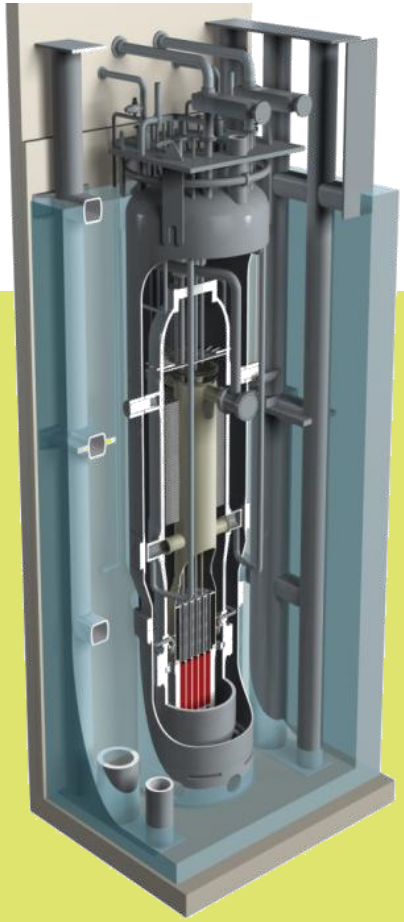


NuScale SMR Technology

UK IN SMR; SMR IN UK

Conference - Manchester, UK

Tom Mundy, EVP Program Development

September 25, 2014

NuScale Power™

Acknowledgement & Disclaimer

- "This material is based upon work supported by the Department of Energy under Award Number DE-NE0000633."

NuScale Power History

- NuScale first of current U.S. SMRs to begin design of commercial NPP
- NuScale technology in development and design since 2000 (DOE) MASLWR program
- Electrically-heated 1/3-scale integral test facility first operational in 2003
- Began NRC design certification (DC) pre-application project in April 2008
- Acquired by Fluor in October 2011
  - One of the world's leading publicly traded EPC, maintenance, and project management companies
- ~380 FTE's currently on project, ~$230MM spent project life-to-date
- 115 patents pending/granted, 17 countries

NuScale Engineering Offices Corvallis, Oregon

One-third scale Test Facility

NuScale Control Room Simulator

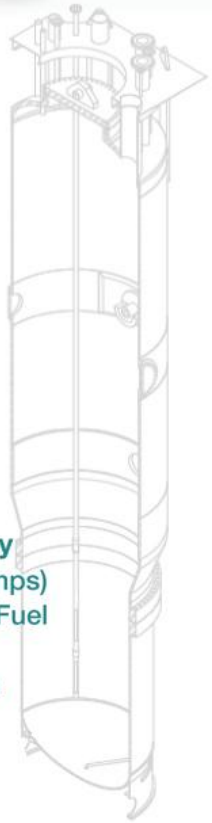
NuScale Power™

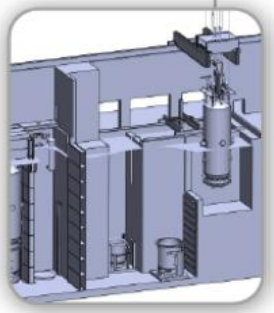
NuScale and DOE Complete Agreement

- Competition winner announced December 12, 2013
- DOE to provide $217M in funding
- Contract executed May 28, 2014
  - *PORTLAND, Ore. - NuScale Power announced today that it has finalized the cooperative agreement with the US Department of Energy (DOE) as an awardee under the program for "Cost-Shared Development of Innovative Small Modular Reactor Designs."*
- Funding to be used to perform the engineering and testing needed to proceed through the U.S. Nuclear Regulatory Commission Design Certification process

Plant Design Overview

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





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

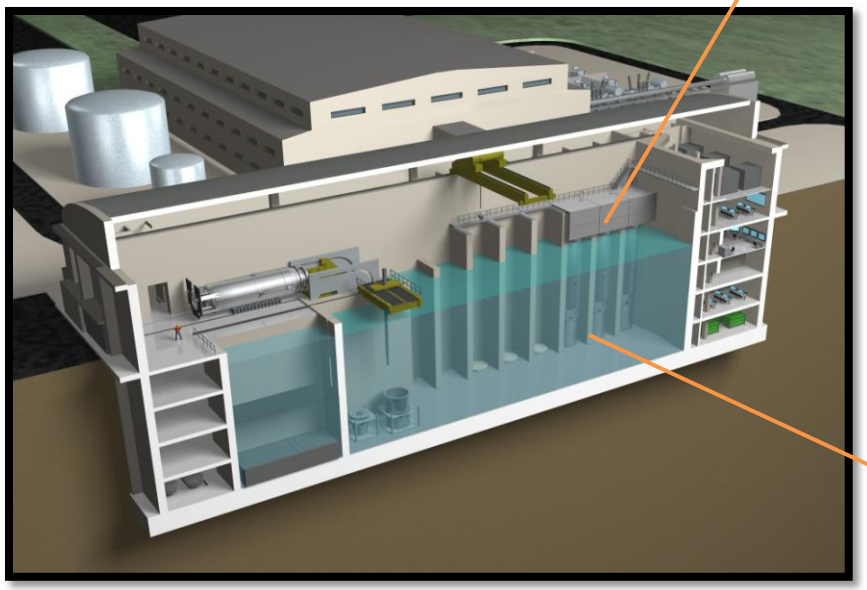
Each Module Installed in its own Isolated Bay

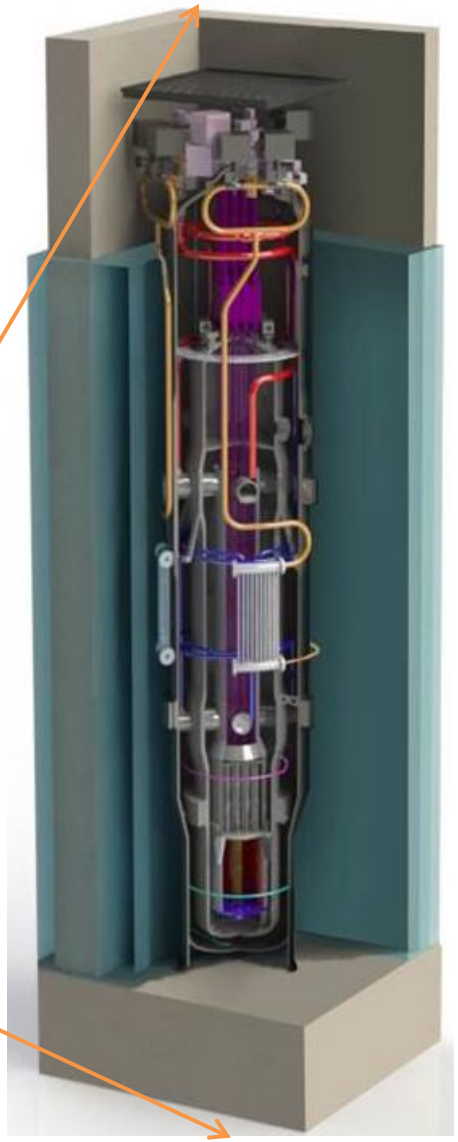
- Natural Circulation (No Reactor Coolant Pumps)
- 37 Standard 17x17 PWR Fuel (Half-Height) Fuel Assemblies
- Standard Magnetic Jack Control Rod Drives
- Internal Helical Coil Steam Generators and Pressurizer
- 50 MWe Gross Power

