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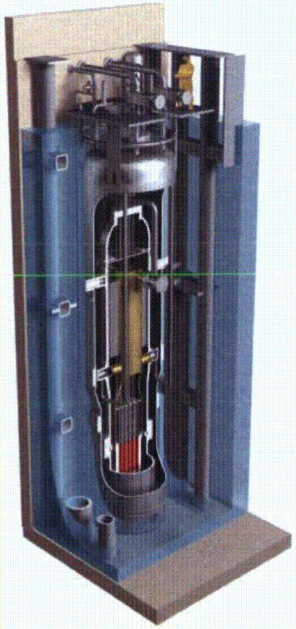
Security by Design



Ross Snuggerud,
Plant Operations Engineer/SRO
October 4, 2012

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Agenda

- Purpose
- Plant overview
- Background
- Regulations and related guidance
- Security by design
- Summary
- Feedback and next steps

Purpose

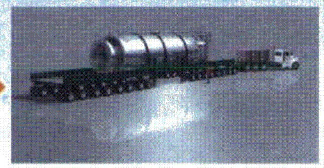
- Communicate NuScale's process for integrating security into the plant design
- Obtain Nuclear Regulatory Commission (NRC) feedback on NuScale's implementation process
- Discuss aspects of the Standard Review Plan guidance to be included in the Design-Specific Review Standard (DSRS)

Plant Overview

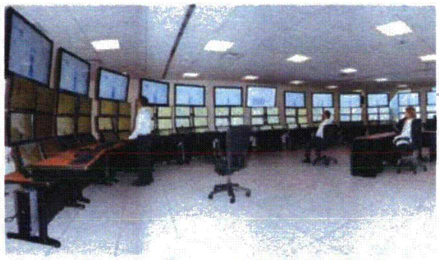
Factory Manufacturing

Module includes Containment and Reactor Vessel

Shipped by Truck, Rail, or Barge

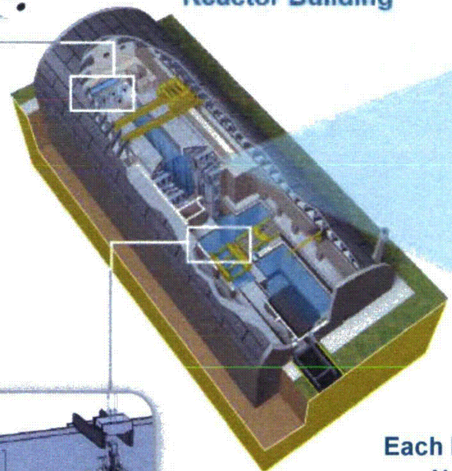


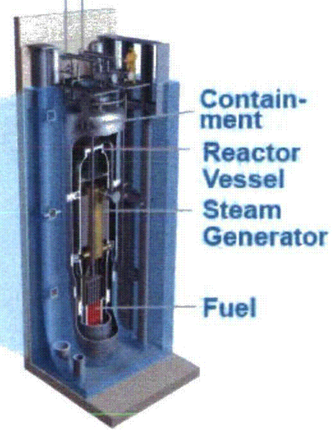
Skid-Mounted Steam Turbine/Generator



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

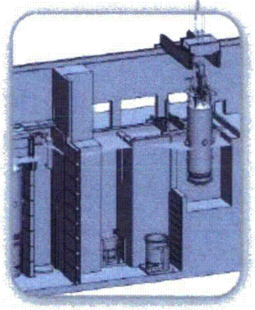
12 Module Reactor Building





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

- Refueled once every 24 months
- 10 Day Refueling Target



Each Module installed in its own isolated bay

- **Natural Circulation (No Reactor Coolant Pumps**
- **Standard 17x17 PWR Fuel**
- **Standard Magnetic Jack Control Rod Drives**
- **Internal Steam Generator and Pressurizer**
- **45 MWe Net Power**

