NuScale Technology Overview

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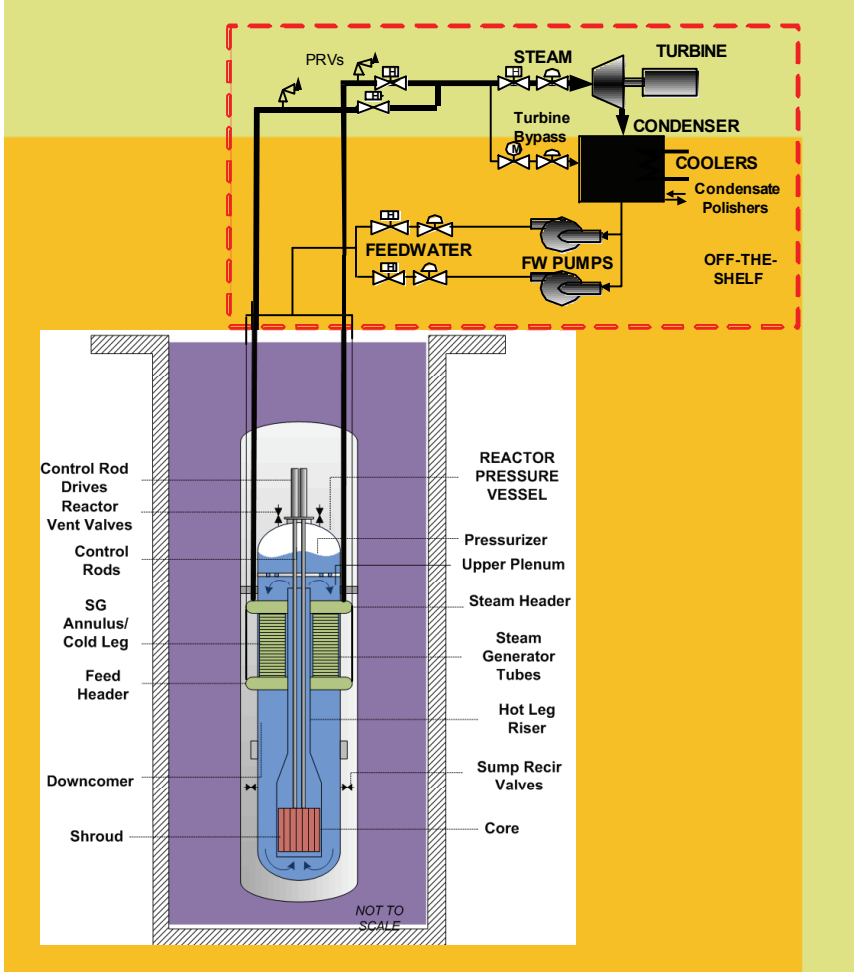
Pre-Application Meeting
Rockville, MD

NuScale Power

NuScale Technology

NuScale: Prefabricated, Simple, and Safe

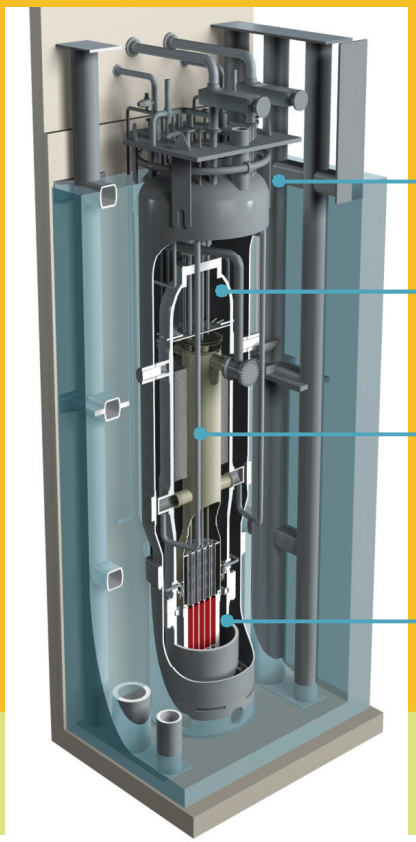
- Construction Simplicity:
  - Major components prefabricated and shipped by rail, truck or barge
- Natural Circulation Cooling:
  - Inherently safe – Eliminates major accident scenarios
  - Improves economics - Eliminates pumps, pipes, valves
    - -- Large natural heat sink
  - Simplifies and enhances safety case
- Proven Technology
  - CRDM and fuel rely on existing technology; no pump issues
- Below Ground
  - Enhances security and safety



NuScale Power

NuScale Technology

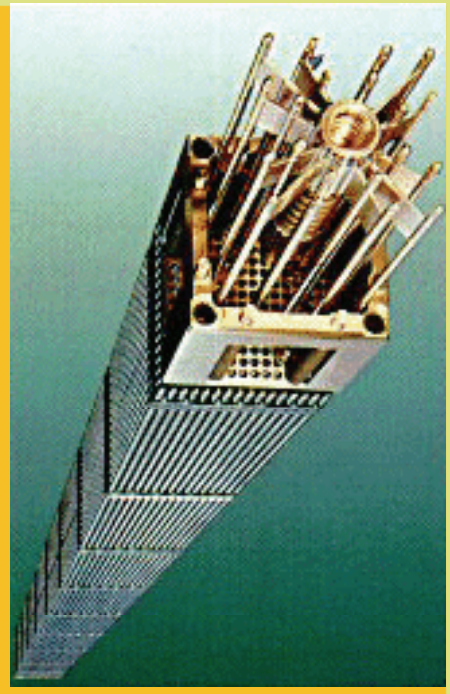
NSSS and Containment



NuScale Technology

Fuel

- Approximately Half Height
- 17x17 Lattice
- UO_2 fuel pellets
- Clad Material – Zirc-4 or Advanced Clad
- Negative Reactivity Coefficients
- 24 Month Cycle Length at 95% capacity factor (695 EFPD)
- U235 Enrichment < 4.95 %