NuScale Power™

What is a NuScale Power Module?

- NuScale Power Module (NPM) (50 MWe)
  - Includes the reactor vessel, steam generators, pressurizer and containment in an integral package that eliminates reactor coolant pumps and large bore piping (no LB-LOCA)
  - Completely factory built for easy transport and installation
  - Each NPM has its own skid-mounted steam turbine-generator and condenser
- Each NPM is installed below-grade in a seismically robust, steel-lined, concrete pool
- NPMs can be incrementally added to match load growth - up to 12 NPMs for 570 MWe (net) total facility output





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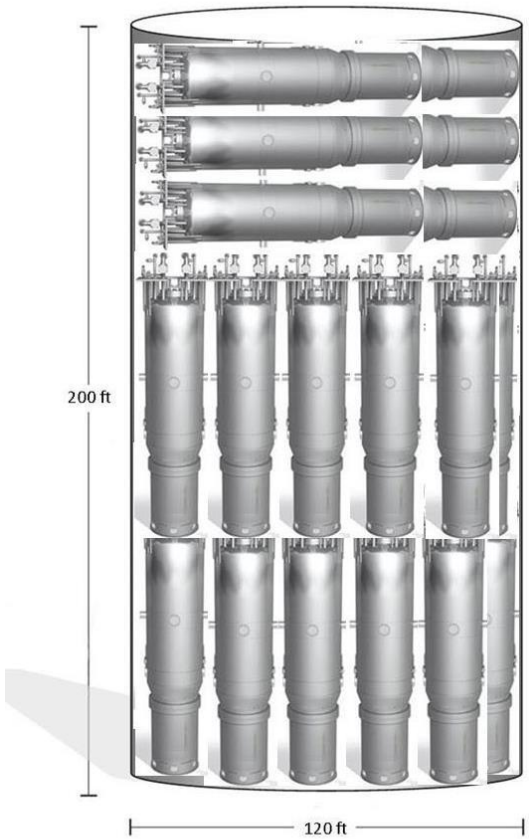
Size Comparison