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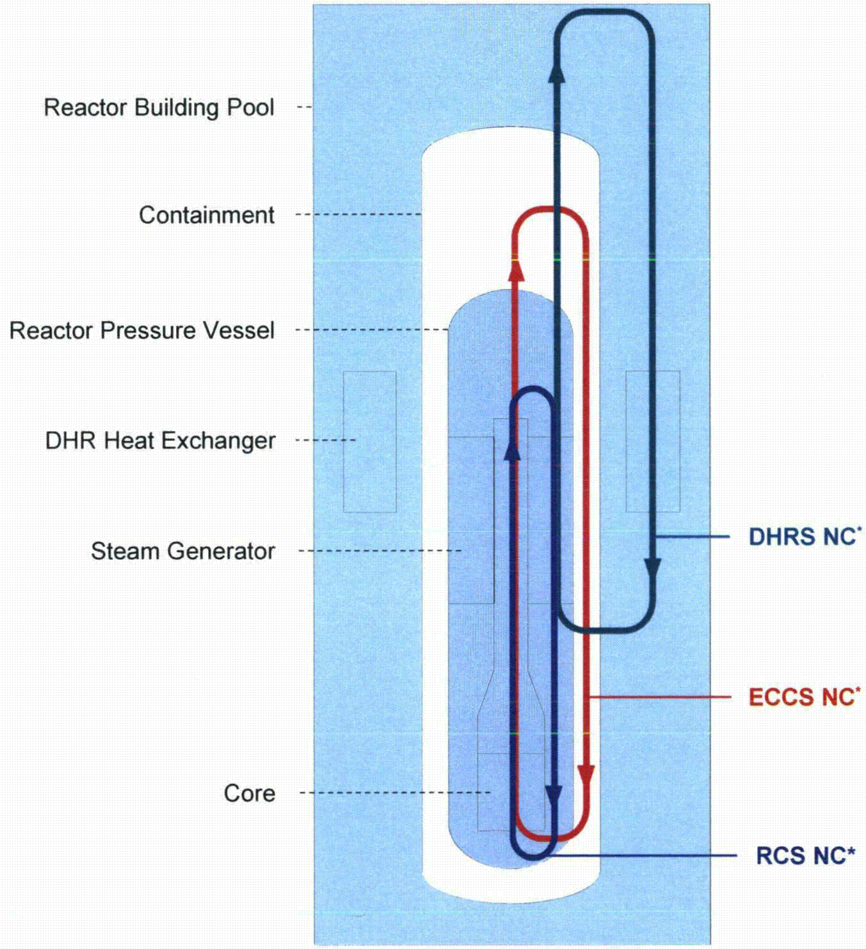
Plant Overview – Natural Circulation



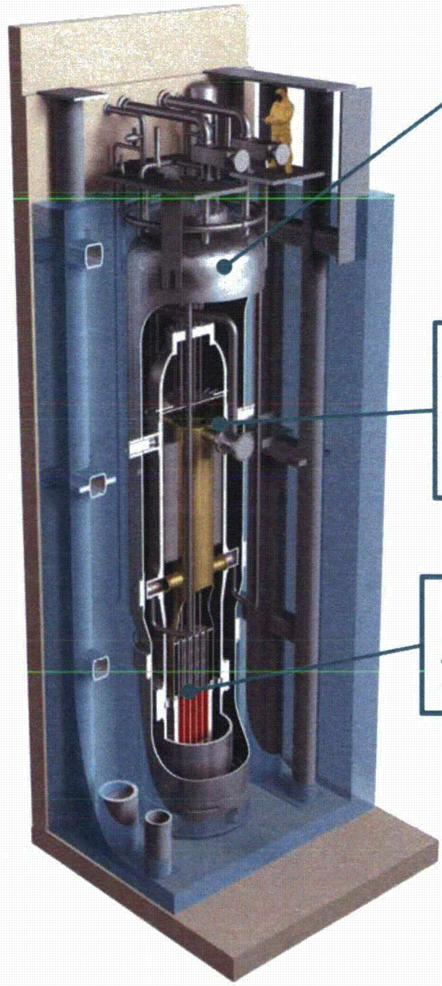
* NC: Natural Circulation

- **Natural circulation in the reactor coolant system (RCS)**
- **Natural circulation in the decay heat removal system (DHRS)**
- **Natural circulation in the emergency core cooling system (ECCS)**

Reactor Module Overview

- 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 is 1/20th the size of large reactors
  - 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

45 MWe Reactor Module



Steel containment *10 times stronger* than typical PWR

Water volume to thermal power ratio is *four times larger resulting in better cooling*