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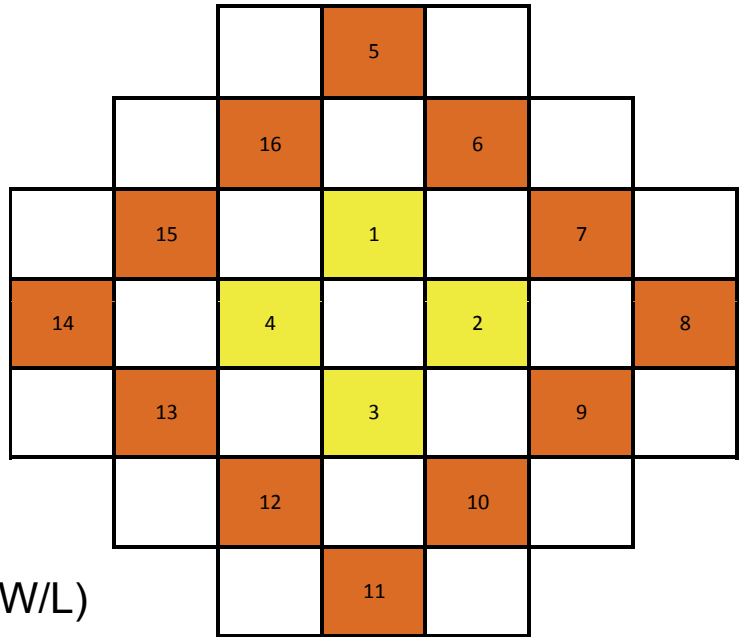
Core Layout

- 37 – 17 x 17 Assemblies
- 16 Control Rod Clusters



Control Rod Banks

4	Group 1
12	Group 2
16	Total

Targets

- Lower Power Density (45-65 kW/L)
- Minimize Power Peaking
- Maximum Node Relative Power Factor ≤ 2.0
- Assembly Average Radial Peaking Factor ≤ 1.3

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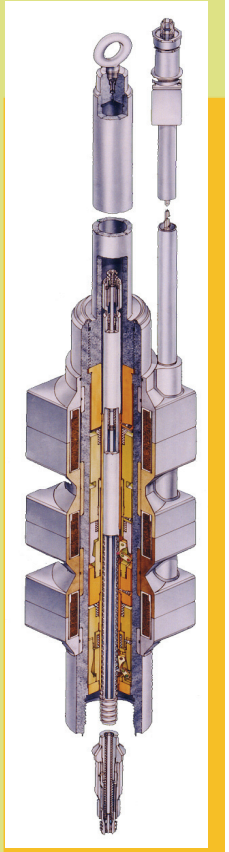
Curtiss Wright – Control Rod Drive Mechanism



EMD, a business unit of Curtiss Wright Flow Control Co., is the most experienced CRDM designer and manufacturer in the world

- Over 45 years of CRDM design and manufacturing experience
- 12 CRDM Designs, latest designs are qualified for 7 million steps
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- Proven reliable designs – over 40 years of successful operation
- Availability > 99.9%

NuScale Technology

Helical Coil Steam Generator

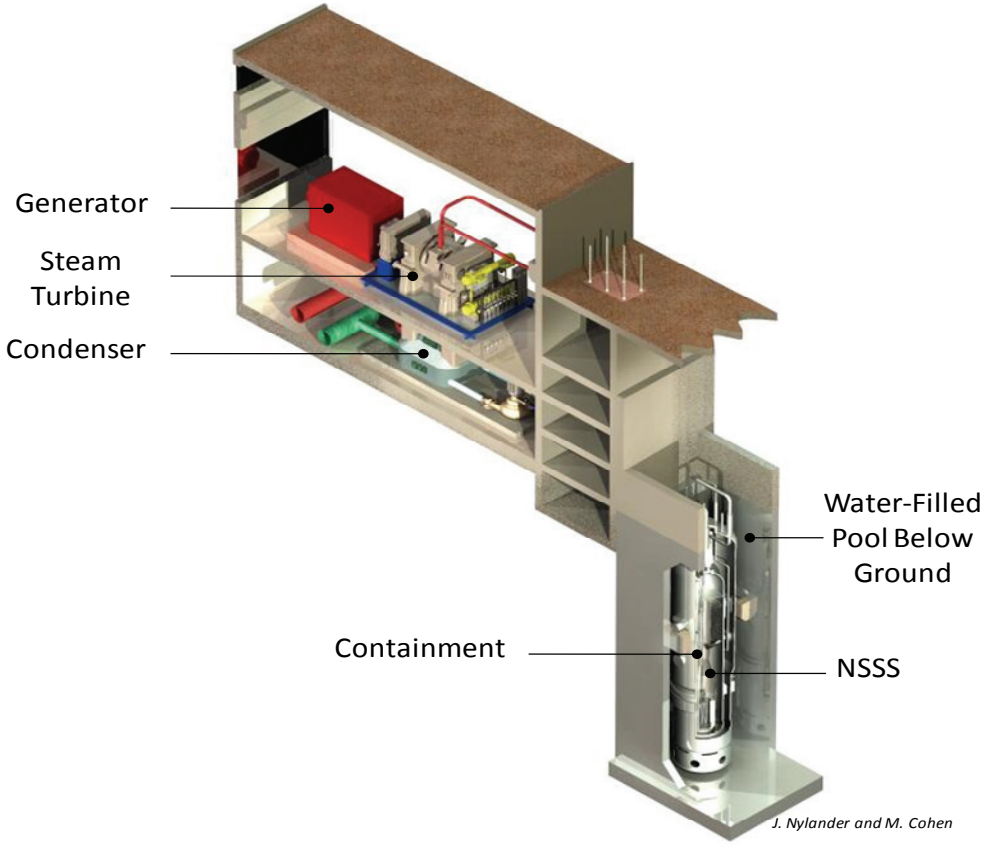
- DESIGN
  - Compact
  - Superheated steam outlet conditions
  - Replaceable
  - Tube lengths and materials Inconel 690 are commercially available
- BENCHMARKS
  - Best Estimate tools benchmarked against full scale HCSG data from Ansaldo, OSU Integral System and separate effects tests
- Tube Inspection System

Extensive test experience on 25 MWt helical coil steam generator validating and informing NuScale design

AnsaldoEnergia
Una Società Finmeccanica

An Introduction to NuScale Power

Each module has dedicated Steam-Turbine Generator



J. Nylander and M. Cohen

An Introduction to NuScale Power

Basic Plant Parameters

Overall Plant	
• Net Electrical Output	540 MW(e)
• Plant Thermal Efficiency	30%
• Number of Power Generation Units	12
• Nominal Plant Capacity Factor	> 90%
Power Generation Unit	
• Number of Reactors	One
• Net Electrical Output	45 MW(e)
• Steam Generator Number	Two independent tube bundles
• Steam Generator Type	Vertical helical tube
• Steam Cycle	Superheated
• Turbine Throttle Conditions	3.1 MPa (450 psia)
• Steam Flow	71.3 kg/s (565,723 lb/hr)
• Feedwater Temperature	149°C (300°F)
Reactor Core	
• Thermal Power Rating	160 MWt
• Operating Pressure	8.72 MPa (1850 psia)
▪ Fuel	UO_2 (< 4.95% enrichment)
▪ Refueling Intervals	24 months

