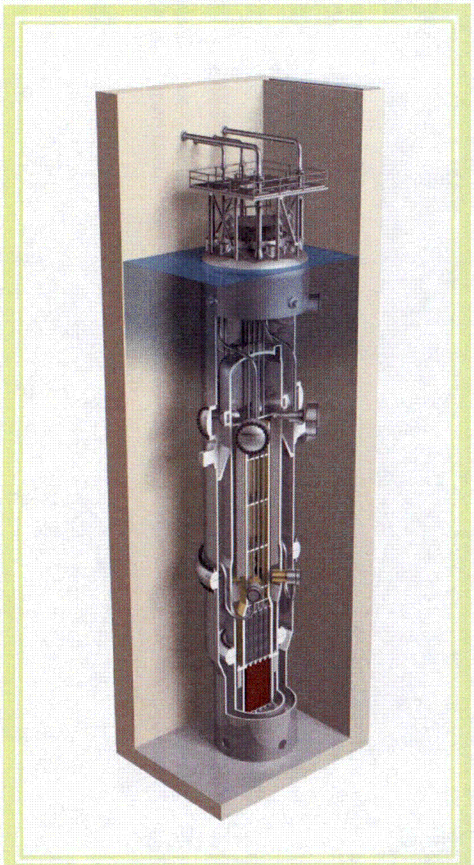
Technical Specifications



Karl Gross

Licensing Engineer

July 24, 2015

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Acknowledgement and Disclaimer

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Agenda

- Design overview
- Operations overview
- Technical specifications (TS) development process and basis
- Some key differences relative to large pressurized water reactor (PWR) technical specifications and the reason for them
- Questions

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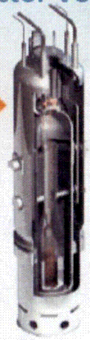
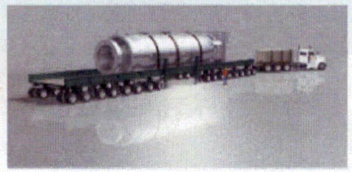
Plant Design Overview

Factory Manufacturing

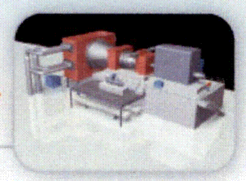
NuScale Power Module includes Containment and Reactor Vessel

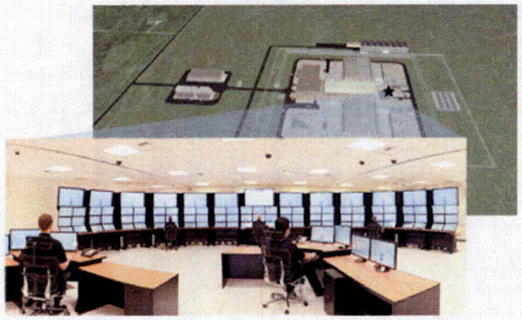


Shipped by Truck, Rail, or Barge



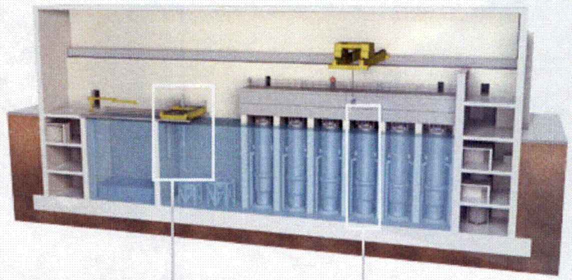
Skid-Mounted Steam Turbine/Generator

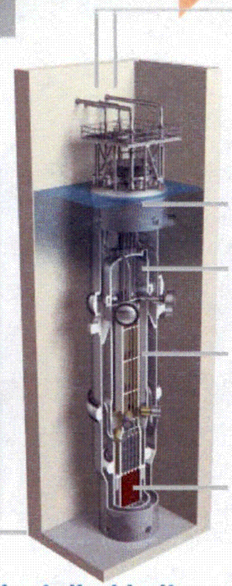


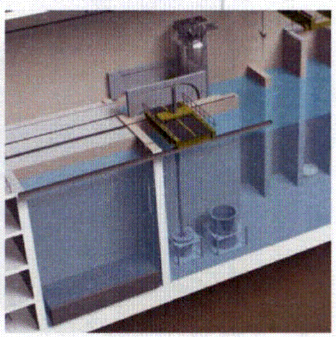


Below-Ground Control Room provides enhanced security and state-of-the-art controls

12 Module Reactor Building







Each Module is refueled underwater while the remainder of the plant produces power

- Refueled once every 24 months
- Capable of 48-month fuel cycle
- 10 Day Refueling Target

Each Module Installed in its own Isolated Bay

- Natural Circulation (No Reactor Coolant Pumps)
- 37 Standard 17x17 PWR Fuel (Half-Height) Fuel Assemblies
- Standard Magnetic Jack Control Rod Drives
- Internal Helical Coil Steam Generators and Pressurizer
- 50 MWe Gross Power