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

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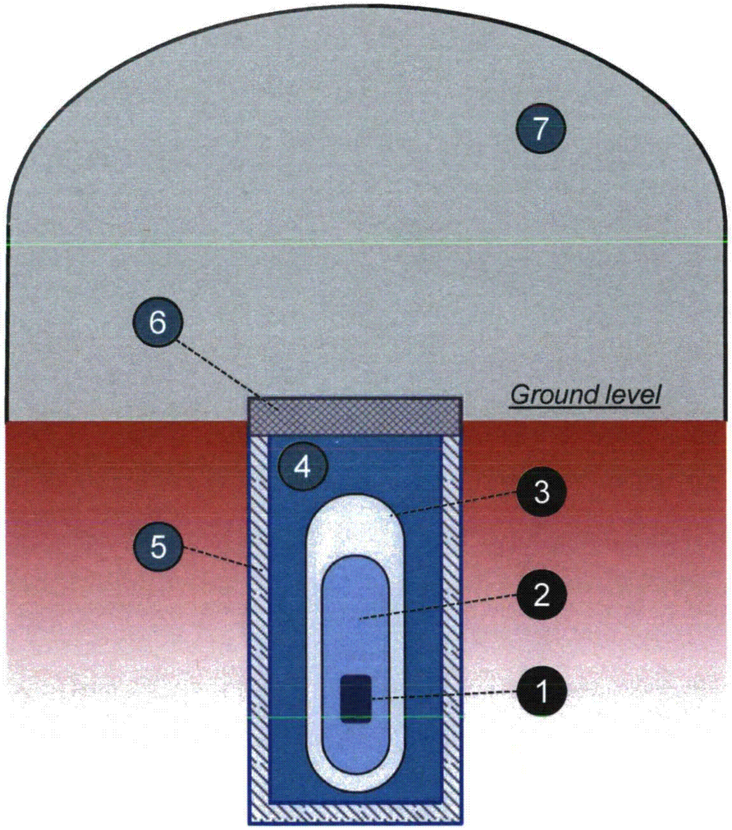
Barriers between Fuel and Environment

Conventional Designs

1. Fuel pellet and cladding
2. Reactor vessel
3. Containment

Additional Features in NuScale Design

4. Water in reactor pool (10 million gallons)
5. Stainless steel lined concrete reactor pool
6. Biological shield covers each reactor
7. Reactor building (Seismic Category I)



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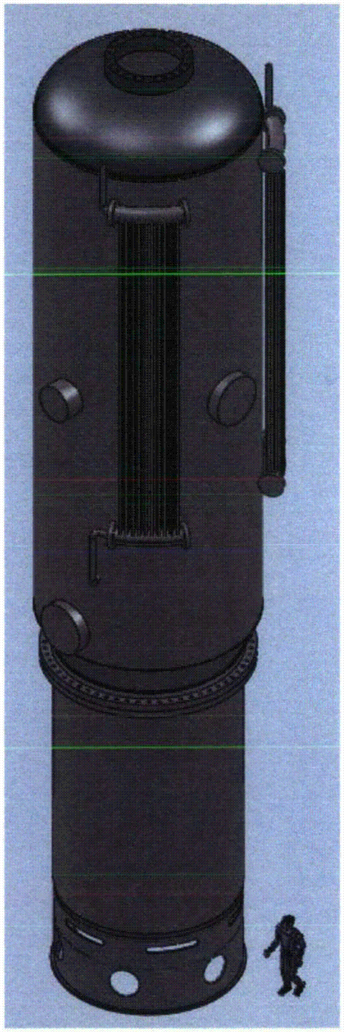
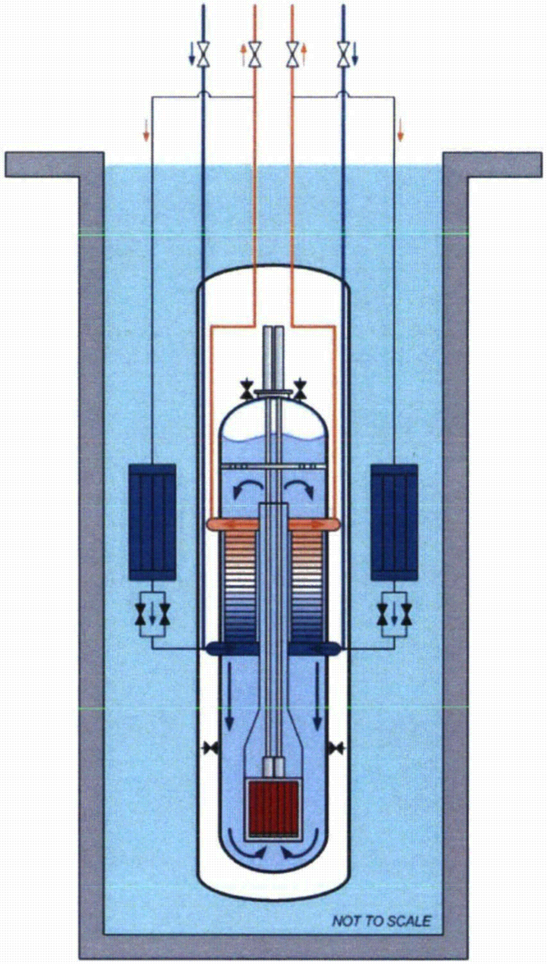
Passive Decay Heat Removal System