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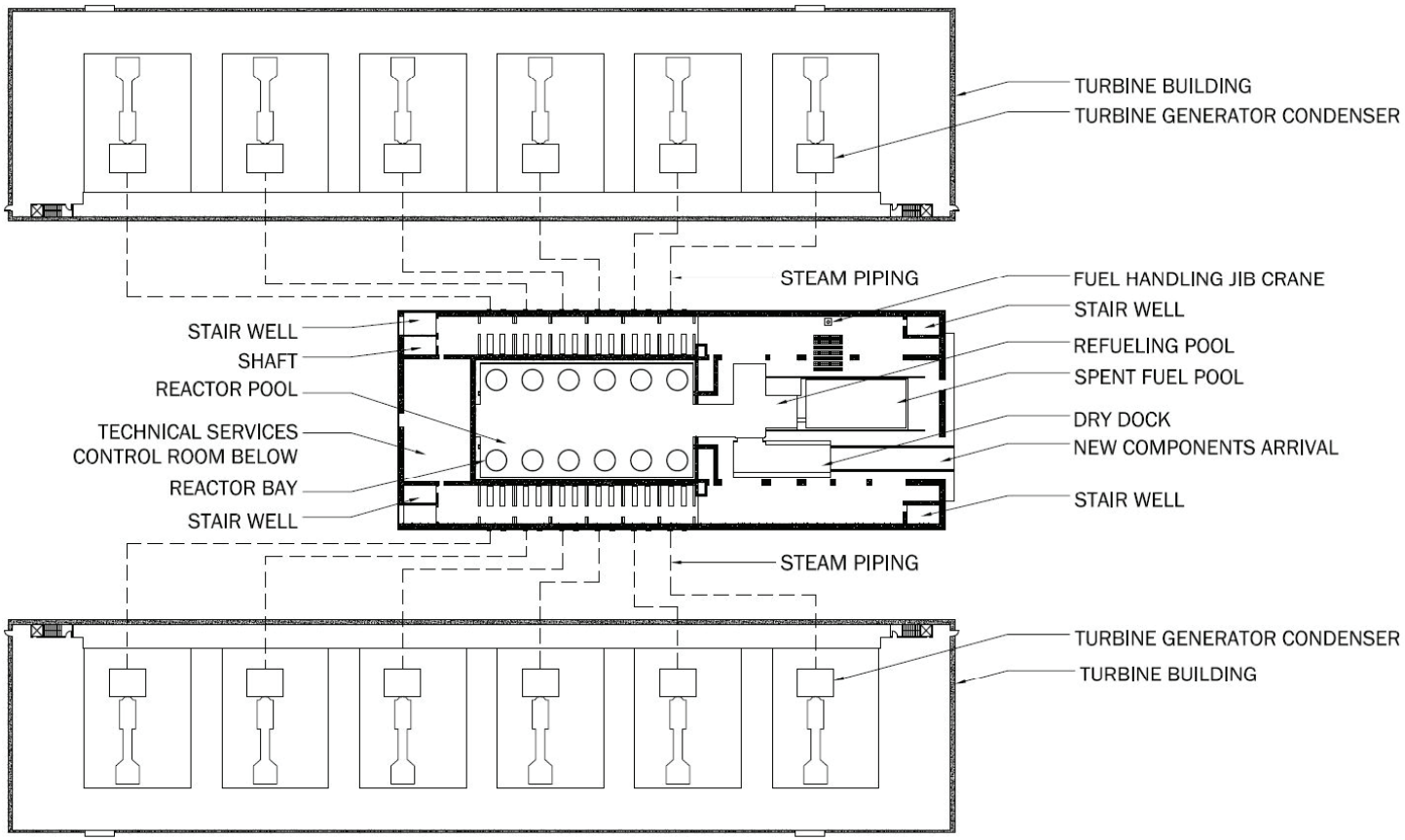
NuScale Base Design – 12 modules, 540 MWe



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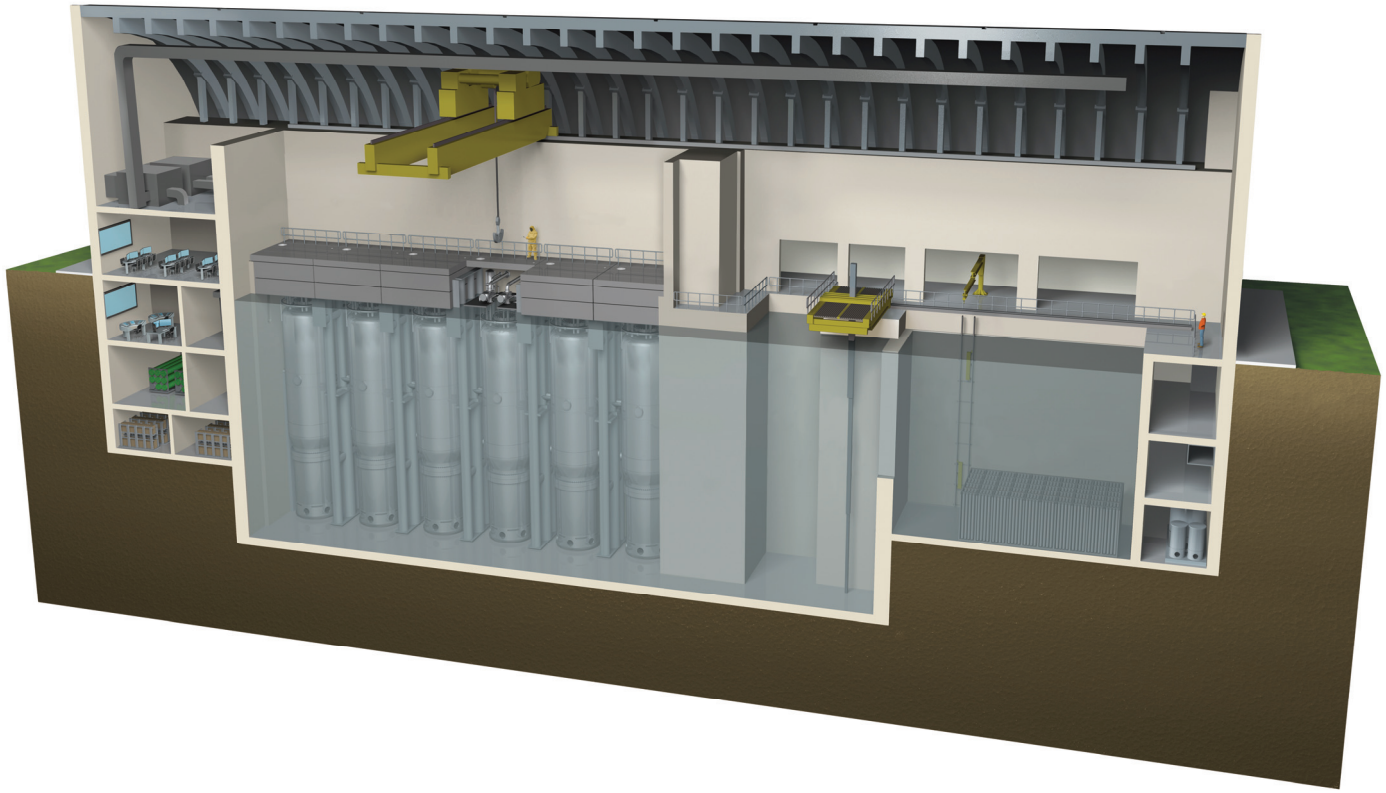
Cross-sectional view of 6 modules