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

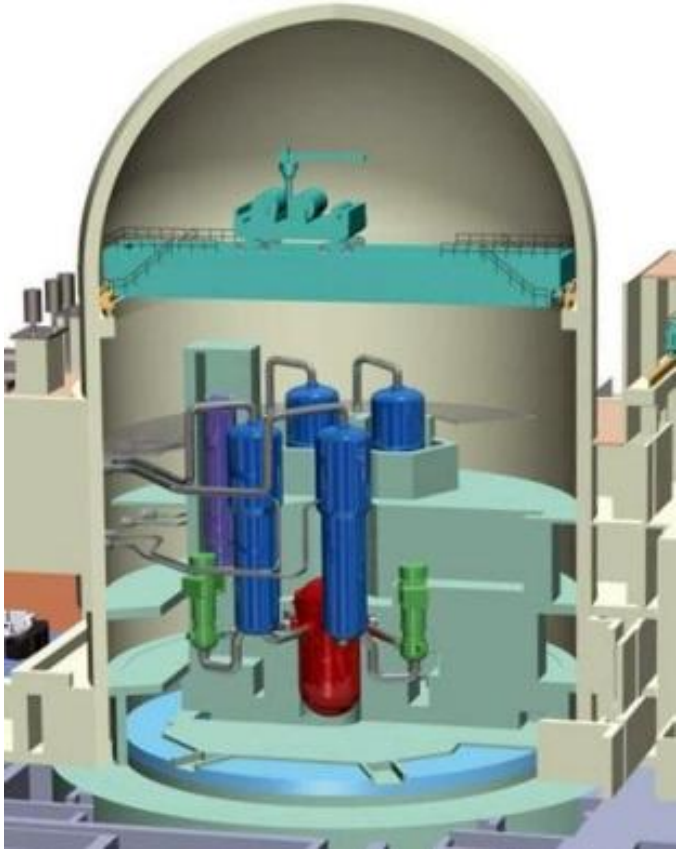
126 NuScale Power Modules



Containment

NuScale's combined containment vessel and reactor system

Typical Pressurized Water Reactor

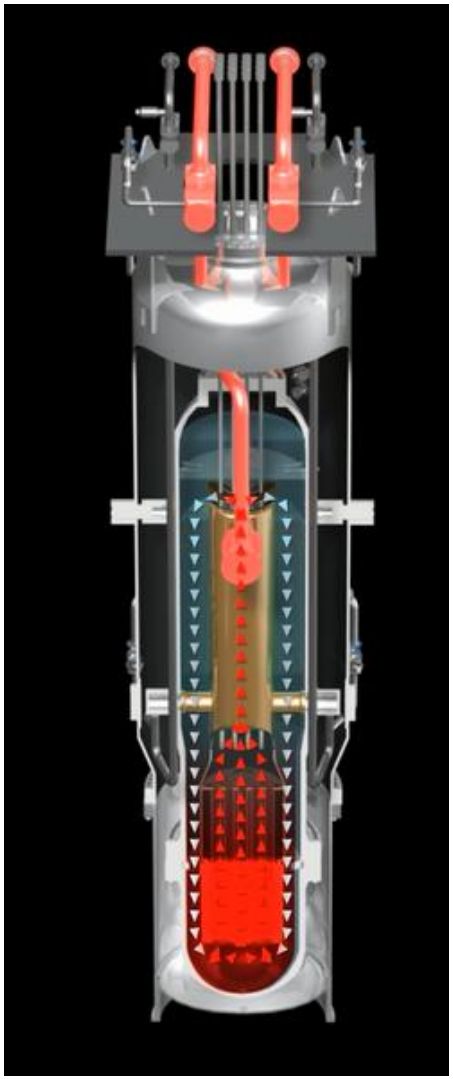


*Source: NRC

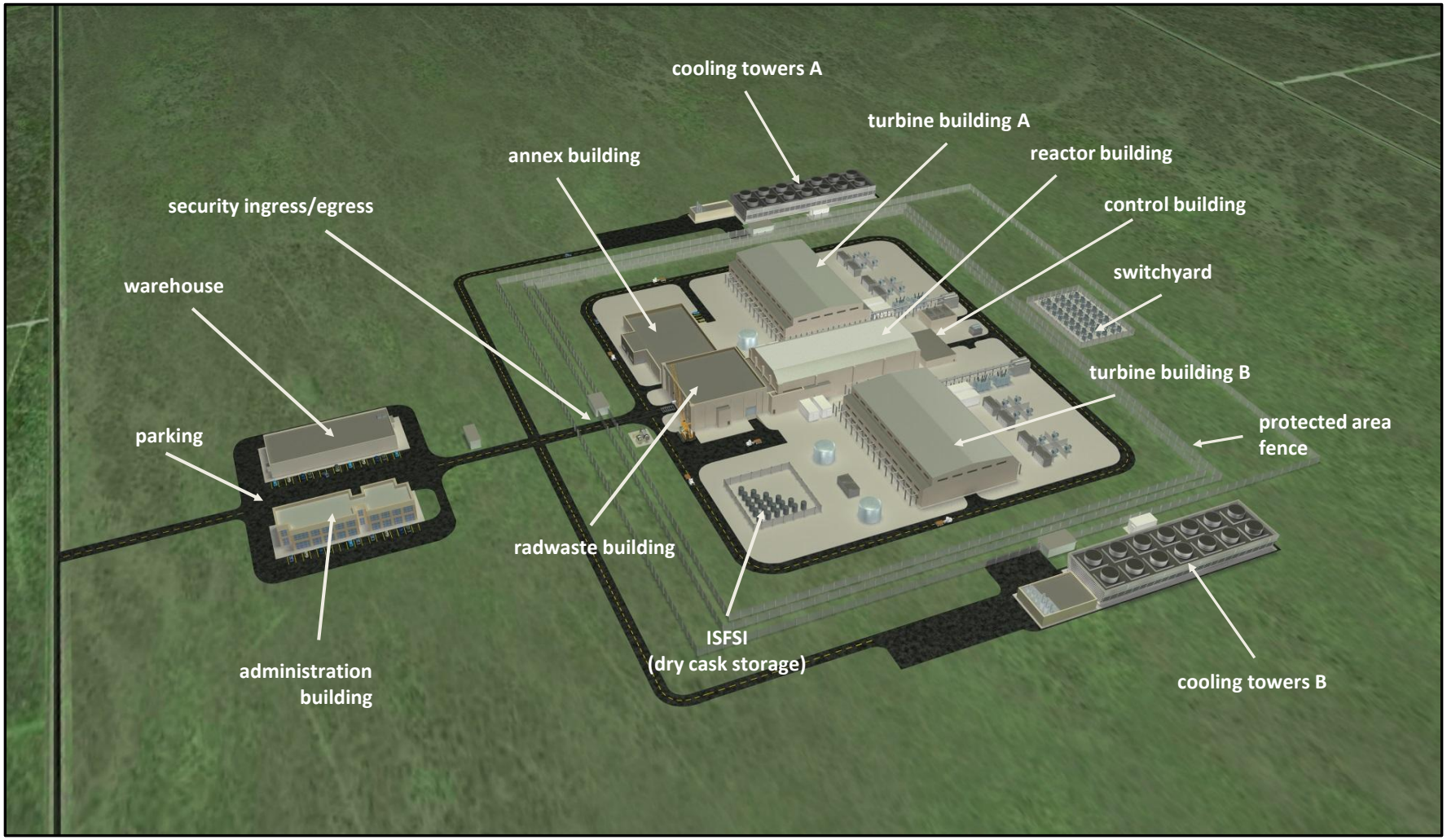
NuScale Power™

Natural Circulation Operation

- Integrated reactor vessel
  - Steam generator, pressurizer, fuel inside a single vessel
- Natural circulation flow
  - No reactor coolant pumps
  - No external power
- Helical coil steam generator
  - Designed to maximize thermal efficiency under low flow conditions