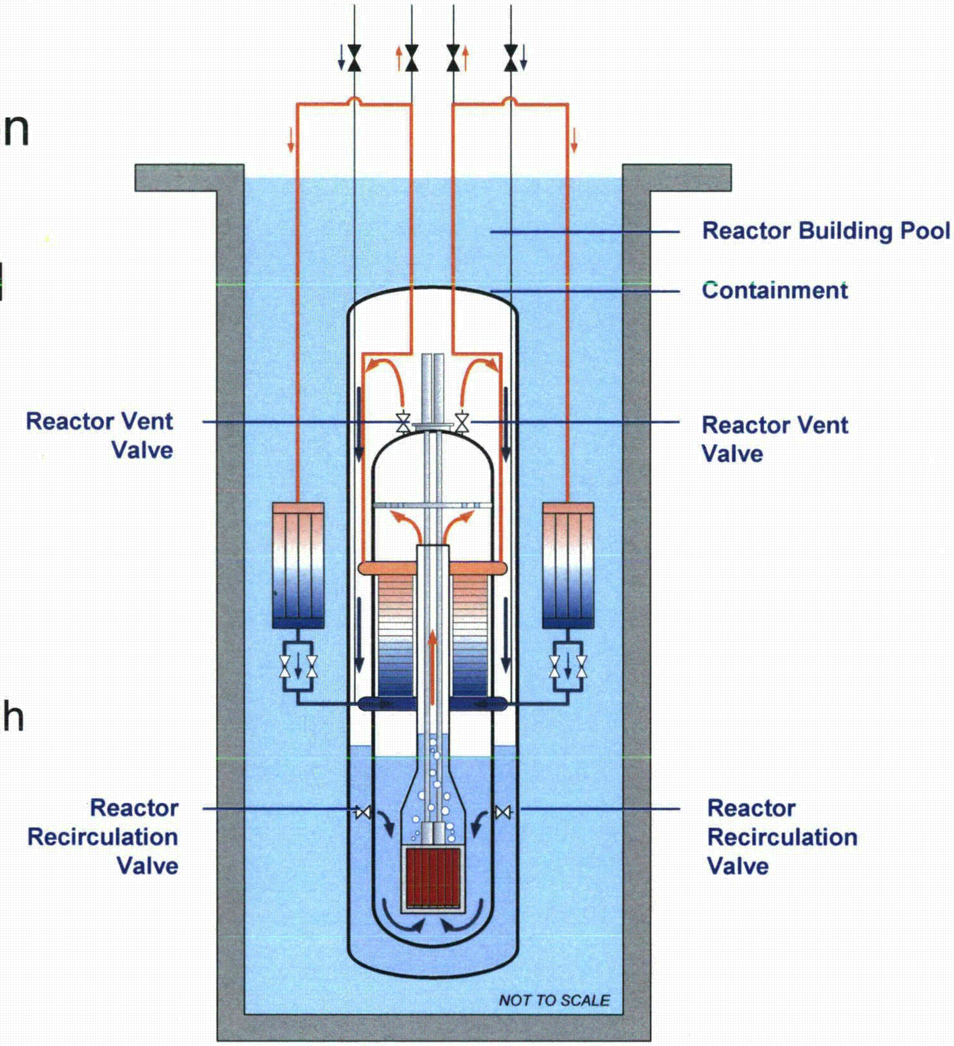


- Main steam and main feedwater isolated
- Decay heat removal (DHR) isolation valves opened
- Decay heat passively removed via the steam generators and DHR heat exchangers to the reactor pool