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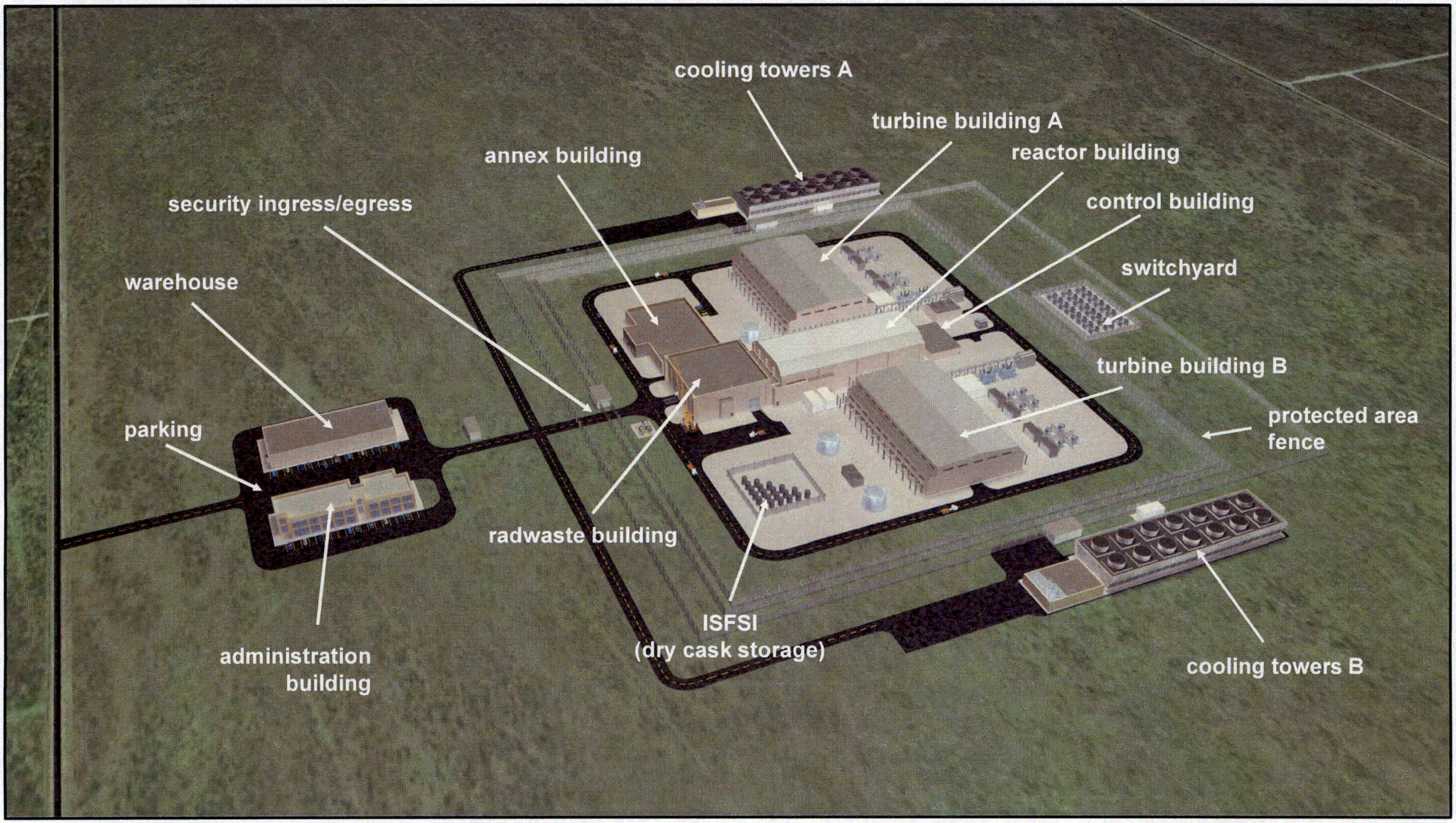
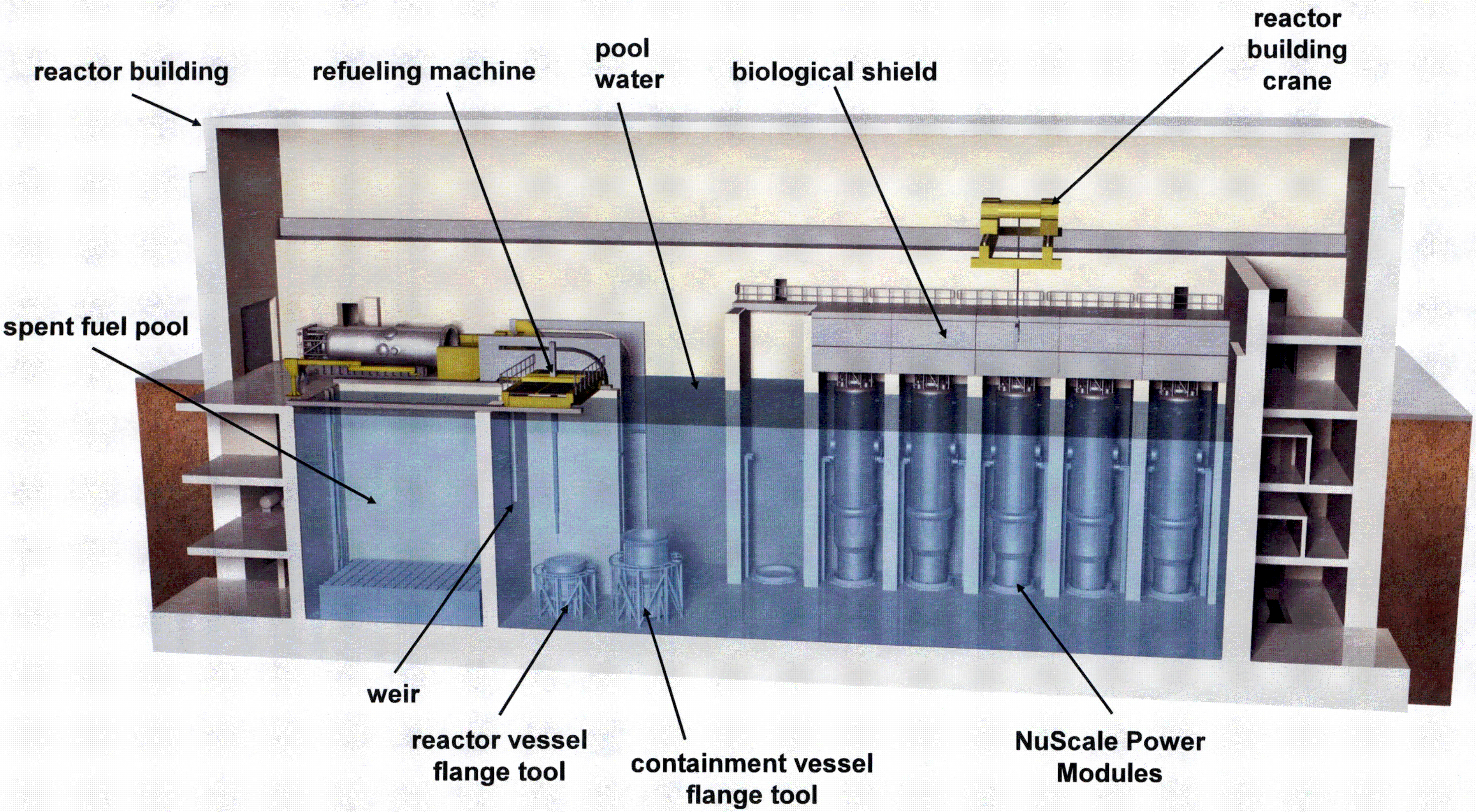
Site Aerial View