Site Aerial View



NuScale Power™

NuScale Announces Major Breakthrough in Safety

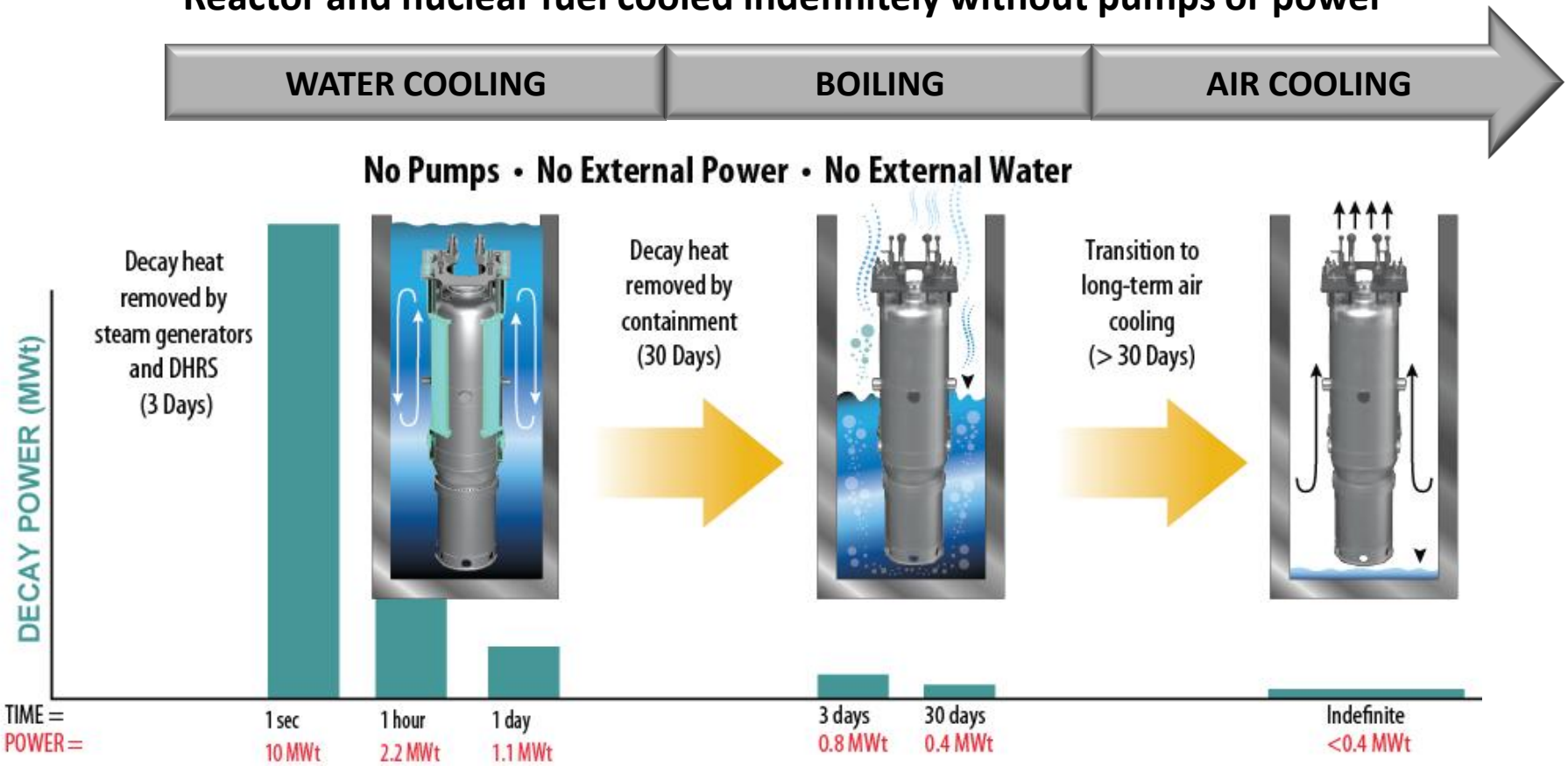
Wall Street Journal April 16, 2013

- NuScale design has achieved the "Triple Crown" for nuclear plant safety. The plant can safely shut-down and self-cool, indefinitely, with:
  - **No Operator Action**
  - **No AC or DC Power**
  - **No Additional Water**
- Safety valves align in their safest configuration on loss of all plant power
- Details of the Alternate System Fail-safe concept were presented to the NRC in December 2012

NuScale Power™

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*

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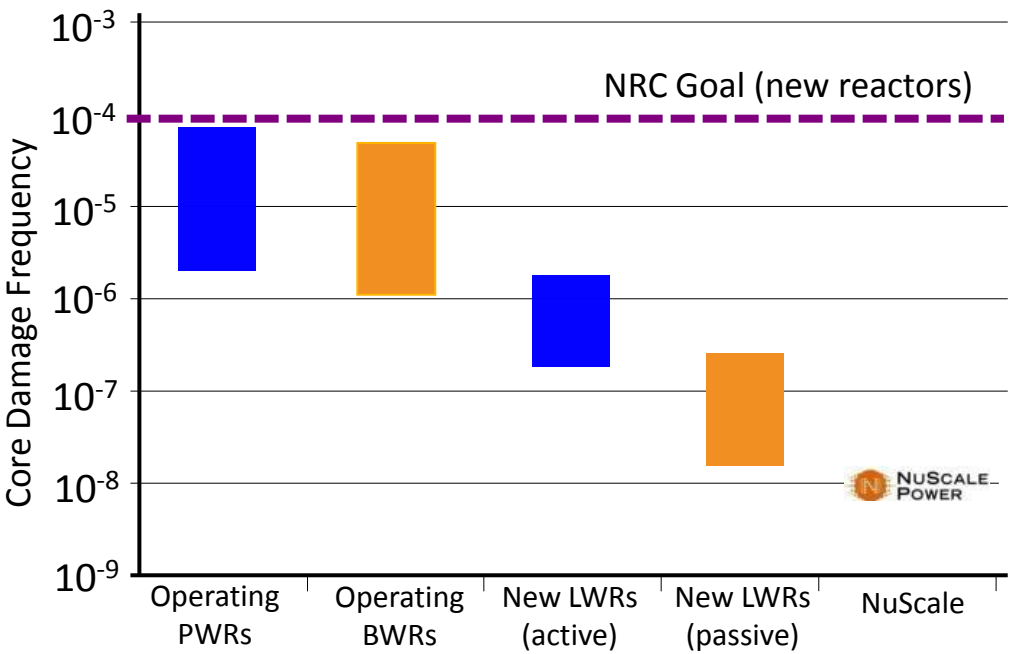
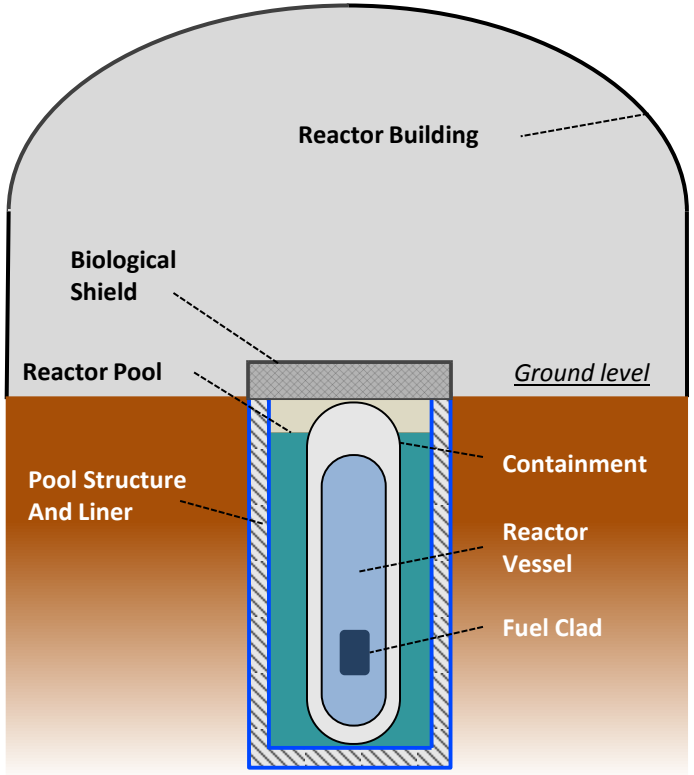
Reducing Plant Risk

