESPONSIBILITY

Small Isn't Always Beautiful

Safety, Security, and Cost Concerns about Small Modular Reactors

Ed Lyman,
Union of Concerned Scientists

On Safety …

- None of these critiques challenge the basic safety premise
  - The advantage of an infinite heat sink
  - The ability to respond to a total plant blackout with …
    - No need for operator response
    - No electrical backup
    - No supplemental heat source
  - They ignore the evacuated containment and the high pressure capacity of the smaller containment
  - They trivialize the elimination of the large pipe LOCA
  - They ignore the safety enhancements of added barriers

On Safety …

- Instead, they make claims, often contrived, suggesting a desperation to challenge these safety advances:
  - The smaller containment is weaker
    - Wrong
  - A modular configuration increases risks
    - Wrong
  - SMR will require a relaxation of safety requirements to achieve their economics
    - Fewer operators
    - A smaller EPZ
- SMR's are "unproven"
  - Displays an ignorance of the licensing requirements for all nuclear power plants

NuScale Evolved from OSU's "World Class" Nuclear Testing Programs

- Early 1990's – Westinghouse Introduces Passive Safety Systems in their AP600 and AP1000 designs
- NRC rules require R&D to support Design Certification
  - Without "adequate" R&D, NRC will require a "prototype" to be built
- OSU solved this problem for Westinghouse
  - A world class integral system test facility was built by Oregon State University to provide the necessary test information to support Certification of the AP600 and AP1000 without requiring a "prototype"

NuScale Licensing will be supported by testing in Integral System Test Facility

- Q/A Program in place at OSU
- Test Facility Scaling Methodology sent to NRC - 12/10
- IAEA international standard problem test 3/11
- NRC Certification Testing begins in 2011.

NUSCALE POWER™

On Economics …

- "Economies of small" are trivialized
  - The 8-3-1 rule
  - Simplicity is ignored
- "The economics of mass production of SMRs cannot be proven until hundreds of units have been produced."
  - NuScale economics rely on latent manufacturing capability; nth of a kind costs can be achieved with the first ten modules
- Reduced financial risks are ignored
- They have no actual cost data – potential customers are interested because they have

UAMPS has announced intent to build the first NuScale SMR !!!

- Western Initiative for Nuclear (WIN) launched in July 2013
- Washington State Joint Select Energy Task Force
  - ✓ Appointed by Governor in 2013 to reconsider the role of nuclear power in the Northwest
  - ✓ Specifically focused on siting a NuScale plant at Hanford
- Utah Associated Municipal Power Systems (UAMPS)
  - ✓ Announced plans for a "Carbon Free Power Project" – a NuScale Plant for initial operation in 2023
  - ✓ Plant operator to be Energy Northwest

UAMPS Video #1 UAMPS Video #2 UAMPS Video #3

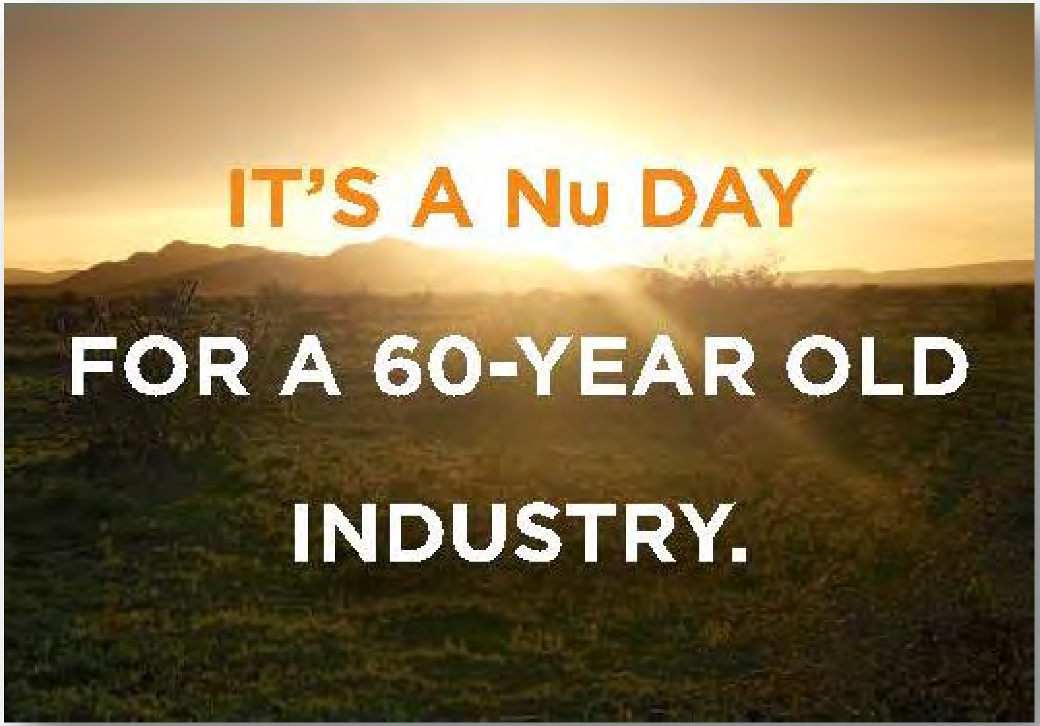
6650 SW Redwood Lane, Suite 210
Portland, OR 97224
503.715.2222