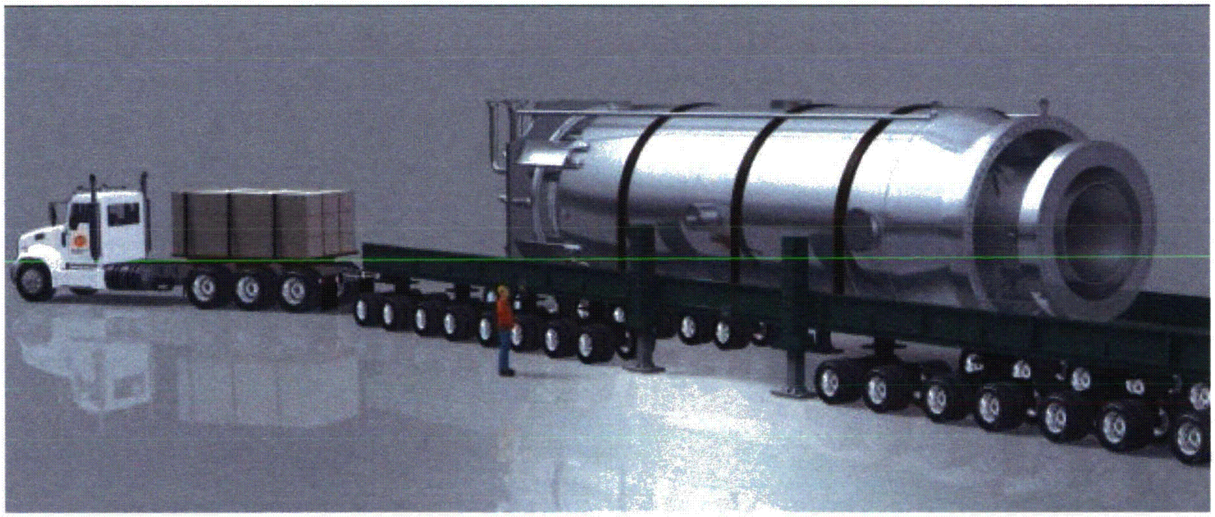
ECCS/Containment Heat Removal

- Reactor vent valves opened on safety signal
- When containment liquid level is high enough, reactor recirculation valves open.
- Decay heat removed
  - condensing steam on inside surface of containment vessel
  - convection and conduction through liquid and both vessel walls



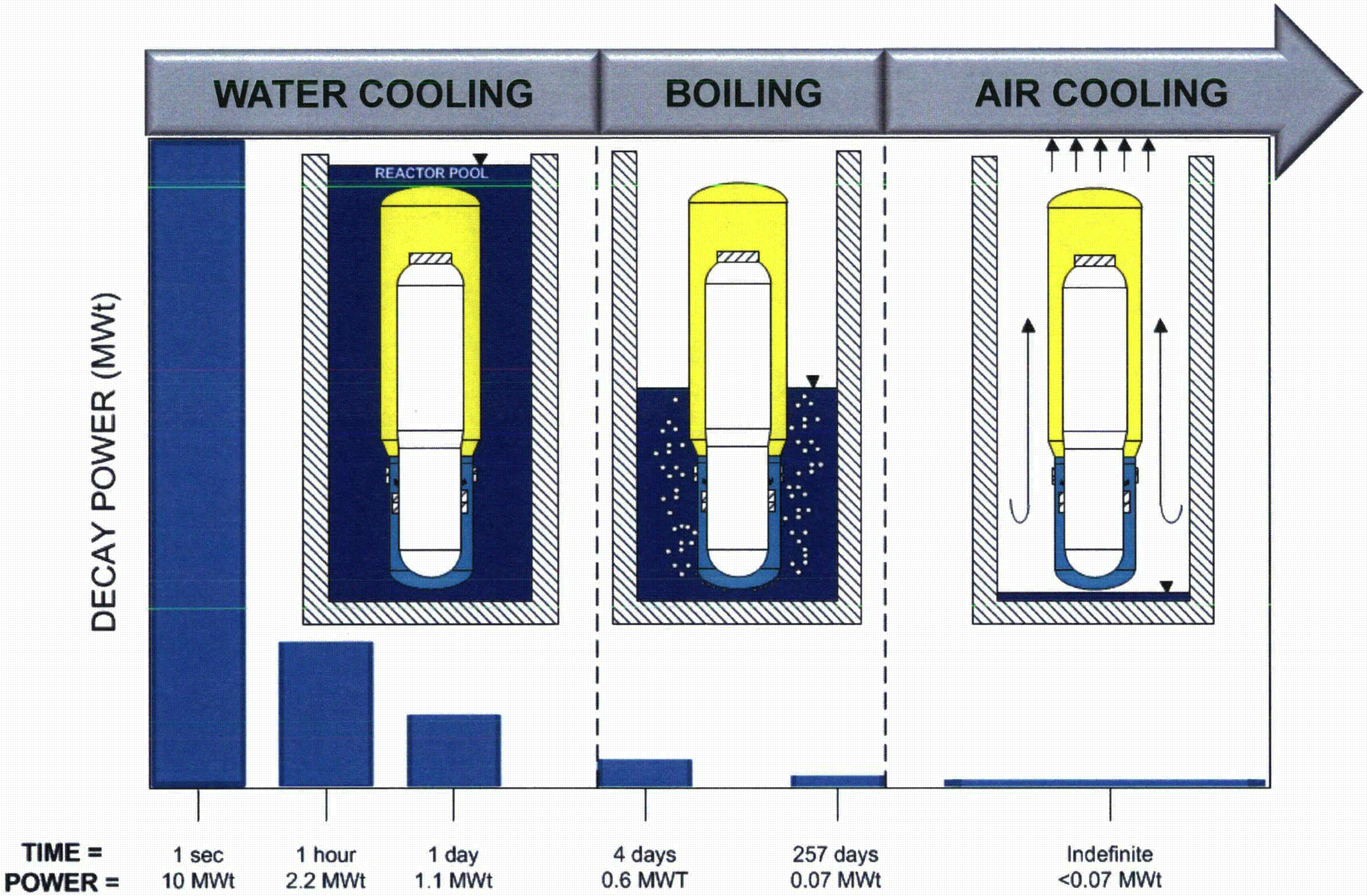
Ship by Truck, Rail, or Barge

- Integrated reactor module
- Factory manufactured
- Transportable by truck, rail, or barge
- 15 meters x 4.5 meters
  - 400 tons