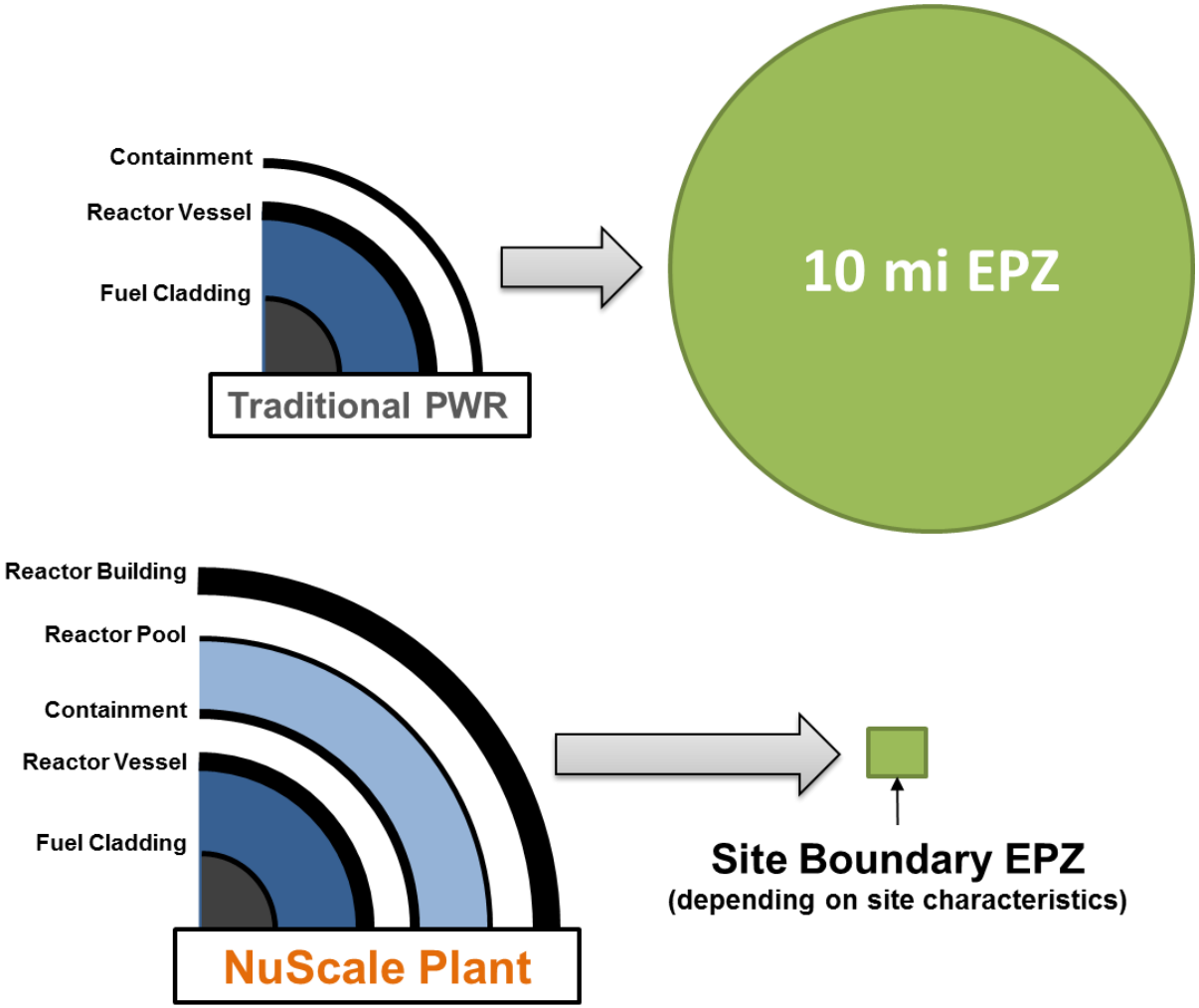
Risk = (frequency of failure) X (consequences)





*Probability of core damage due to NuScale reactor equipment failures is **1 in 100,000,000 years***

Smaller Emergency Planning Zone



- *Passive Safety*
- *Additional Fission Product Barriers*
- *Significant Delay in Release of Fission Products*

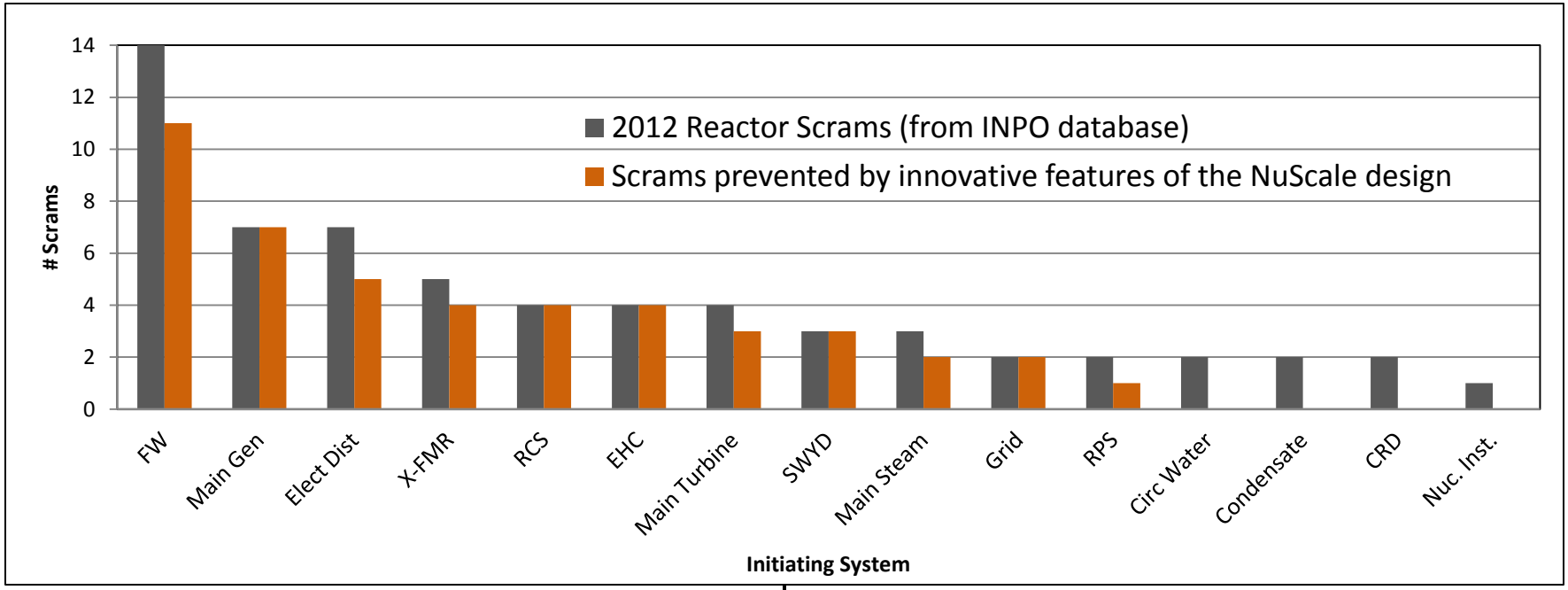
NuScale Power™

Simplicity - NuScale Safety Systems

Systems and Components Needed to Protect the Core:

- Reactor Pressure Vessel
- Containment Vessel
- Reactor Coolant System
- Decay Heat Removal System
- Emergency Core Cooling System
- Control Rod Drive System
- Containment Isolation System
- Ultimate Heat Sink
- Residual Heat Removal System
- Safety Injection System
- Refueling Water Storage Tank
- Condensate Storage Tank
- Auxiliary Feedwater System
- Emergency Service Water System
- Hydrogen Recombiner or Ignition System
- Containment Spray System
- Reactor Coolant Pumps
- Safety Related Electrical Distribution Systems
- Alternative Off-Site Power
- Emergency Diesel Generators
- Safety Related 1E Battery System
- Anticipated Transient without Scram (ATWS) System

Fewer Systems, 73% Fewer SCRAMS



58% of events caused by power conversion systems

86% of power conversion related scrams prevented by NuScale design

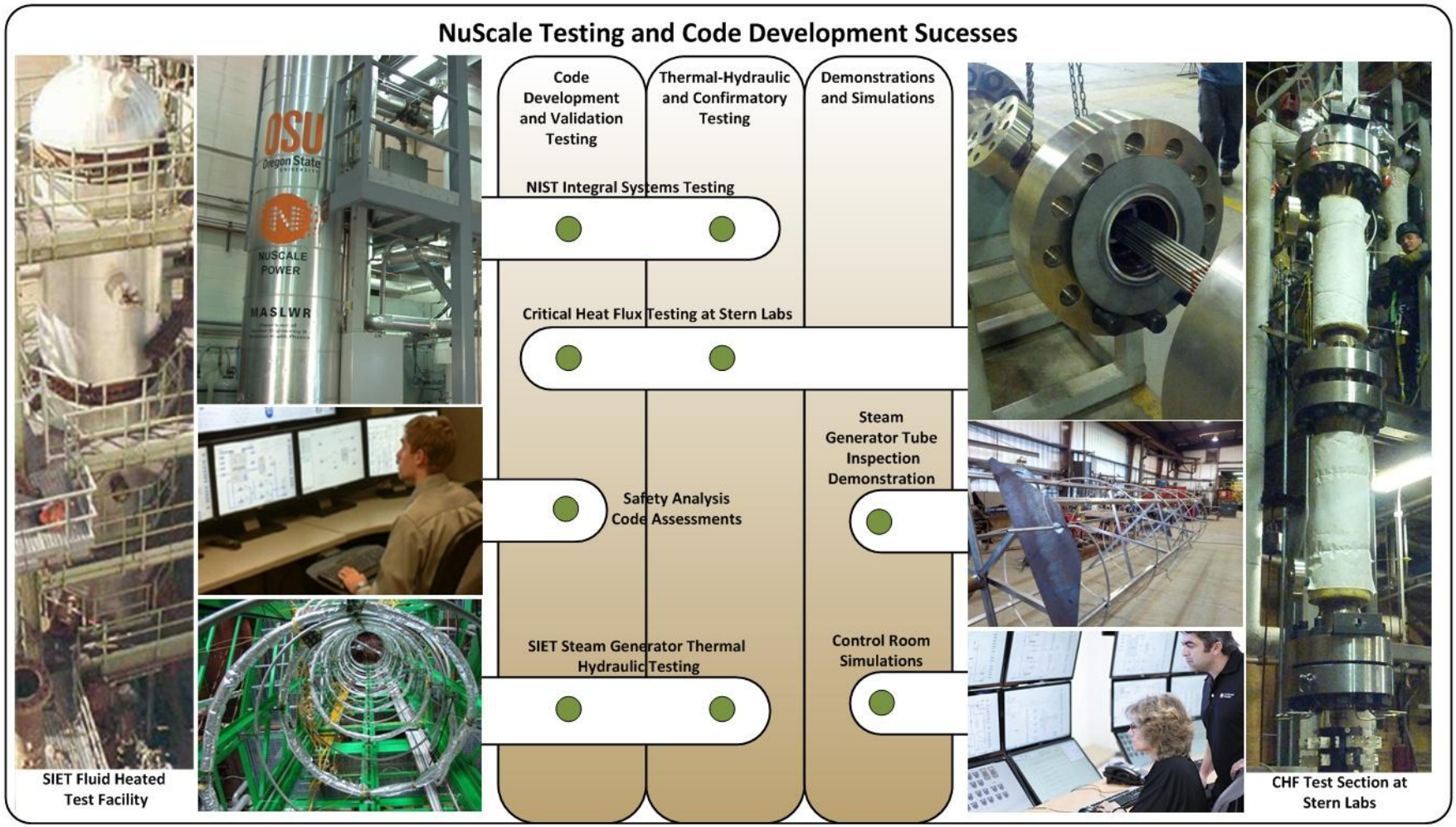
27% of events caused by electrical distribution system

82% of electrical related scrams prevented by NuScale design

NuScale Power™

Comprehensive Testing Program

- NuScale's testing supports reactor safety code development and validation, reactor design, and technology maturation to reduce first-of-a-kind risk