Reactor Building Cross-Section

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



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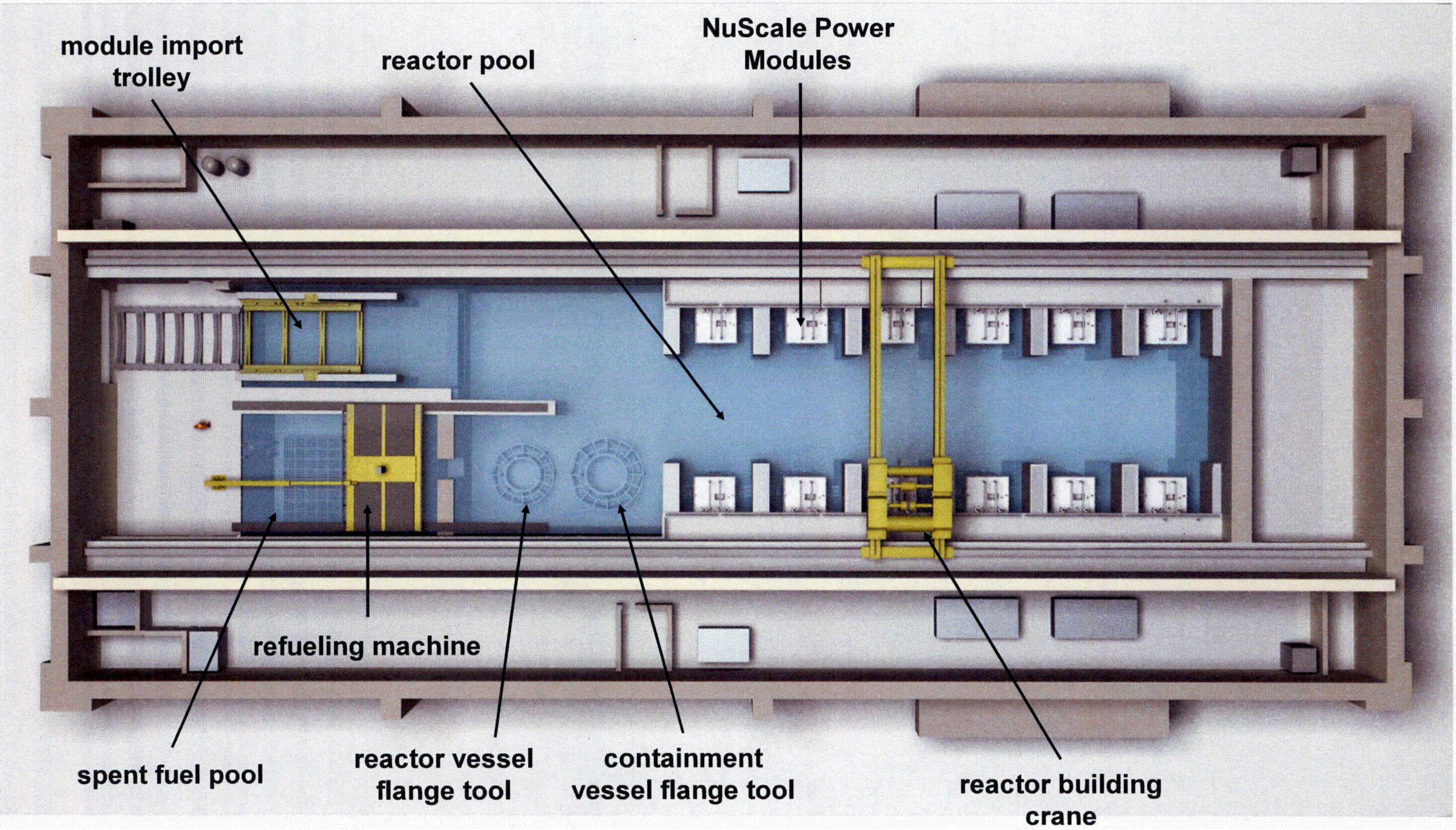
Reactor Building Overhead View



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Basic Plant Parameters

Overall Plant	
▪ Net electrical output	Up to 570 MWe (nominal)
▪ Plant thermal efficiency	> 31%
▪ Number of power generation units	Up to 12
▪ Nominal plant capacity factor	> 95%
▪ Total plant protected area ▪ Total owner controlled area	~32 acres ~70 acres
Power Generation Unit	
▪ Number of reactors	One
▪ Gross electrical output	50 MWe
▪ Steam generator number	Two independent tube bundles (50% capacity each)
▪ Steam generator type	Vertical helical coil tube (secondary coolant boils inside tube)
▪ Steam cycle	Superheated
▪ Turbine throttle conditions	3.3 MPa (475 psia)
▪ Steam flow	67.5 kg/s (536,200 lb/hr)
▪ Feedwater temperature	149° C (300 °F)
Reactor Core	
▪ Thermal power rating	160 MWth (gross)
▪ Operating pressure	12.7 MPa (1850 psia)
▪ Fuel design	UO_2 (< 4.95% U^{235} enrichment); 37 half height 17x17 geometry lattice fuel assemblies; AREVA M5 advanced cladding material; negative reactivity coefficients
▪ Refueling interval	24 months (capable of 48 months)

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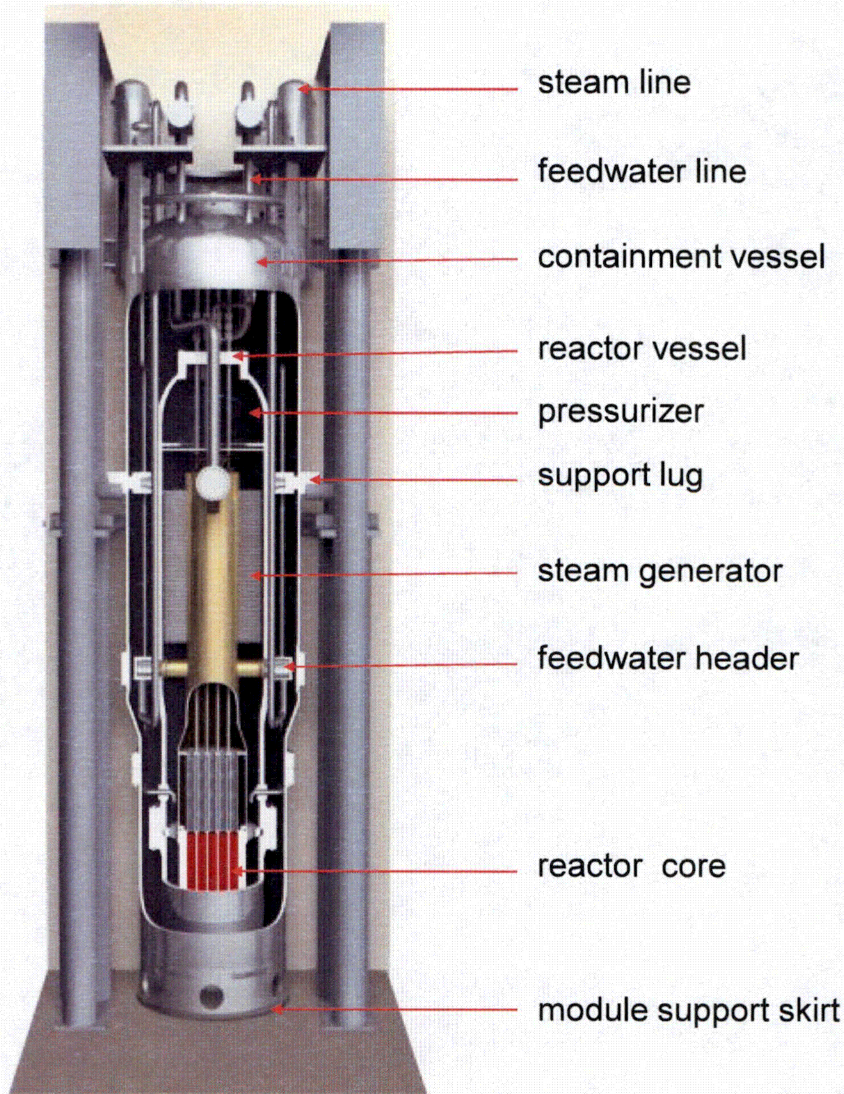
Reactor Module Overview

Natural convection for cooling

- passively safe, driven by gravity, natural circulation of water over the fuel
- no safety-related pumps, no need for emergency generators

Simple and small

- reactor is 1/20th the size of large reactors
- integrated reactor design, no large-break loss-of-coolant accidents