1100 NE Circle Blvd., Suite 200
Corvallis , OR 97330
541.360.0500

11333 Woodglen Ave., Suite 205
Rockville, MD 20852
301.770.0472

6060 Piedmont Row Drive South, Suite 1000
Charlotte, NC 28287

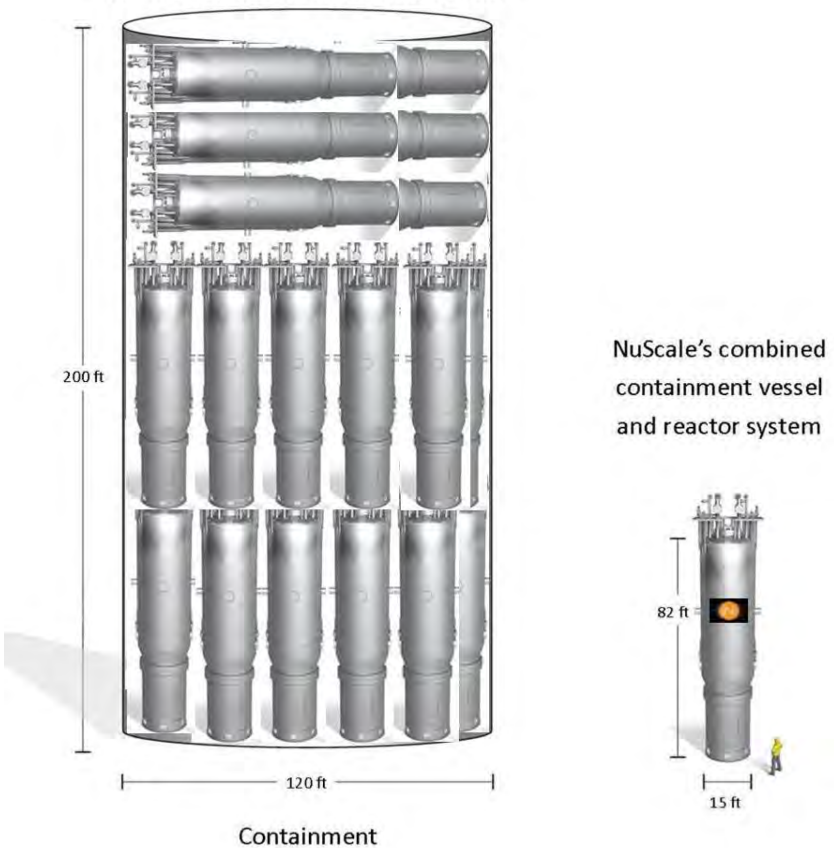
http://www.nuscalepower.com



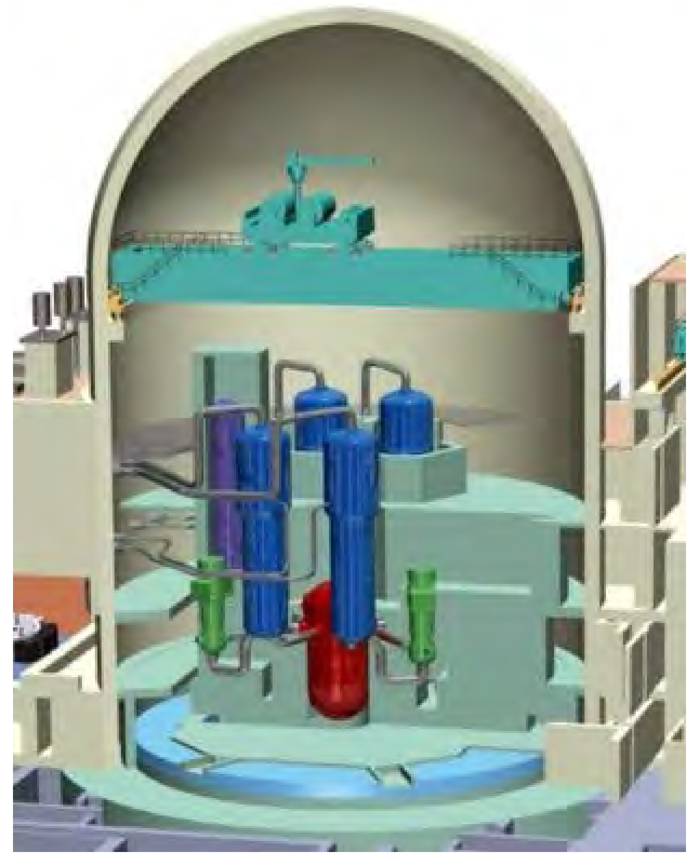
Size Comparison

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

126 NuScale Power Modules



Typical Pressurized Water Reactor



*Source: NRC

NuScale Scalable Modular Design