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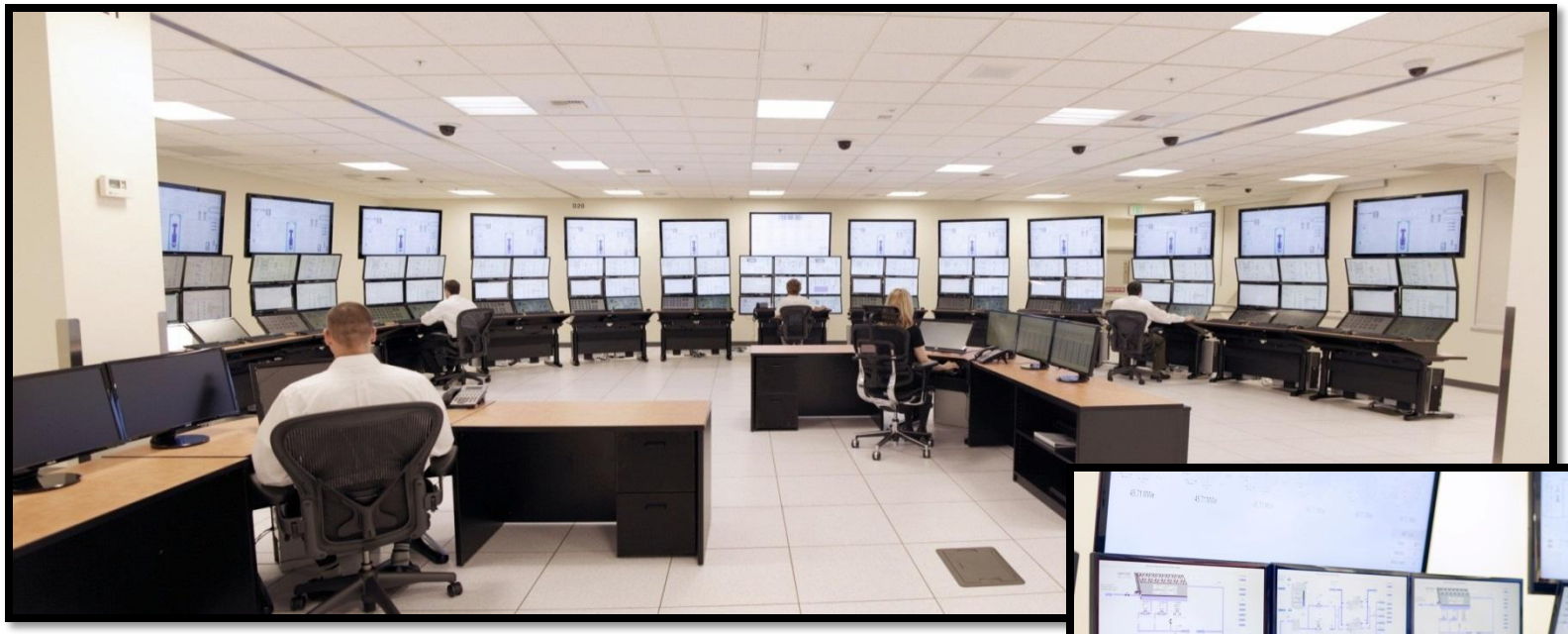
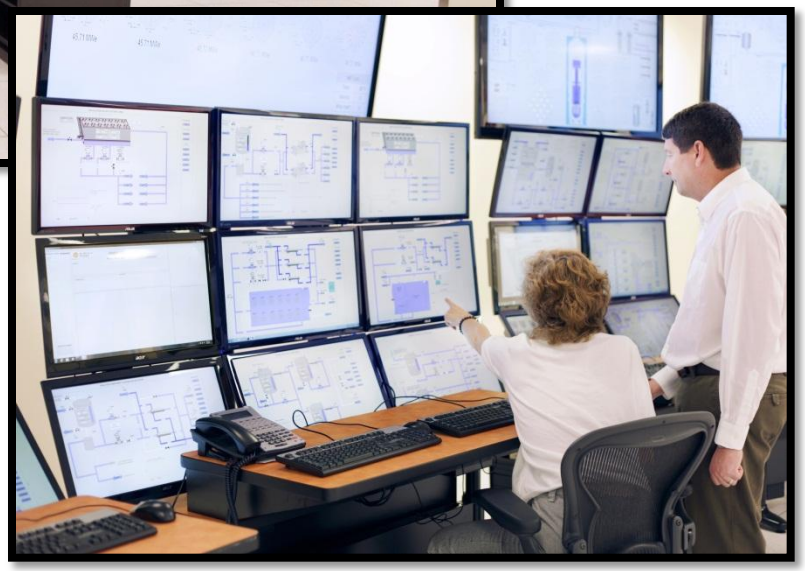
Full-Scale Main Control Room

