



# NAYGN Webinar: Westinghouse Small Modular Reactor Program



**Presented by Emily Tavrides and Alex Harkness**

# Safety Brief

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# Webinar Overview

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- Why do we need Small Modular Reactors (SMRs)?
  - Original Need vs. Current Need
  - Benefits
  - Market and Competitive Landscape
- Westinghouse SMR
  - Design and Technology
  - Layout
  - Modularity
- Westinghouse SMR Program
  - Program Overview
  - Current Activities
- Questions and Answers

# Original Need for Small Reactors

- USS Nautilus
  - U.S. Navy submarine
  - Launched in 1954
  - Designed by Westinghouse Electric Company
- ~140 ships are powered by small reactors, and more than 12,000 reactor years of marine operation has been accumulated
- Most original small reactors are submarines, but they range from icebreakers to aircraft carriers
- With small, underwater nuclear reactors, submarines did not need to resurface for fuel

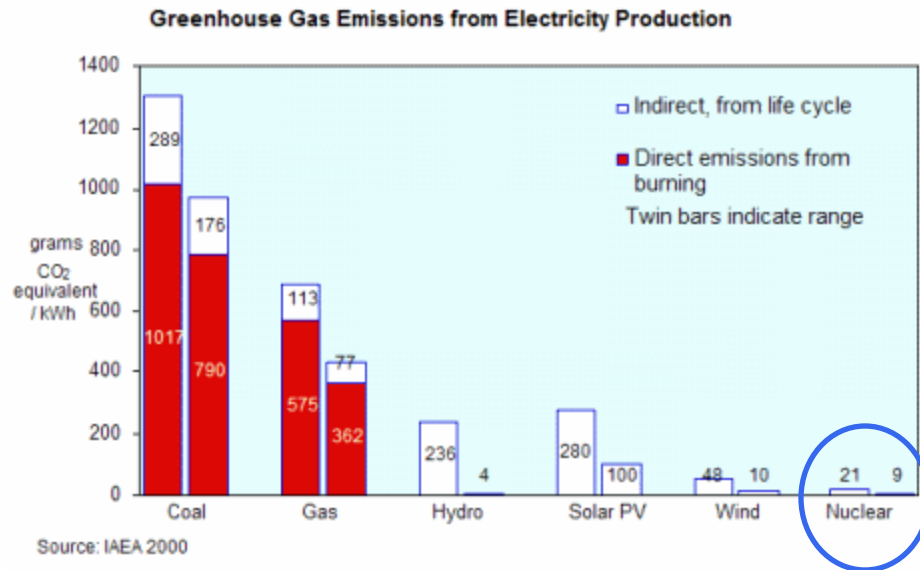


Official U.S. Navy Photograph



# Current Need for Nuclear Energy, including SMRs

## Small Greenhouse Gas Footprint



## Scalable Electricity



Source: [www.world-nuclear.org](http://www.world-nuclear.org)

# Economic Benefits of SMRs

## Ease of Licensing

- Shift from active to passive safety systems
- Smaller source term
- Integral on-site used fuel management

## Ease of Financing

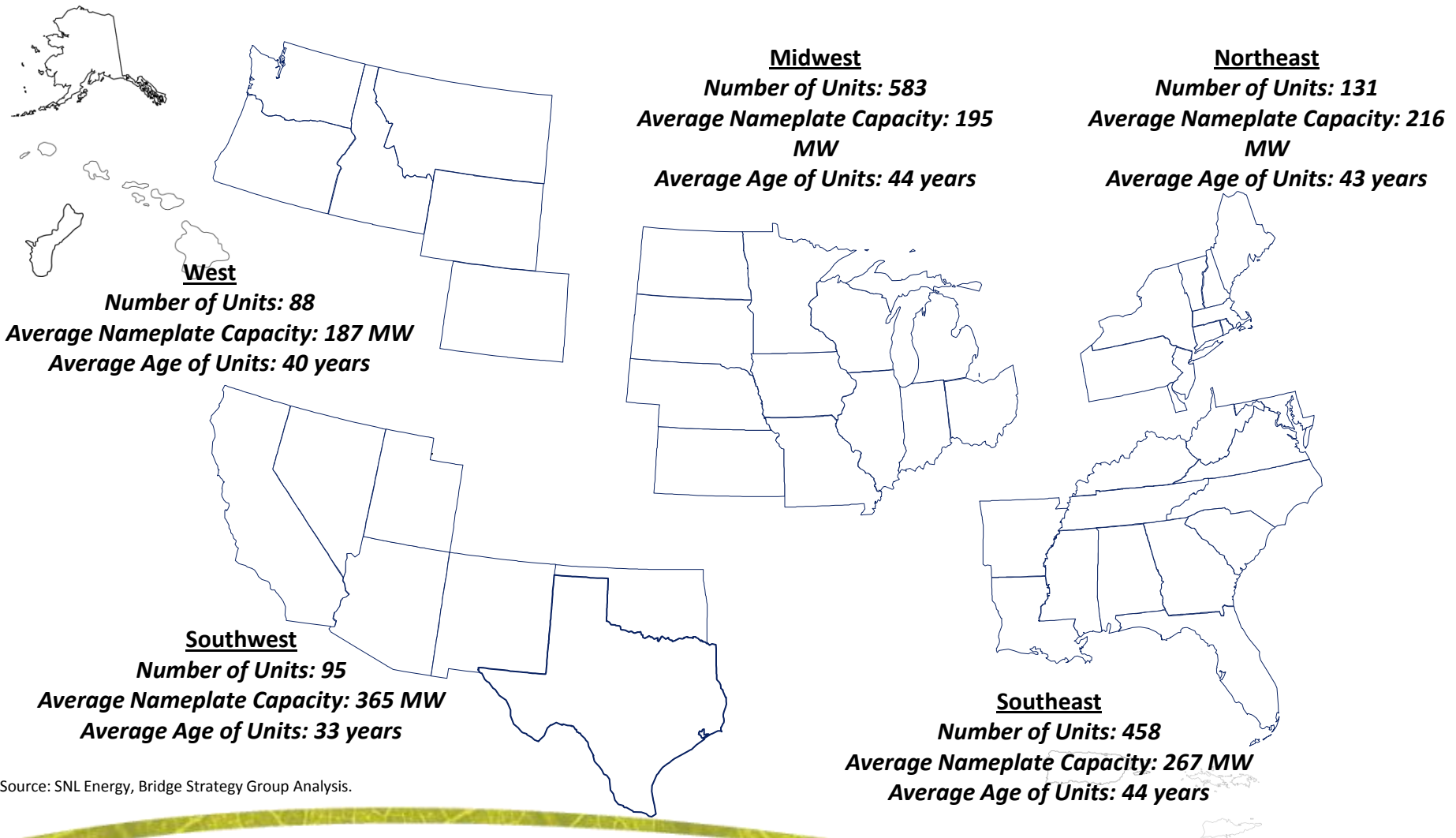
- Smaller capital cost
- Shorter development time to first revenue
- Lower project costs