Stable Long-Term Cooling without Pumps or Power

Containment and fuel cooled indefinitely for all 12 modules without pumps or power



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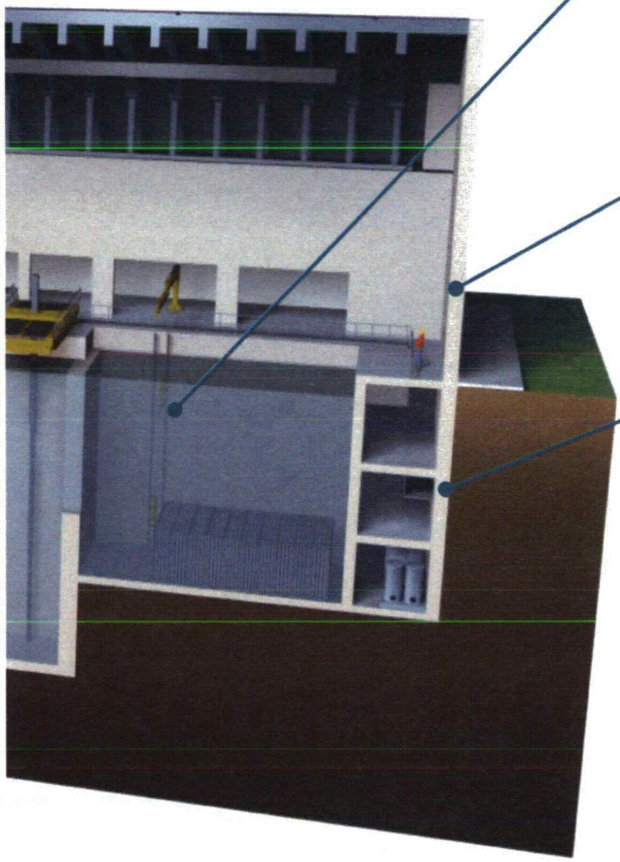
Spent Fuel Pool Safety



Increased Cooling Capacity

- ***More water volume for cooling per fuel assembly*** than current designs
- Redundant, cross-connected reactor and refueling pool heat exchangers provide full back-up cooling to spent fuel pool.

External Coolant Supply Connections

- Auxiliary ***external water supply connections are easily accessible*** to plant personnel and away from potential high radiation zones (current problem in Japan).

Below Ground, Robust Deep-Earth Structure

- Below ground spent fuel pool is housed in a ***seismically robust reactor building.***
- Stainless steel refueling ***pool liners are independent from concrete structure to retain integrity .***
- Pool wall located underground is ***shielded from tsunami wave impact and damage.***
- ***Construction of structure below ground in engineered soil limits the potential for any leakage.***