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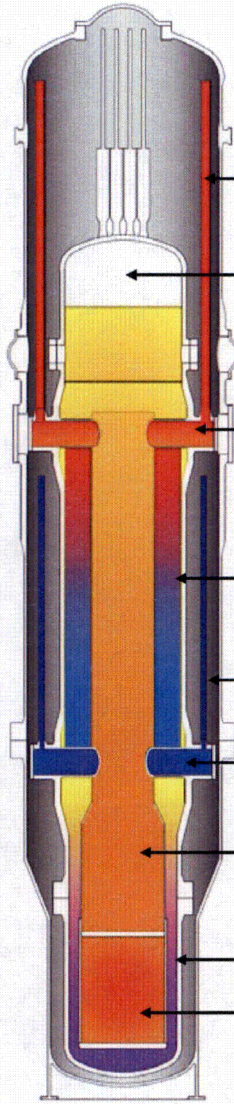
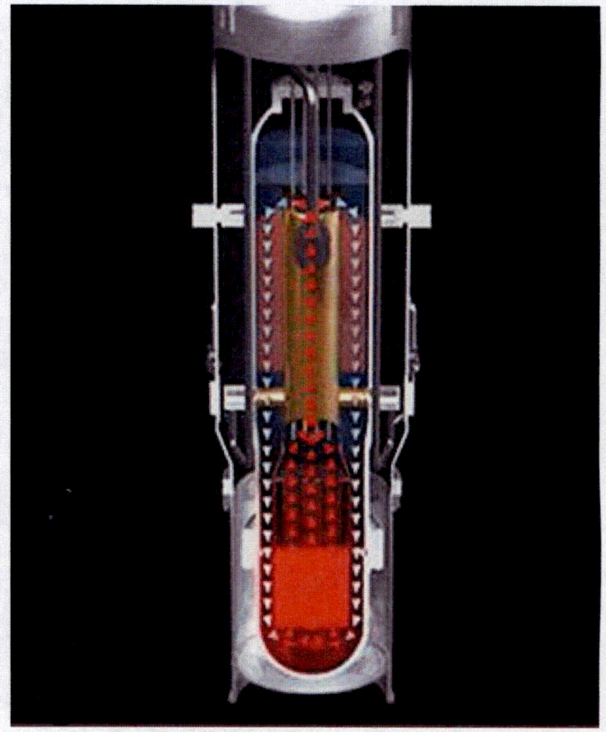
Module Normal Operation

- Primary side
  - natural circulation
  - integral pressurizer
- Secondary side
  - feedwater plenums
  - two helical steam generators
  - steam plenums





primary coolant flow path

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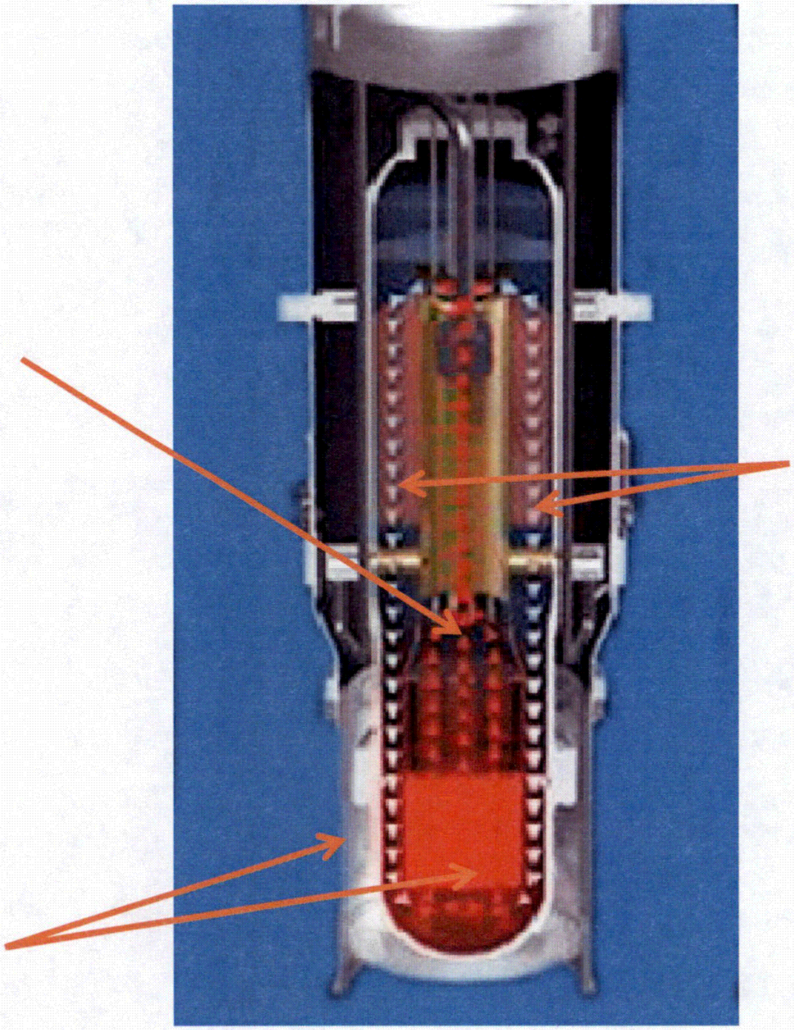
Coolant Flow Driven by Physics

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



Conduction—heat is transferred from the primary coolant through the walls of the tubes in the steam generator, heating the water (secondary coolant) inside them to turn it to steam

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

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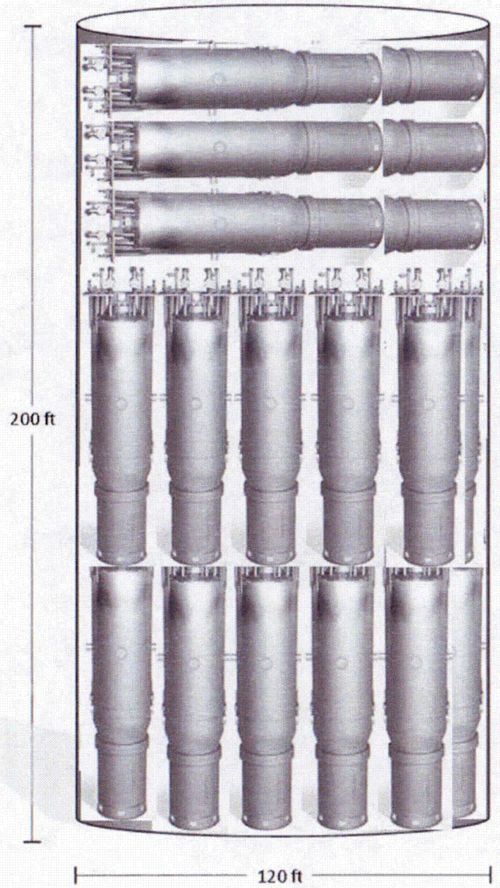
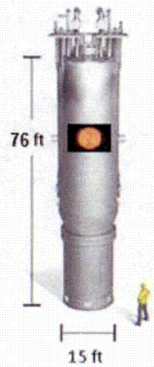
Size Comparison