## Ease of Deployment

- Simplified on-site assembly
- Shorter deployment times
- Better matching to electricity demand

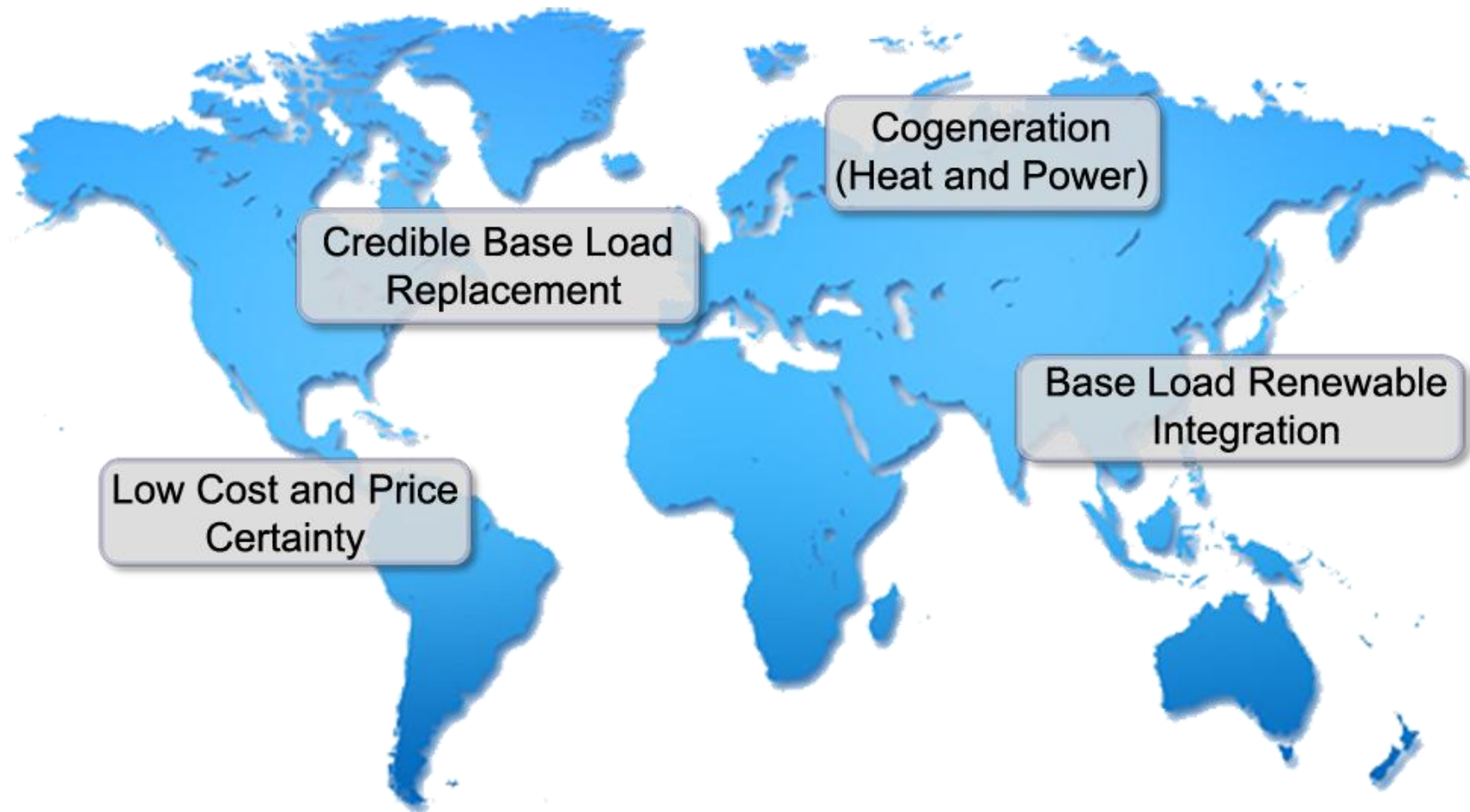
**SMRs have the potential to be an attractive economic option... but it will take a joining of the industry beyond vendor companies to include regulators and customers in order to achieve a plant that can be standardized and factory-built**