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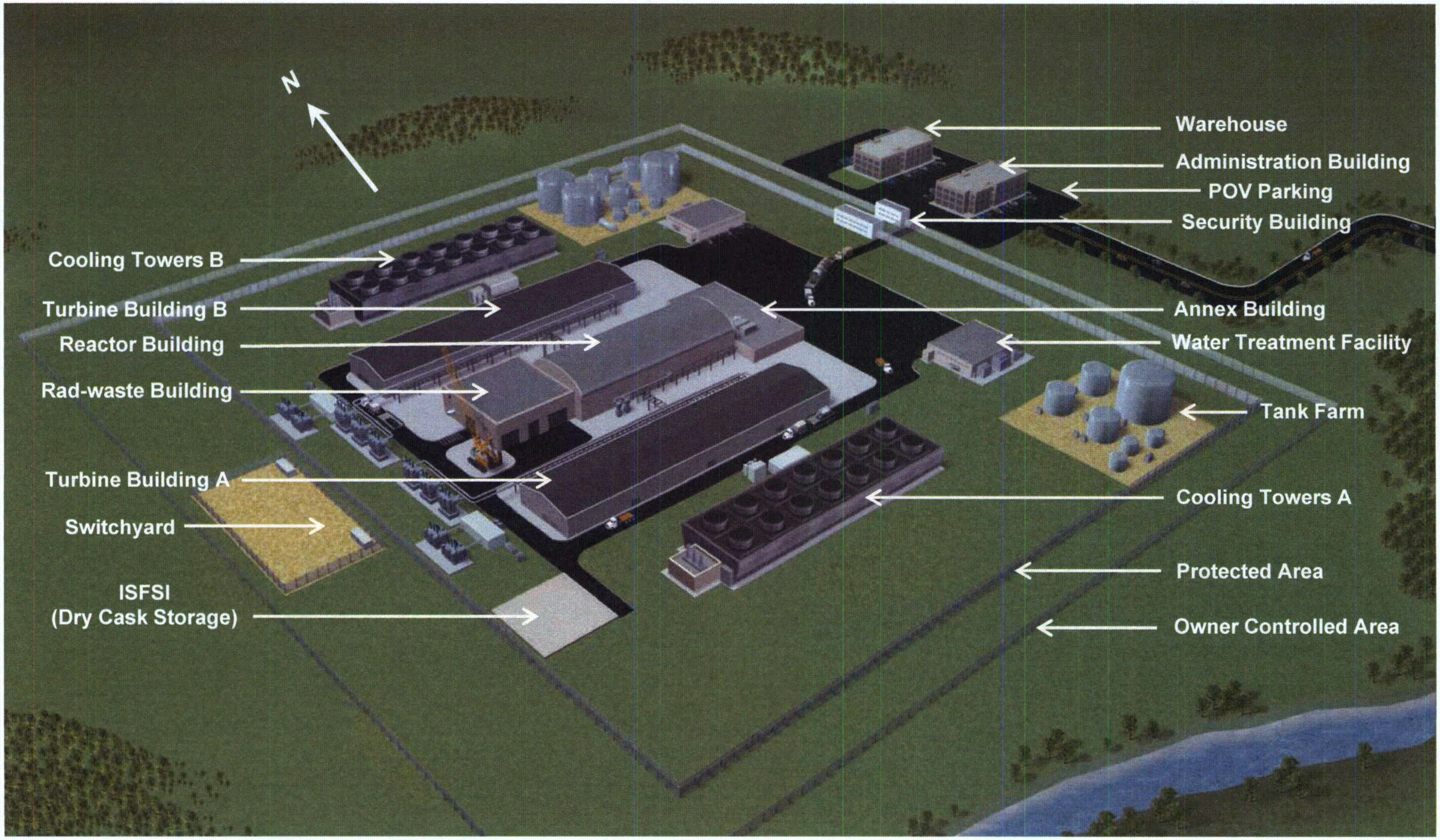
Background

- October 2011 meeting with the NRC
- Gap Analysis (as it relates to physical security requirements and guidance)
- NuScale's Security by Design process established
- NEI Small Modular Reactor task force involvement

Site Aerial View



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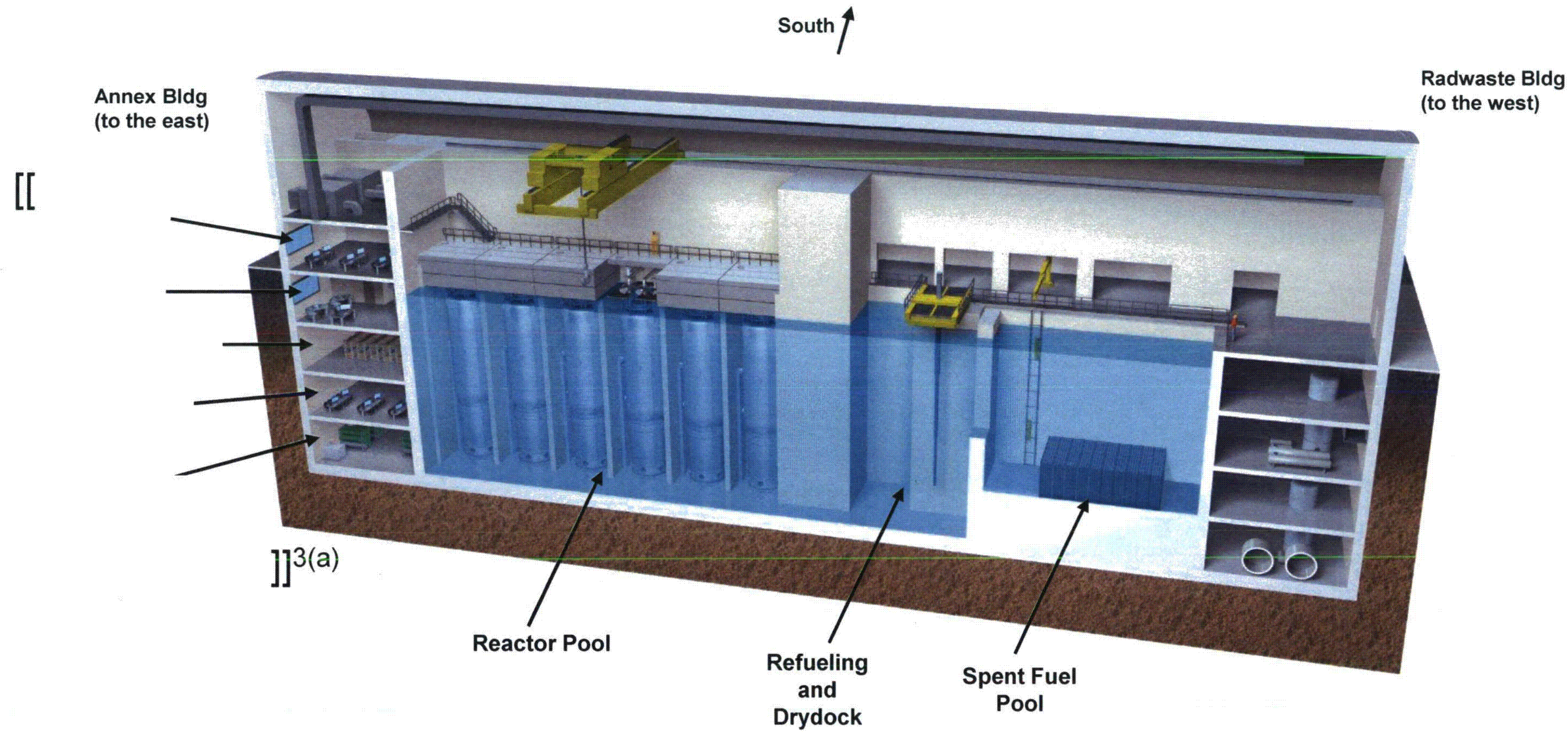
Reactor Building Cutaway View