126 NuScale Power Modules

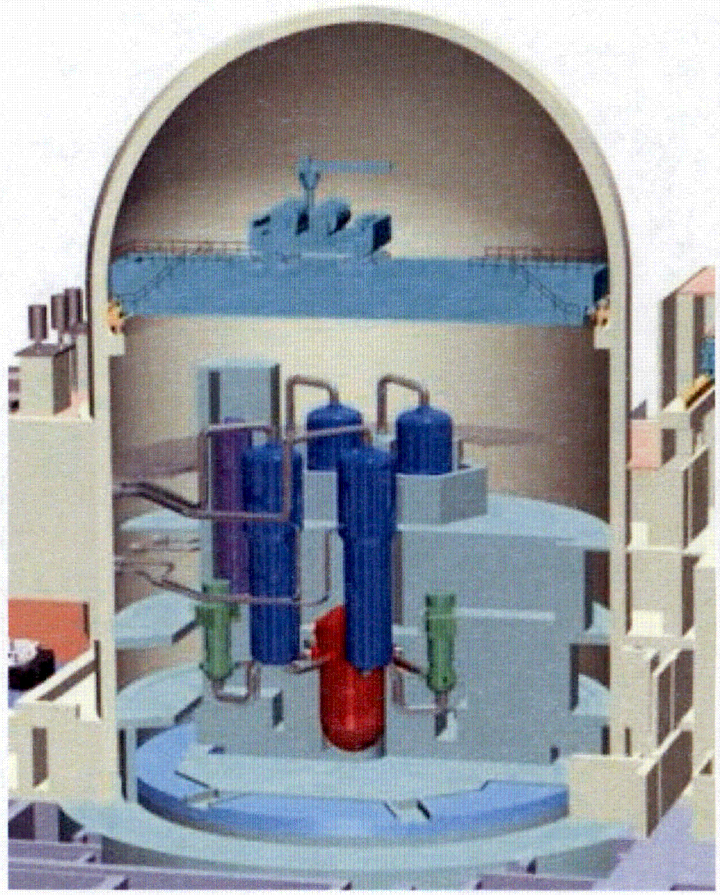


Containment

NuScale's combined containment vessel and reactor system

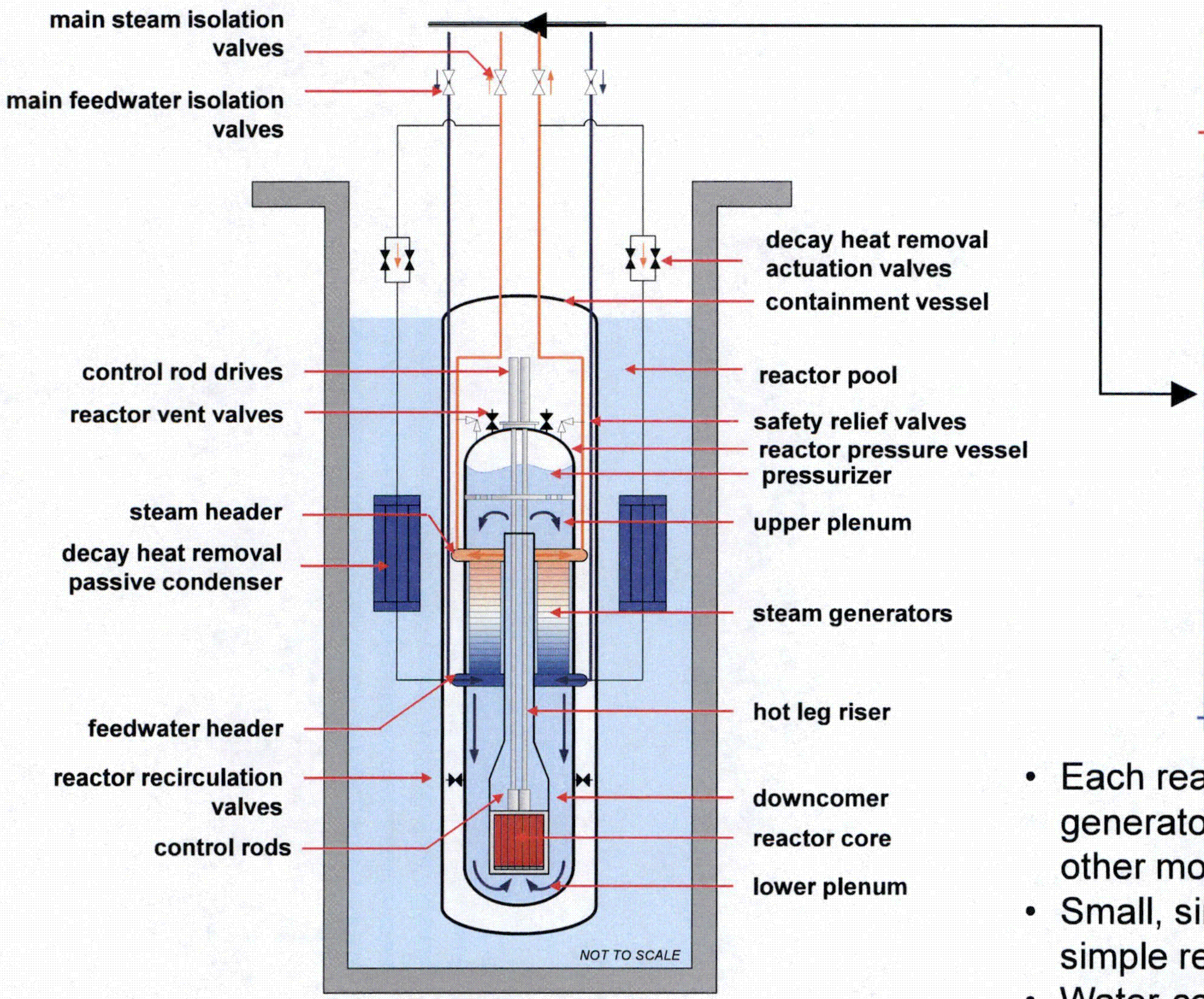


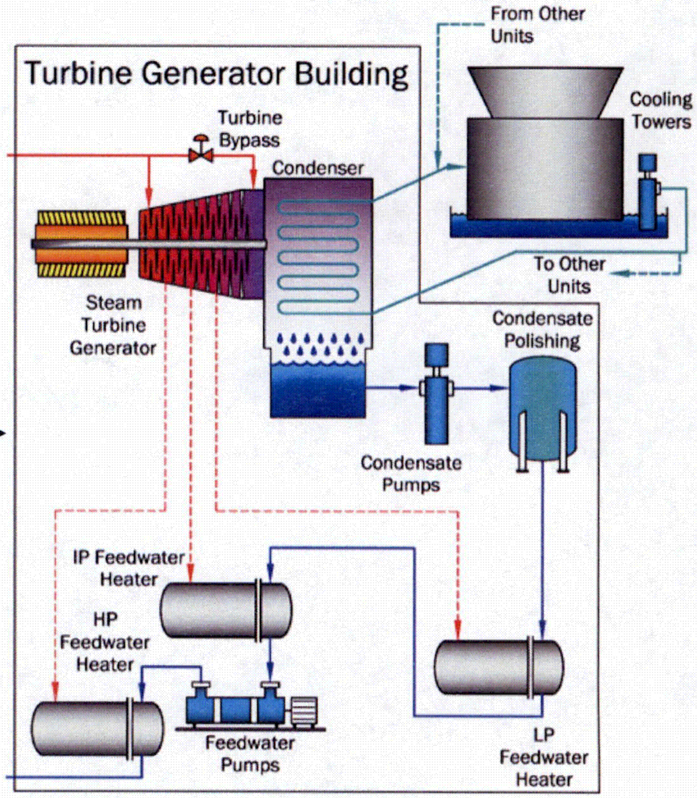
Typical Pressurized-Water Reactor



*Source: NRC

NuScale Power Train



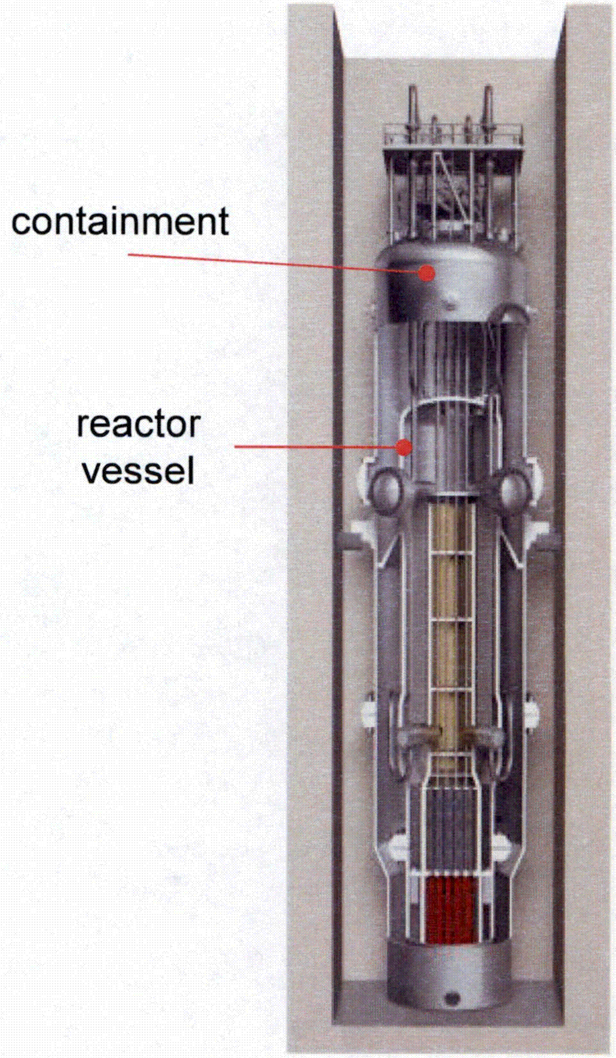


- Each reactor module has a dedicated turbine generator (TG) train eliminating the loss of other modules in the event of a turbine trip
- Small, simple components support short simple refueling outages
- Water-cooled or air-cooled condenser
- Air-cooled generator

Containment Design

Evacuated Containment—Enhanced Safety

- Containment volume sized so that core does not uncover following a LOCA