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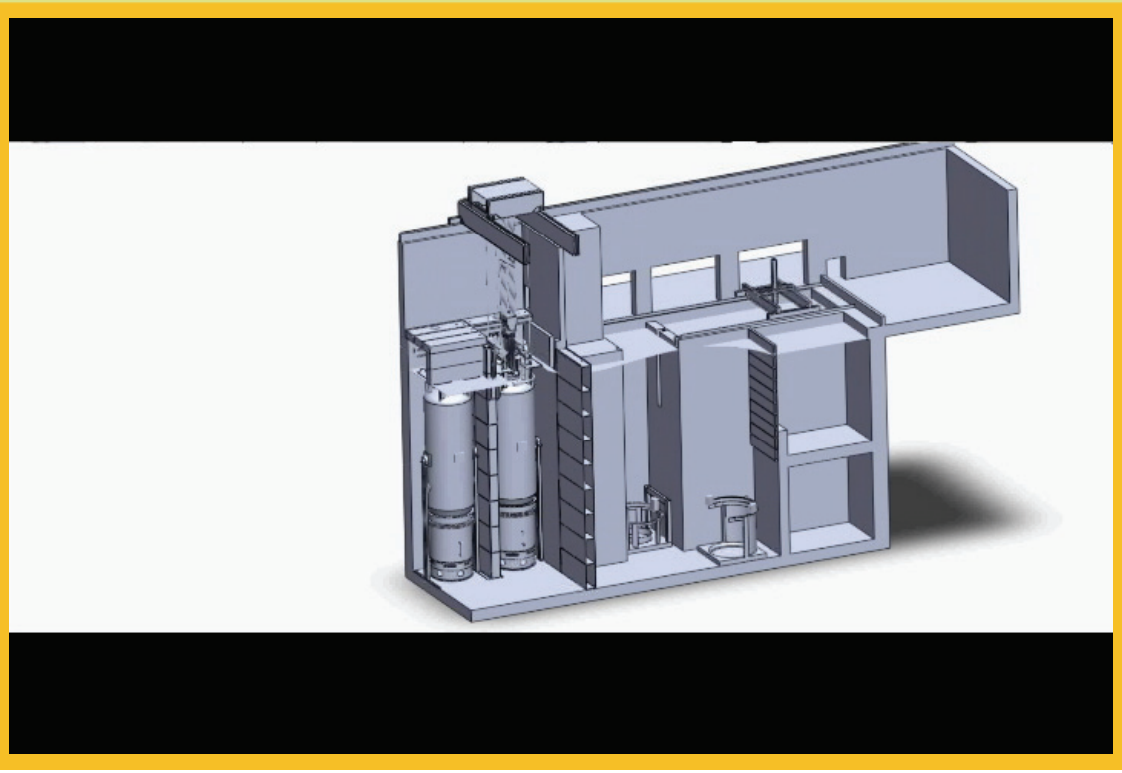
Refueling Animation



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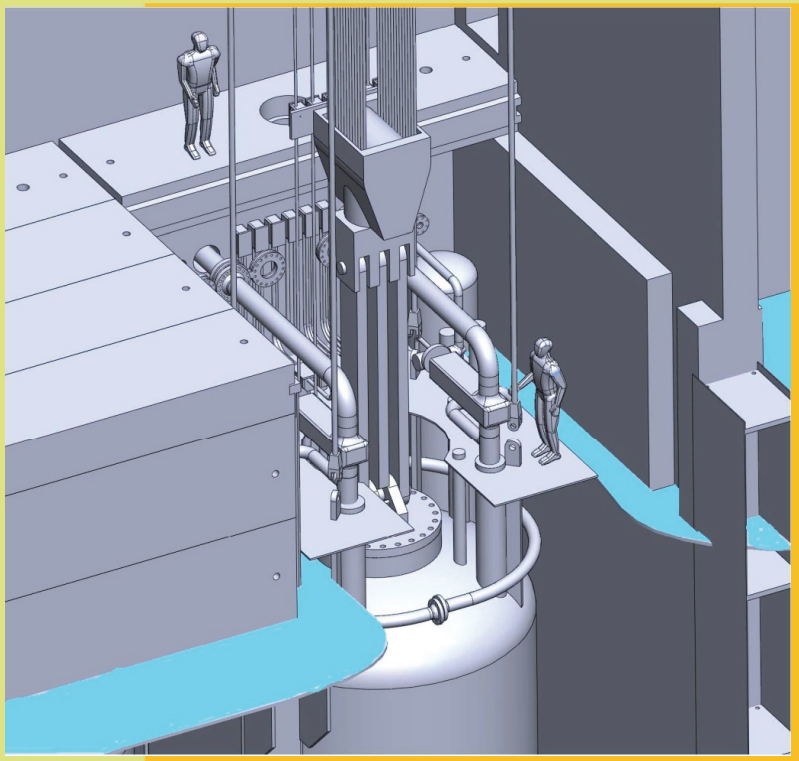
Refueling Cranes and Module Assembly