- NRC Review of HFE Program and site visit Jan.'13



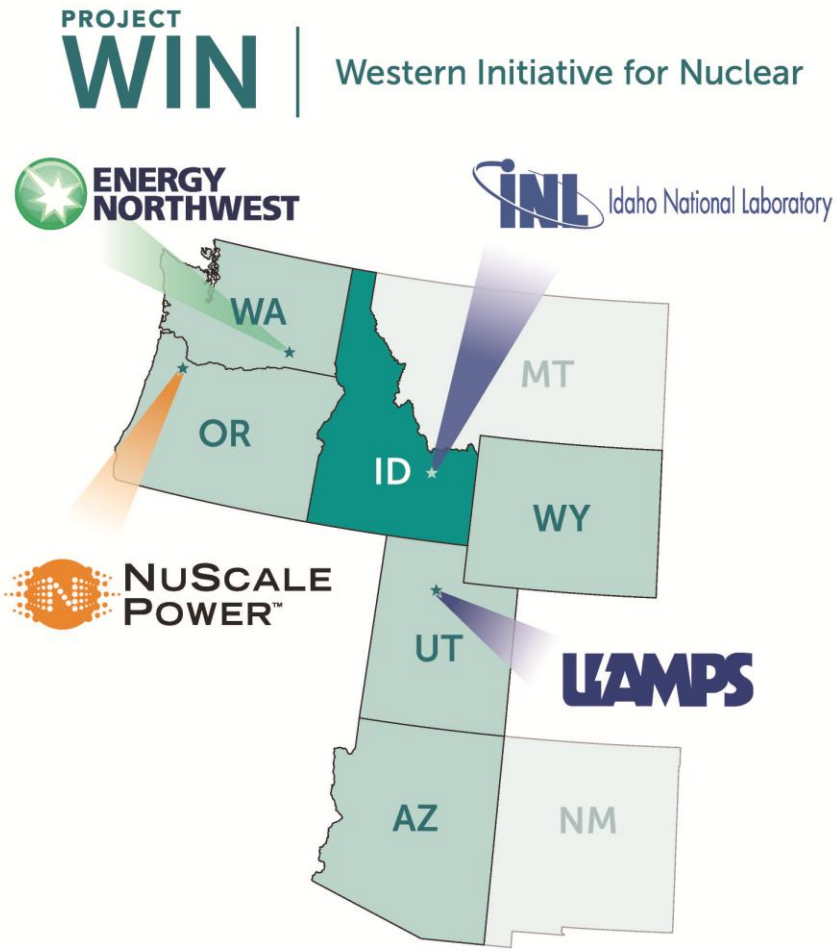


- Simulator used for HFE and operational program development

NuScale Power™

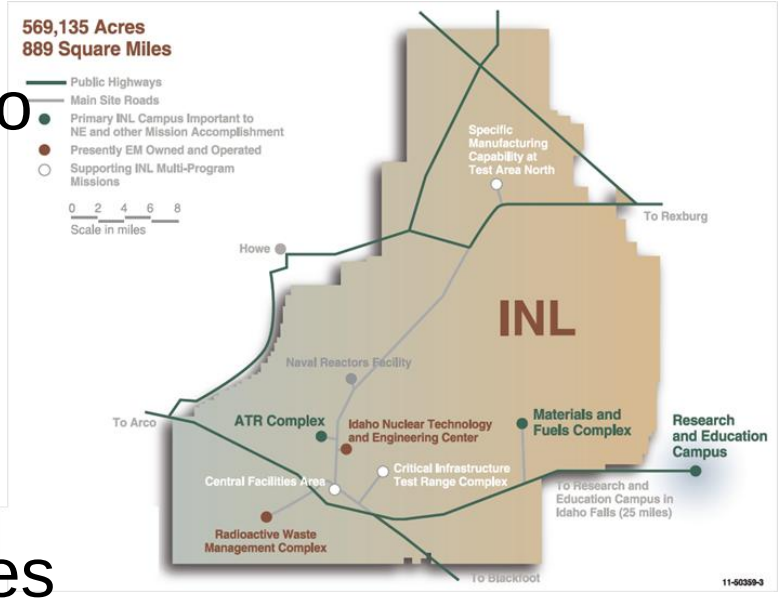
First Deployment: Project WIN

- "Western Initiative for Nuclear" (WIN) is a multi-western state collaboration to deploy NuScale technology
- First deployment state - Idaho
- Project participants:
  - NuScale
  - UAMPS,
  - Energy Northwest
  - States of: ID, UT, OR, WA, WY, AZ
  - Potential support from NM, MT

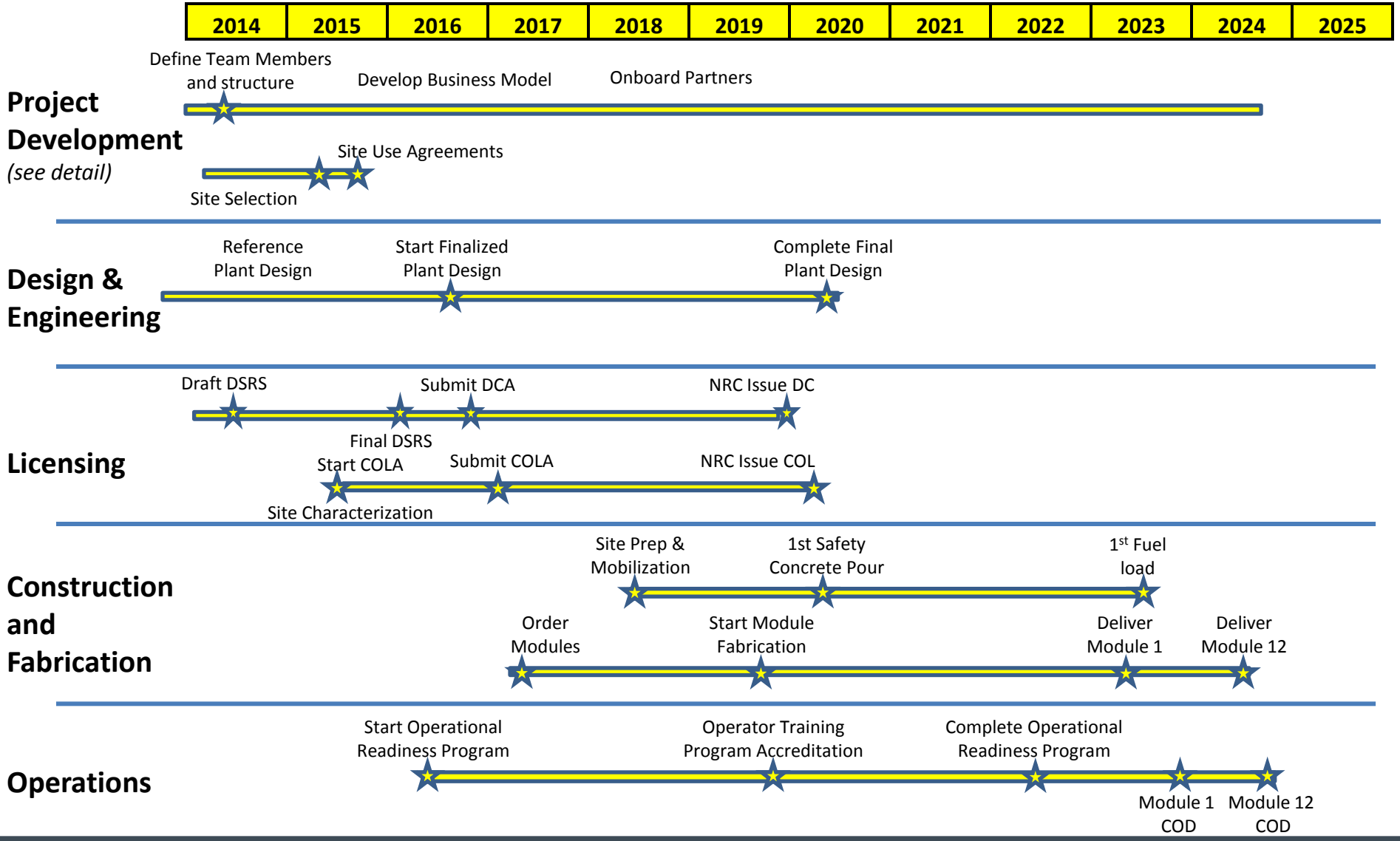


Project WIN Details

- First commercial project: Preferred location within the Idaho National Laboratory (INL) Site
- Commercial operation - 2023
- Reference Plant
  - 12-module facility (570 MWe)
- Will provide immediate advantages to the Western region:
  - Provide clean, affordable energy and professional jobs
  - Demonstrate the operations and benefits of this SMR technology
  - Catalyst for subsequent SMR energy facilities throughout the Western states



Overall WIN Project Schedule



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