- Large reactor pool keeps containment shell cool and promotes efficient post-LOCA steam condensation
- Insulating vacuum
  - significantly reduces conduction and convection heat transfer during normal operation
  - eliminates requirement for insulation on the reactor vessel, thereby minimizing sump screen blockage concerns (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



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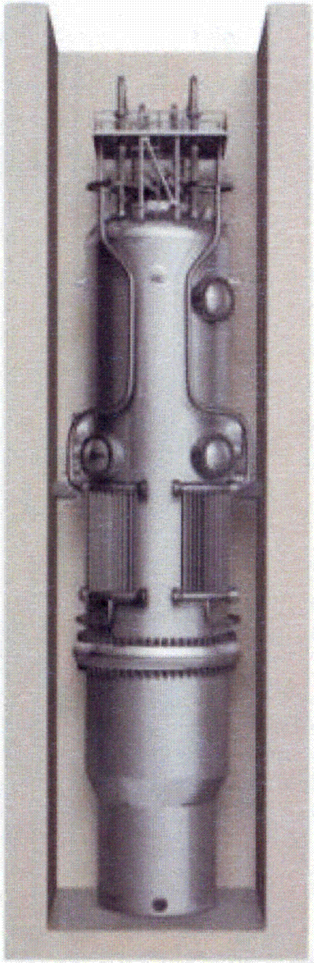
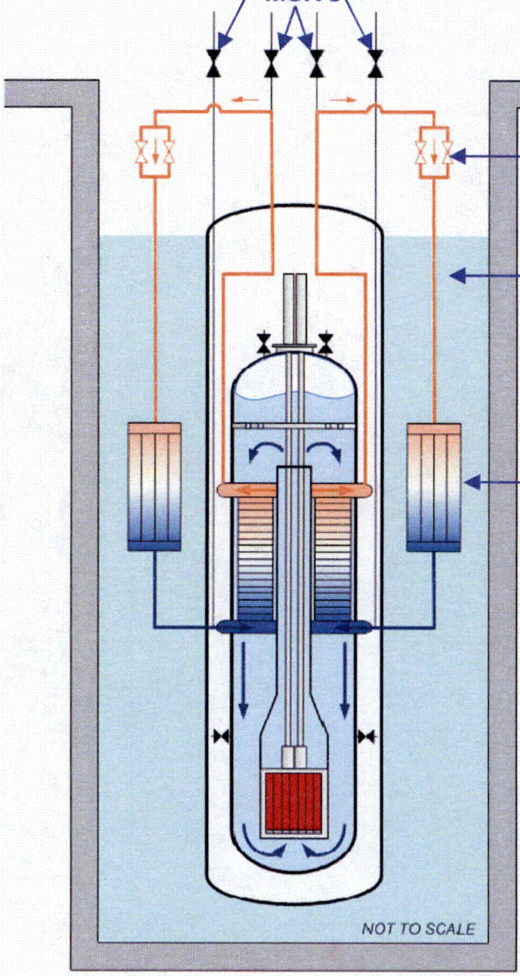
Passive Decay Heat Removal System

- Main steam and main feedwater isolated
- Decay heat removal (DHR) valves opened
- Decay heat passively removed via the steam generators and DHR heat condensers to the reactor pool
- DHR system is composed of two independent single failure proof trains (1 of 2 trains needed)