Single Failure Proof Cranes, Fuel Handling, and Module Assembly Equipment

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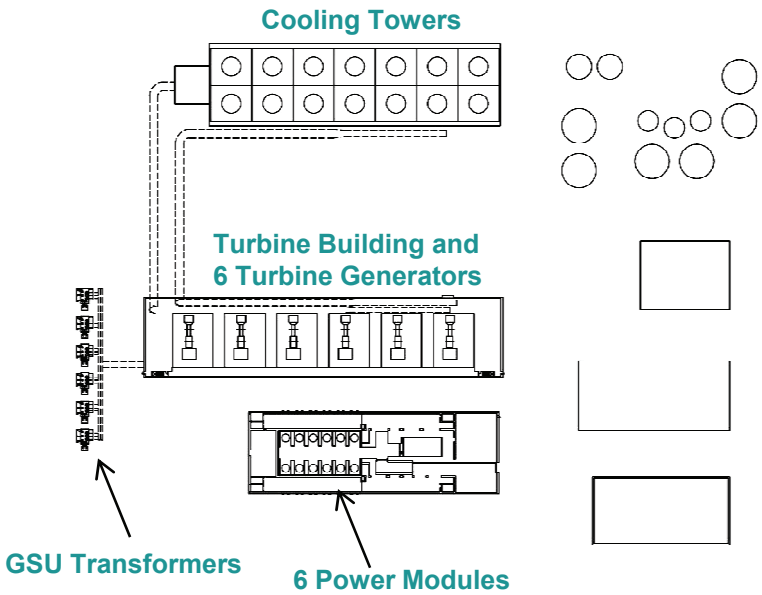
Multi - Module Control Room Layout

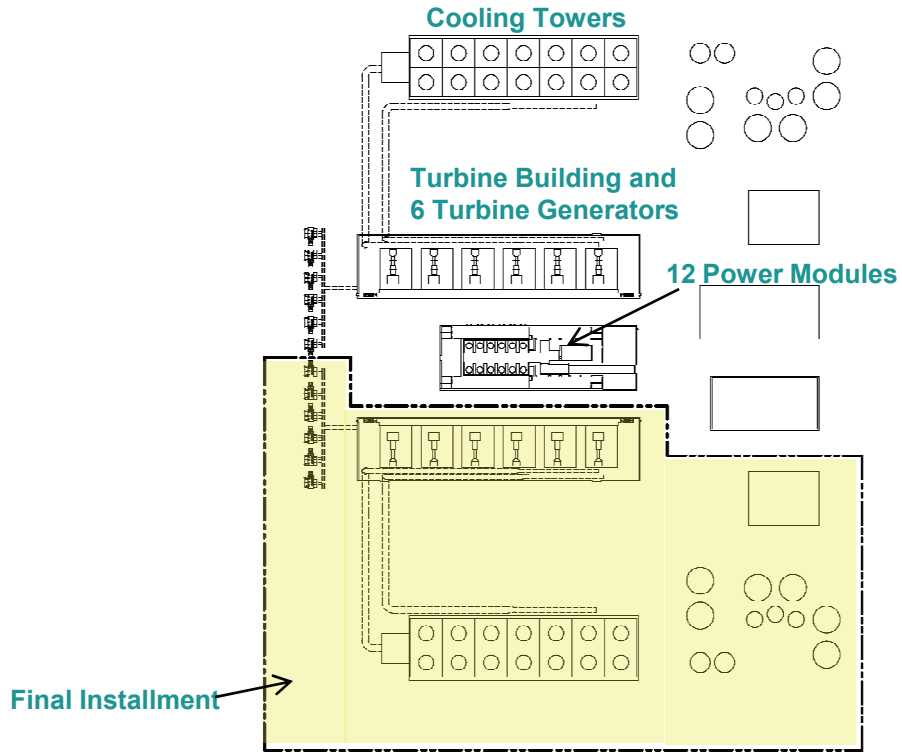
An Introduction to NuScale Power

Incremental build out minimizes financial risk, matches demand growth

Initial installment (270 Mwe)



Final Installment (540 Mwe)



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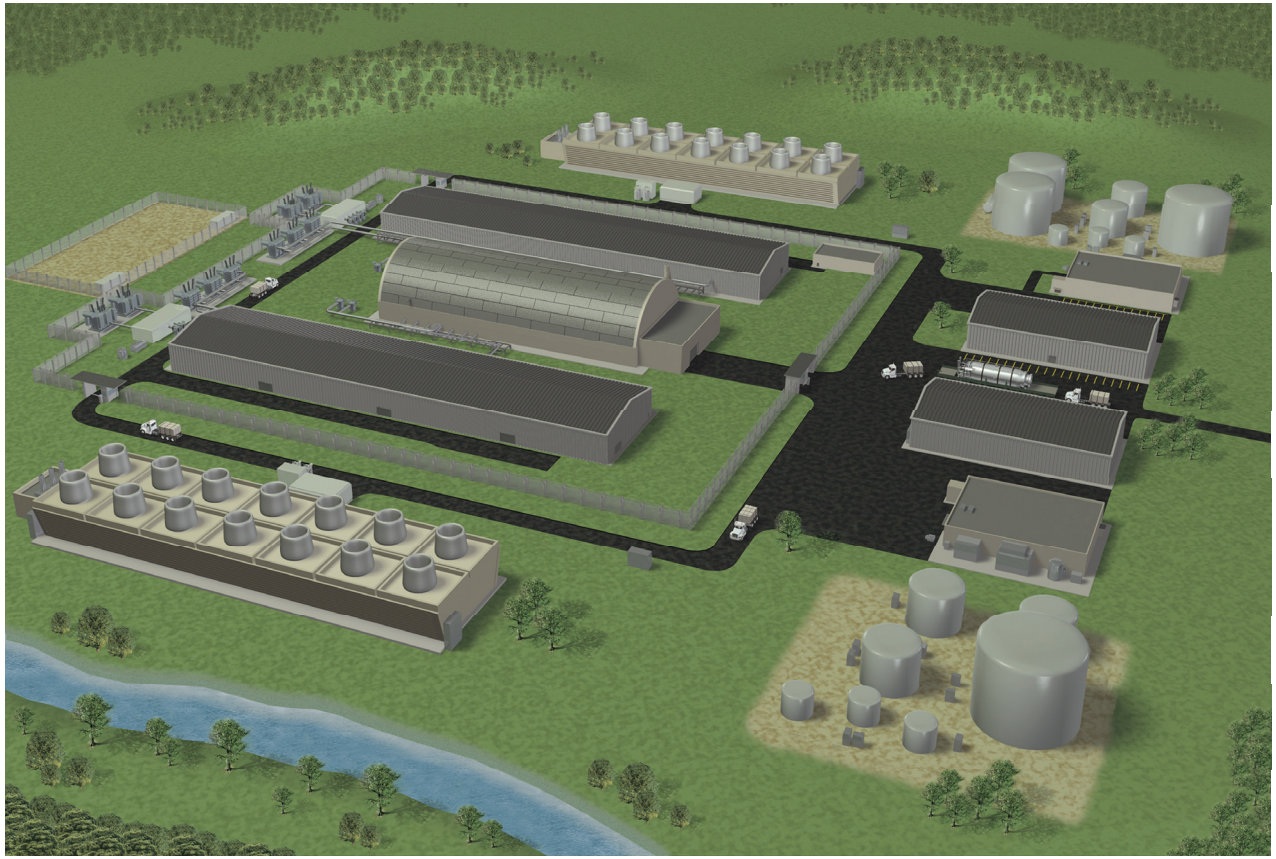
NuScale Site Perspective