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Regulations and Related Guidance

- Regulations
  - Part 50.150 - Aircraft Impact Assessment
  - Part 50.54(hh)(1) - Conditions of Licenses (Potential Aircraft Threat)
  - Part 73.20 - General Provisions
  - Part 73 - Physical Protection Requirements at Fixed Sites (73.40, 73.45, 73.46, 73.50,73.51, 73.54-61)
- Regulatory Guides
  - RG 5.7, "Entry/Exit Control for Protected Areas, Vital Areas, and Material Access Areas."
  - RG 5.12, "General Use of Locks in the Protection and Control of Facilities and Special Nuclear Materials."
  - RG 5.44, "Perimeter Intrusion Alarm Systems."
  - RG 5.65, "Vital Area Access Controls, Protection of Physical Security Equipment, and Key and Lock Controls."
  - RG 5.76, "Physical Protection Programs at Nuclear Power Reactors."
- NUREGs
  - NUREG-0800 Section 13.6.2, "Physical Security – Design Certification"

Security by Design

Primary Goals

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Security by Design

NuScale Design – Positive Attributes

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- Ultimate heat sink for decay heat removal is internal to the hardened reactor building
- Limited number and compact size of safety systems reduce the amount of vital equipment to protect
- Safety-related structures, systems, and components (SSCs) located mostly underground within the hardened reactor building
- Integral pressurized water reactor design eliminates the hot and cold leg piping from target sets

Security by Design

NuScale Design – Positive Attributes (continued)

- Small fission product inventory in each individual module

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Security by Design

History of Security by Design at NuScale

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Security by Design

Security by Design Team

- NuScale Plant Operations
- NuScale Building and Structures Engineering
- NuScale System, Electrical, and I&C Engineering
- NuScale Safety Analysis (Probabilistic Risk Assessment)
- NuScale Licensing
- Security consultants
- Safety Analysis consultants
- NuScale Customer Advisory Board (utility partners)

Security by Design

Security by Design Deterministic Approach

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Security by Design

Risk-Informed Approach to Security by Design

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Security by Design

Risk-Informed Approach to Security by Design (continued)

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Security by Design

Risk Informed Security Approach - Simple Example

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Security by Design

Preliminary PRA Results

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Security by Design

Examples of Security Impact on the Design

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Examples of Security Impact on the Design (continued)

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Deviations from Typical Light Water Reactors

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Security by Design

NuScale DCA Submittal and DSRS

- NUREG-0800, Section 13.6.2, “Physical Security – Design Certification” Revision 1 dated October 2010
  - Table 1 of SRP 13.6.2 lists 8 required physical security elements
  - Table 2 of SRP 13.6.2 lists 21 voluntary physical security elements
- NuScale considers the voluntary security elements identified in Table 2 to be applicable to COL applications and not within DCA scope.

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Summary

- NuScale has a security design team in place.
- The team is employing both deterministic and risk informed methods.
- The plant design has been informed by the team.
- Future design changes will be evaluated by the team.
- The NuScale facility will provide COLA applicant with the ability to develop an efficient and robust security plan.

Feedback and Next Steps

- Comments and questions on NuScale's process for security by design
- Agreement on regulatory guidance for DSRS
  - applicability to NuScale DCA
- Future topics or interactions needed to finalize DSRS or discuss NuScale progress