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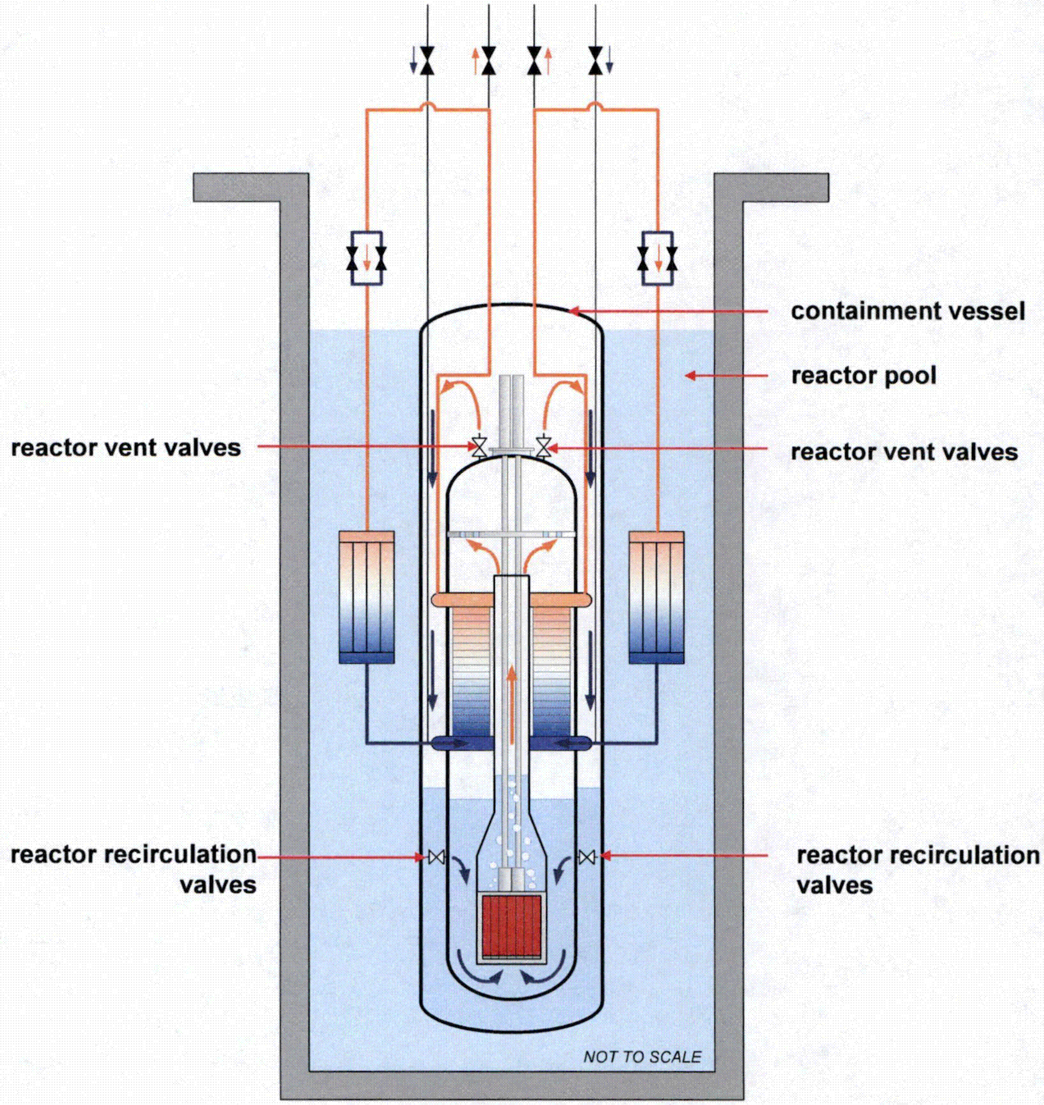
Emergency Core Cooling System and Containment Heat Removal

- Adequate core cooling is provided without the need for safety-related injection
- Reactor vent valves opened on safety signal
- Reactor recirculation valves open on ECCS actuation signal
- Decay heat removed
  - condensing steam on inside surface of containment vessel
  - convection and conduction through liquid and both vessel walls



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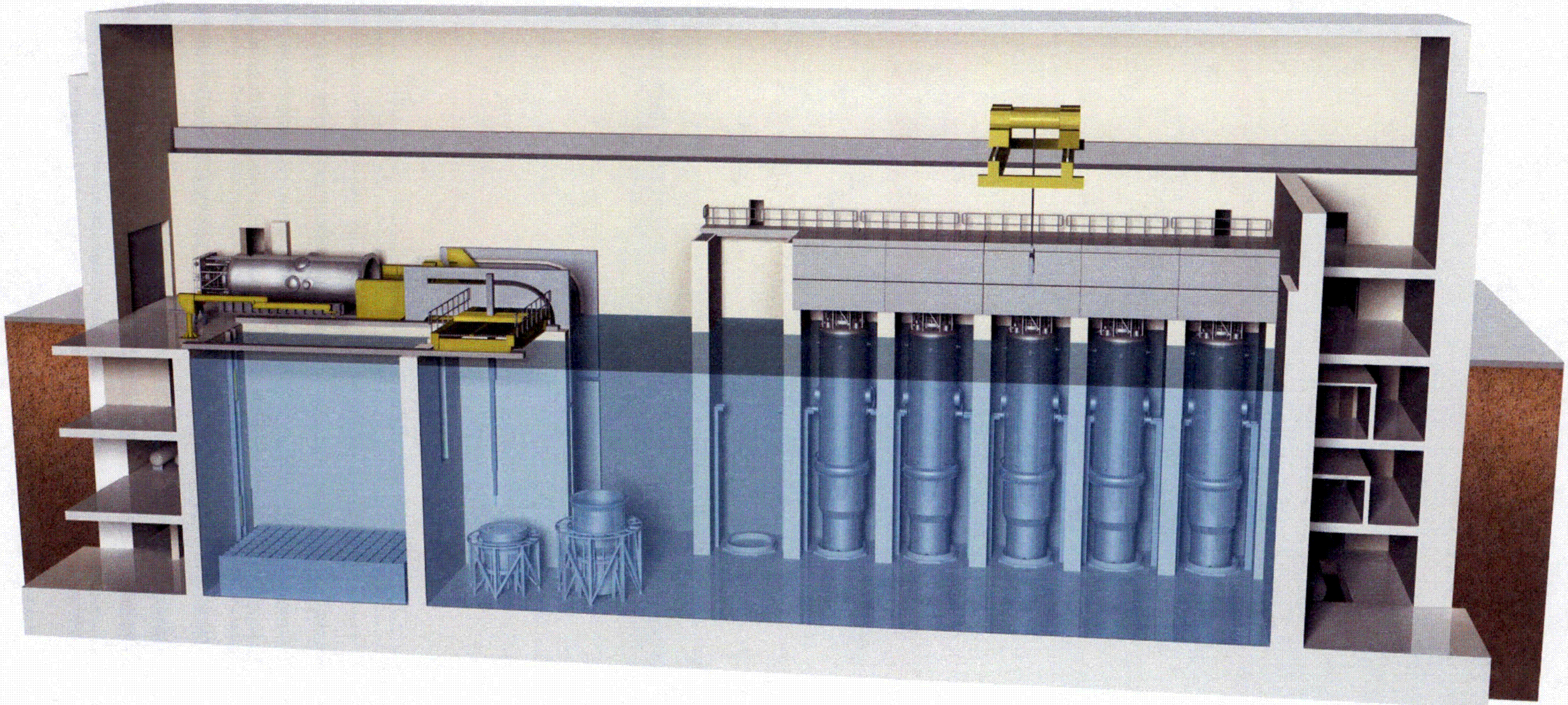
Module Component Assembly



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Design Simplification

- **New systems**
  - containment evacuation
  - containment flooding and drain
- **Eliminated systems**
  - containment spray
  - containment fan cooler
  - auxiliary feedwater
  - ECCS injection and recirculation
  - steam generator blowdown
  - electrical generator hydrogen supply
  - safety-related electrical systems
- **Eliminated components**
  - reactor coolant pumps
  - ECCS pumps, tanks, and RPV injection lines
  - containment sumps and tanks
  - refueling water storage tank
  - reactor coolant hot leg and cold leg piping
  - pressurizer surge line and relief tank
  - reactor vessel and primary coolant system insulation
  - safety-related emergency diesel generators