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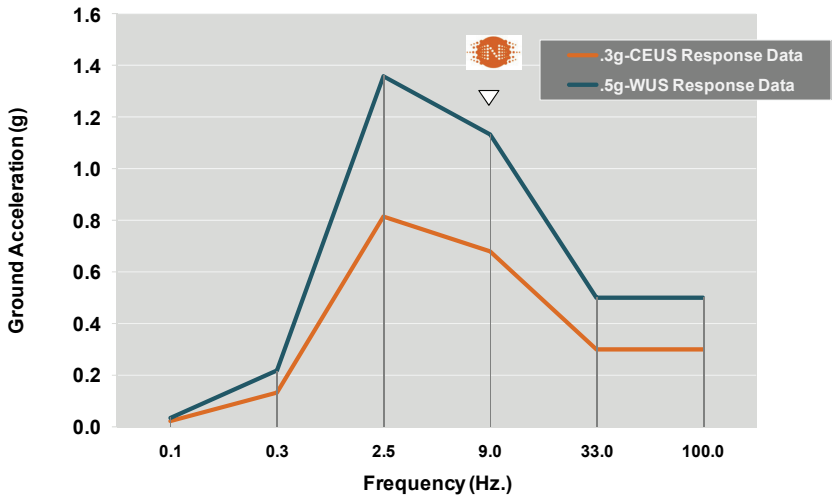
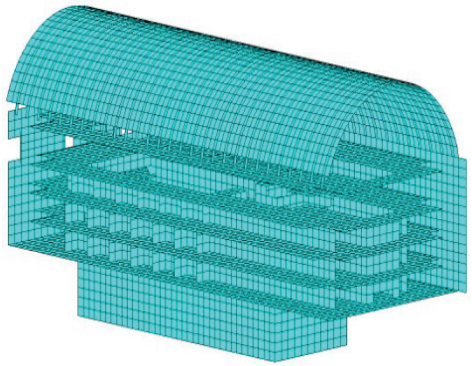
Robust Seismic Design

- Designed for East and West Coast US Seismic Activity
- Structure composed almost entirely out of concrete, with well arranged shear walls and diaphragms which provides for high rigidity
- Significant portion of the structure located below grade partially supported by bedrock
- Large pools filled with water will dampen seismic forces
- High frequency studies and dynamic analysis underway





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Engineered Safety Features

ESF	Primary Function(s)
High Pressure Containment Vessel	Prevents release of fission products to environment and provides core decay heat removal.
Decay Heat Removal System (DHRS)	Provides core decay heat removal and emergency feedwater cooling via natural circulation through two independent helical coil steam generator tube bundles.
Containment Heat Removal System (CHRS)	Provides a means to rapidly reduce containment pressure and temperature during any LOCA. Maintains acceptably low pressure and temperature for extended periods of time.
Emergency Core Cooling System (ECCS) • Reactor Vent Valves • Reactor Recirculation Valves • CHRS	Provides core decay and containment heat removal by steam condensation, natural circulation and sump recirculation. Includes two RVVs on the reactor vessel head to vent steam, two RRVs at the reactor vessel midsection to provide coolant recirculation, and the containment cooling pool to serve as the emergency heat sink.

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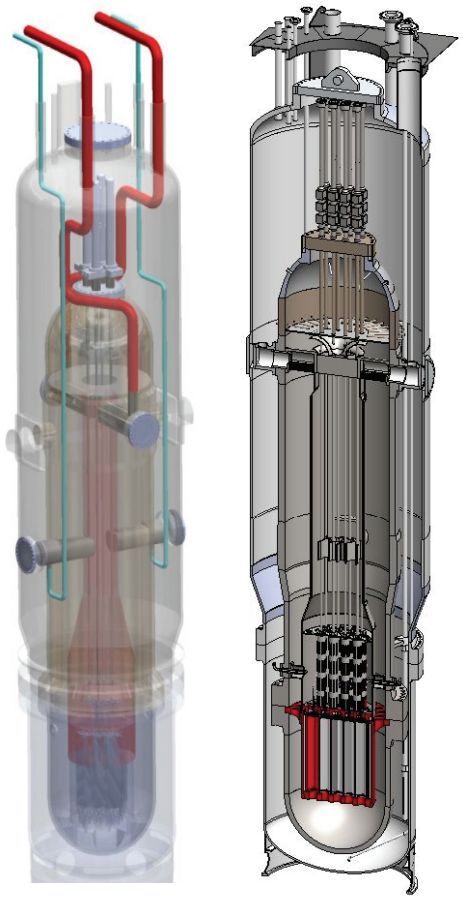
High Pressure Containment – Enhanced Safety

- Pressure Capability - Equilibrium pressure between reactor and containment following any LOCA is always below containment design pressure
- Insulating Vacuum
  - Significantly reduces convection heat transfer during normal operation
  - No insulation on reactor vessel. Eliminates sump screen blockage issue (GSI-191)
  - Improves steam condensation rates during a LOCA by eliminating air
  - Prevents combustible hydrogen mixture in the unlikely event of a severe accident (i.e., little or no oxygen)
  - Eliminates corrosion and humidity problems inside containment