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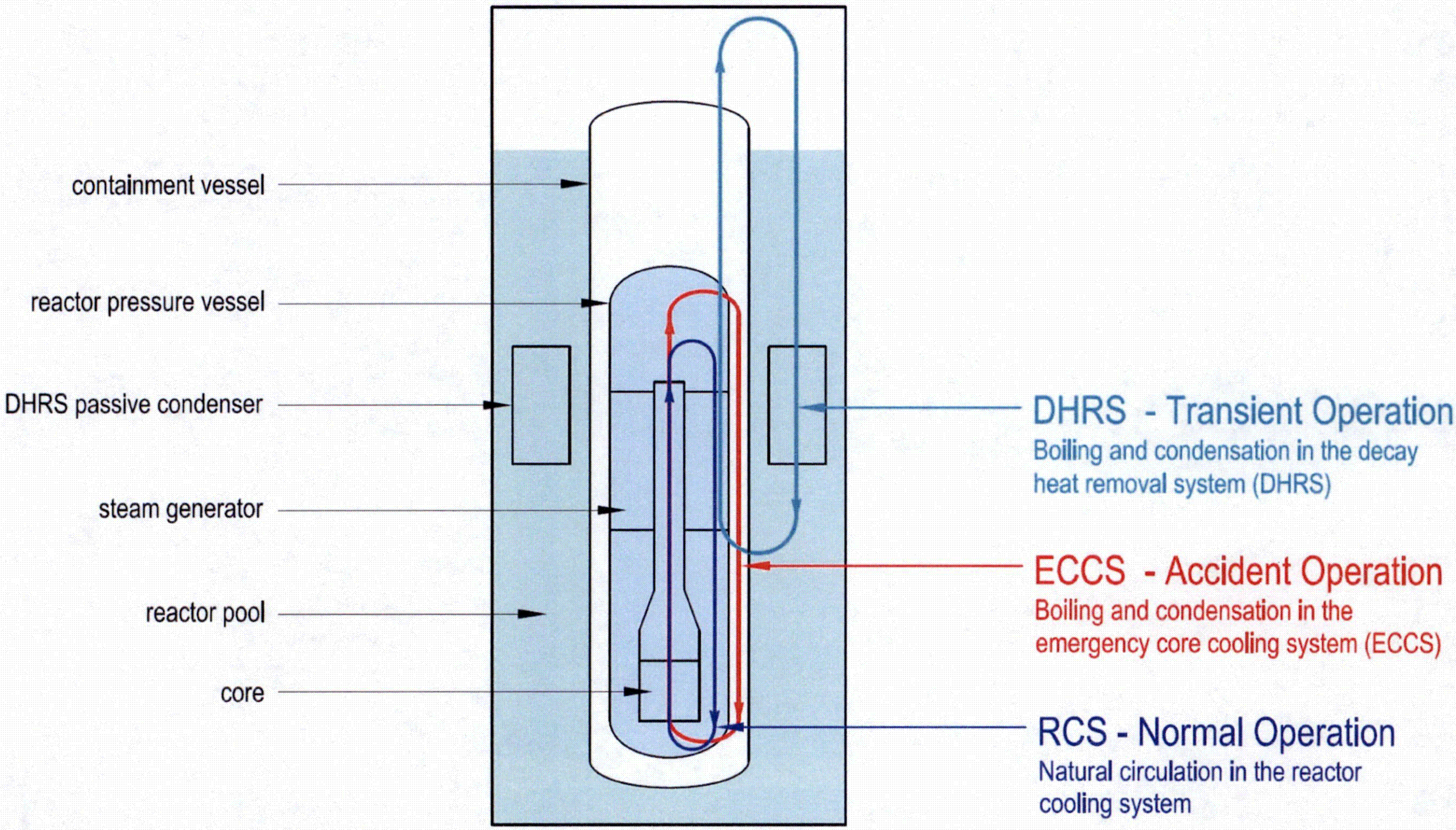
Passive Cooling Systems



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Installation and Operations

- Construction and installation sequence
  - buildings and infrastructure
  - module fabrication off-site and transported to facility
- Module installation, initial fueling, and assembly
- Module relocation to operating position
- Module operations
  - power operations
  - shutdown
- Module relocation to refueling area
- Module disassembly
- Module refueling
- 24-month fuel cycle

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NuScale GTS Development

Generic technical specifications (GTS) are being drafted in parallel with design and DCA development based on

- Appropriate and relevant PWR specs
  - NUREG-1431 - W – Shutdown Margin
  - NUREG-1432 - CE – Control Rod Alignment Limits
- Other new reactor designs with relevant functions
  - AP1000—CVCS Isolation
- NuScale staff experience and knowledge of TS content
- Familiarity with NS design and PWR operations

NuScale GTS Development

- Evolving using information from design finalization and analyses results
- Applying 10 CFR 50.36 and policy statement
  - safety analyses as they are finalized
  - RTNSS analyses results for consideration
  - Technical Specification Task Force (TSTF) travelers since Rev. 4 of NUREG STS
- Developing and tracking differences between source STS/GTS and NS specifications

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NuScale GTS Development

As safety analyses and design are finalized there will be a rigorous application of 10 CFR 50.36 resulting in

- Technical report to describe process and document conformance supporting DCA submission
- Risk insights incorporated into completion times and surveillance requirements frequencies for submission
- Incorporating risk considerations through incorporation of RITSTF initiatives 4b and 5b through application approaches similar to TSTF travelers 505 and 425

NuScale GTS Submittal

- DCD Chapter 16
  - introductory information
  - development process, etc.
  - reference to Part 4 of DCA for GTS content
  - investment protection/availability controls
- Part 4 of DCA
  - NuScale generic technical specifications (GTS)
  - Bases
- Prepare to support GTS transition to standard TS

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Key NuScale Differences with TS Implications

- Modularity
  - 12 reactors with 12 individual sets of TS in a single building sharing a single reactor pool
  - shared ultimate heat sink
  - movement of fueled reactor
  - phased commissioning schedule for each module
- Operations
  - relatively low power per module
  - digital control systems implemented in shared control room
  - natural circulation cooling—no electrical power required
  - passive cooling—no electrical power required

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Key NuScale Differences with TS Implications

- Operations
  - Operations staffing levels
  - many shared procedures (operating, maintenance, administrative)
  - many shared administrative programs (IST, Bases Control Program, Surveillance Frequency Control Program)

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Key NuScale Differences with TS Implications

- Preliminary operational modes

MODE	TITLE	REACTIVITY CONDITION (k_{eff})	REACTOR COOLANT TEMPERATURE (T_h)	MODULE POSITION
1	Operations	≥ 0.99	N/A	Operating
2	Hot Shutdown	< 0.99	≥ 300 F	Operating
3	Safe Shutdown	< 0.99	< 300 F	Operating
4	Transition[(a)]	< 0.95	< 200 F	N/A
5	Refueling[(b)]	< 0.95	< 200 F	N/A

(a) All CVCS connections to MODULE isolated.
(b) One or more reactor vessel head closure bolts less than fully tensioned.

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NuScale TS Challenges

Ongoing design interactions with TS implications

(Each of these is the subject of other preapplication engagements)

- Refueling evolution
- Containment systems
- Electrical systems
- Digital instrumentation and control systems
- Regulatory treatment of nonsafety systems

NuScale GTS concerns

- Unique MODES definitions
- Shared component LCO(s) and completion times

Path Forward

- Future preapplication engagements will include discussion of TS implications as appropriate
- In early 2016 NuScale will propose routine, periodic engagements with the staff to communicate TS progress
  - identify areas of potential concern
  - manage resolution of issues
  - permit staff feedback (e.g., industry lessons learned to be applied, perceived generic TS-related issues)

Questions

Questions or Comments?

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