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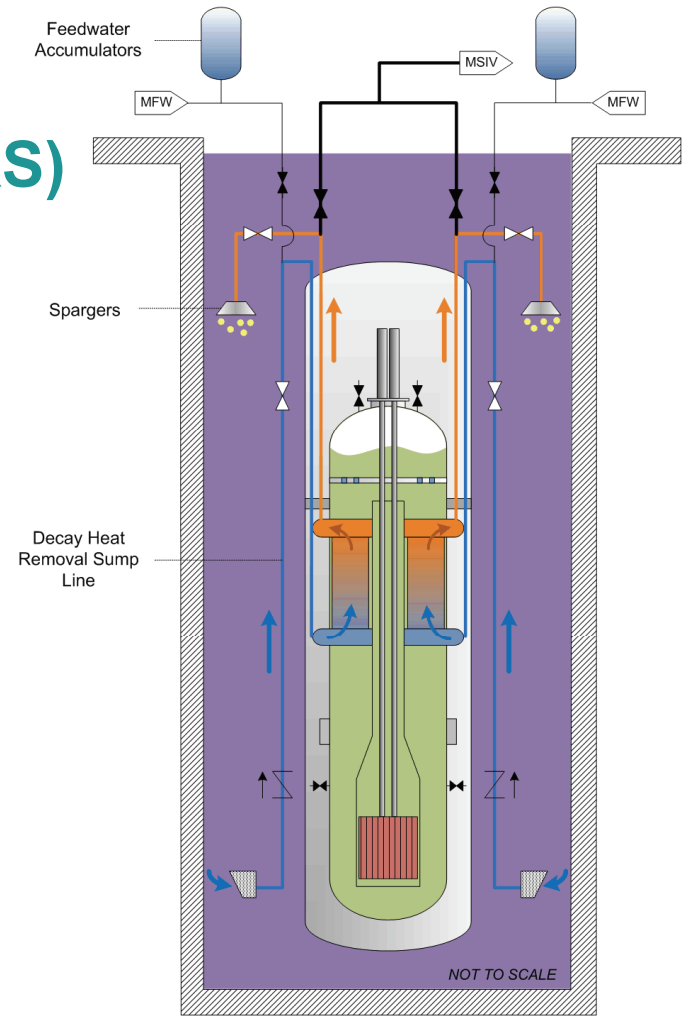
Decay Heat Removal Using Steam Generators (DHRS)

- Two independent trains of emergency feedwater to the steam generator tube bundles.
- Water is drawn from the containment cooling pool through a sump screen.
- Steam is vented through spargers and condensed in the pool.
- Feedwater Accumulators provide initial feed flow while DHRS transitions to natural circulation flow.
- Pool provides a 3 day cooling supply for decay heat removal



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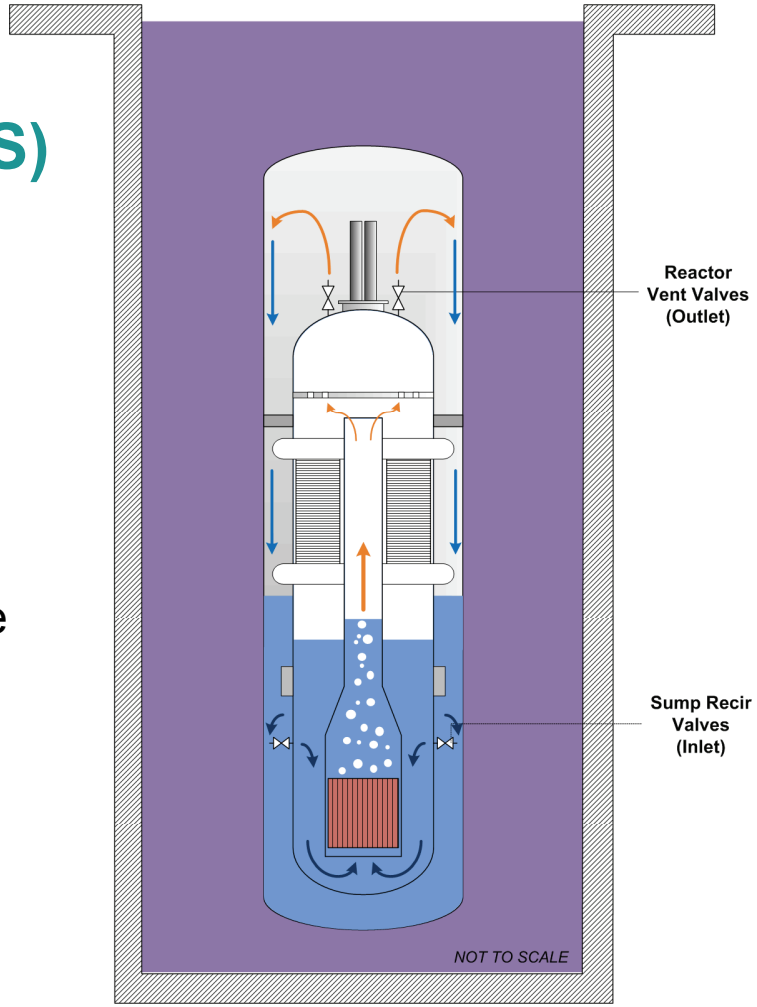
Decay Heat Removal Using the Containment (CHRS)

- Provides a means of removing core decay heat and limits containment pressure by:
  - Steam Condensation
  - Convective Heat Transfer
  - Heat Conduction
  - Sump Recirculation
- Reactor Vessel steam is vented through the reactor vent valves (flow limiter)
- Steam condenses on containment
- Condensate collects in lower containment region (sump)
- Sump valves open to provide recirculation path through the core



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Safety case validated and design "informed" by PRA and independent PIRT panel reviews

- Level I Probabilistic Risk Assessment (PRA) indicates low overall Core Damage Frequency for Internal Events
- June 2008: Thermal Hydraulic and Neutronics PIRT Panel Review
  - Large-break Loss of Coolant Accident (LOCA) eliminated by design
  - Small Break Design Basis LOCA's will not uncover the core, thus do not challenge plant safety
- Feb 2009: Severe Accident PIRT Panel Review
  - PRA is overly conservative with regard to events that lead to core damage.

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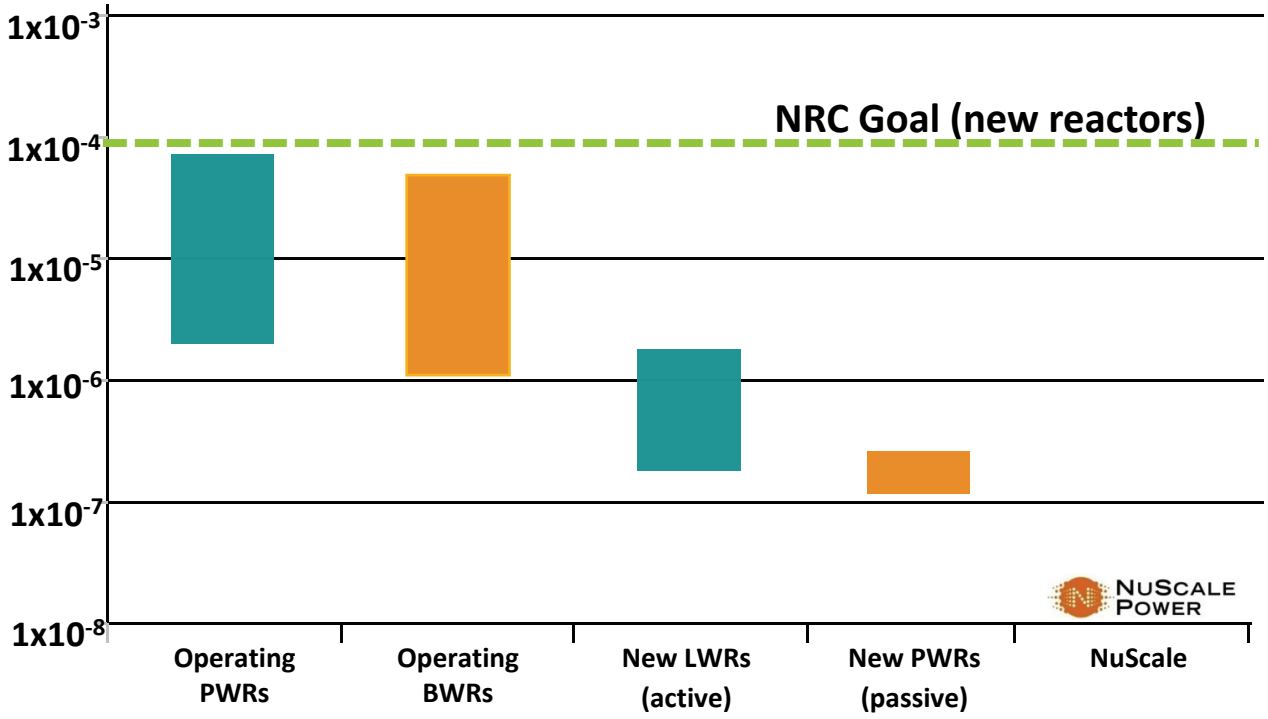
Core Damage Frequency for Internal Events Significantly Reduced



Source: NRC White Paper, D. Dube; basis for discussion at 2/18/09 public meeting –on implementation of risk matrices for new nuclear reactors

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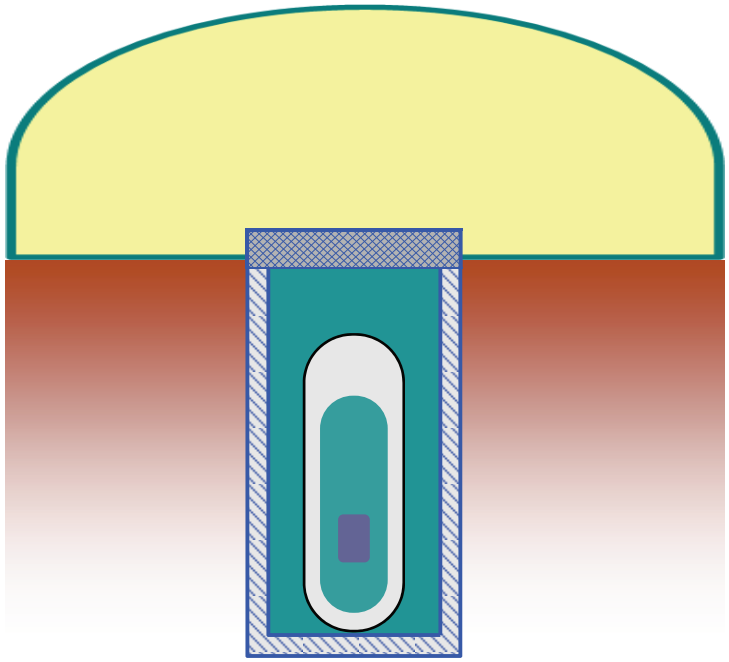
Additional Fission Product Barriers

- Fuel Pellet and Cladding
- Reactor Vessel
- Containment
- Containment Cooling Pool Water
- Containment Pool Structure
- Biological Shield
- Reactor Building



NuScale Technology

Summary

- **Implements well-known LWR technology**
- **Provides enhanced operations**
- **Provides Defense-In-Depth**
  Independent, Diverse and Redundant Engineered Safety Features
    - Decay Heat Removal System
    - Containment Heat Removal System
    - Passive ECCS
    - Additional Fission Product Barriers
- Seismic Isolation
- Module Independence
- **Provides high level of security**
- Underground Main Control Room, Spent Fuel Pool, and Containment

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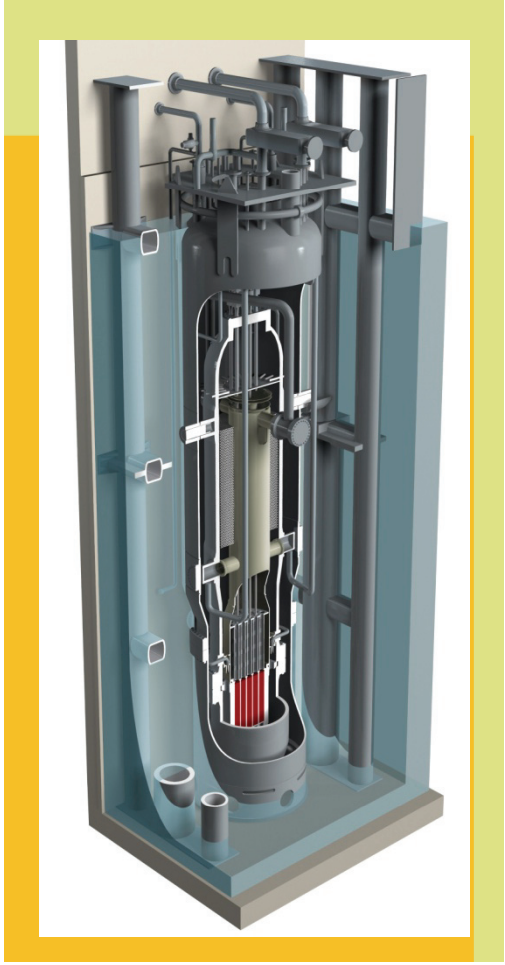
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