# Baseload Energy – U.S. Coal Example



Source: SNL Energy, Bridge Strategy Group Analysis.

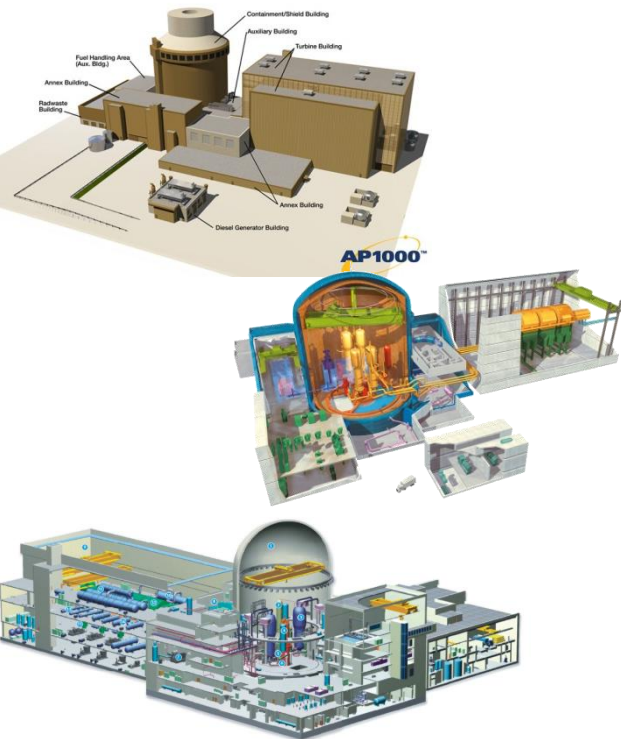
# SMR Global Market Perspective



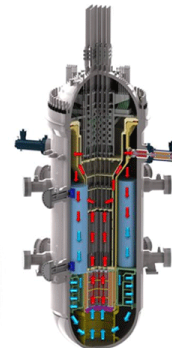


# Competitive Landscape

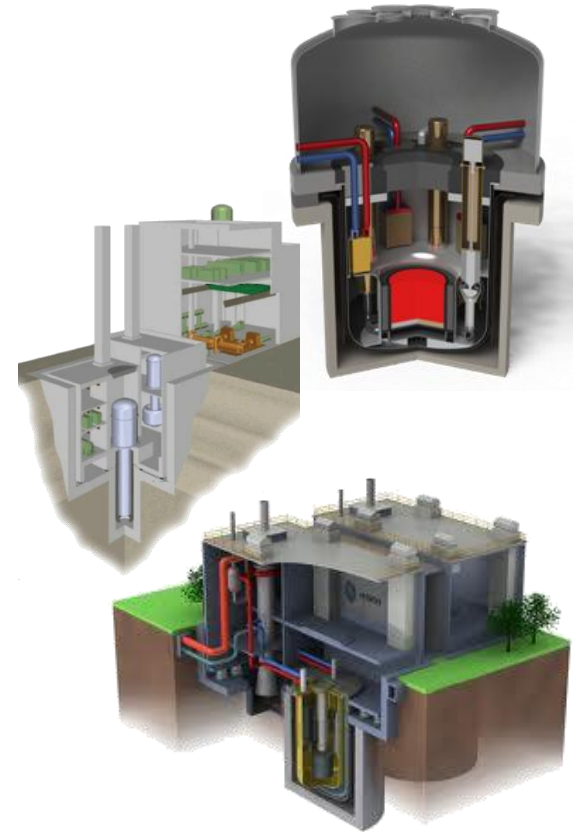
## Commercially Deployable



## LWR SMR



## Exotics



Today

2020

2030

# The Westinghouse Vision

***Westinghouse will be the first to deploy a safe, economic SMR to meet the many needs of existing and new to nuclear customers***

- **Working within constraints**
  - Land, grid, cooling water, financing, distributed service territory
- **Offering clean energy**
  - Offset owner costs for infrastructure development: land, cooling, T&D
  - Generation diversity
  - Operational flexibility
- **Providing project certainty**
  - Reduced licensing risk
  - Short-construction duration
  - Cost predictability and certainty



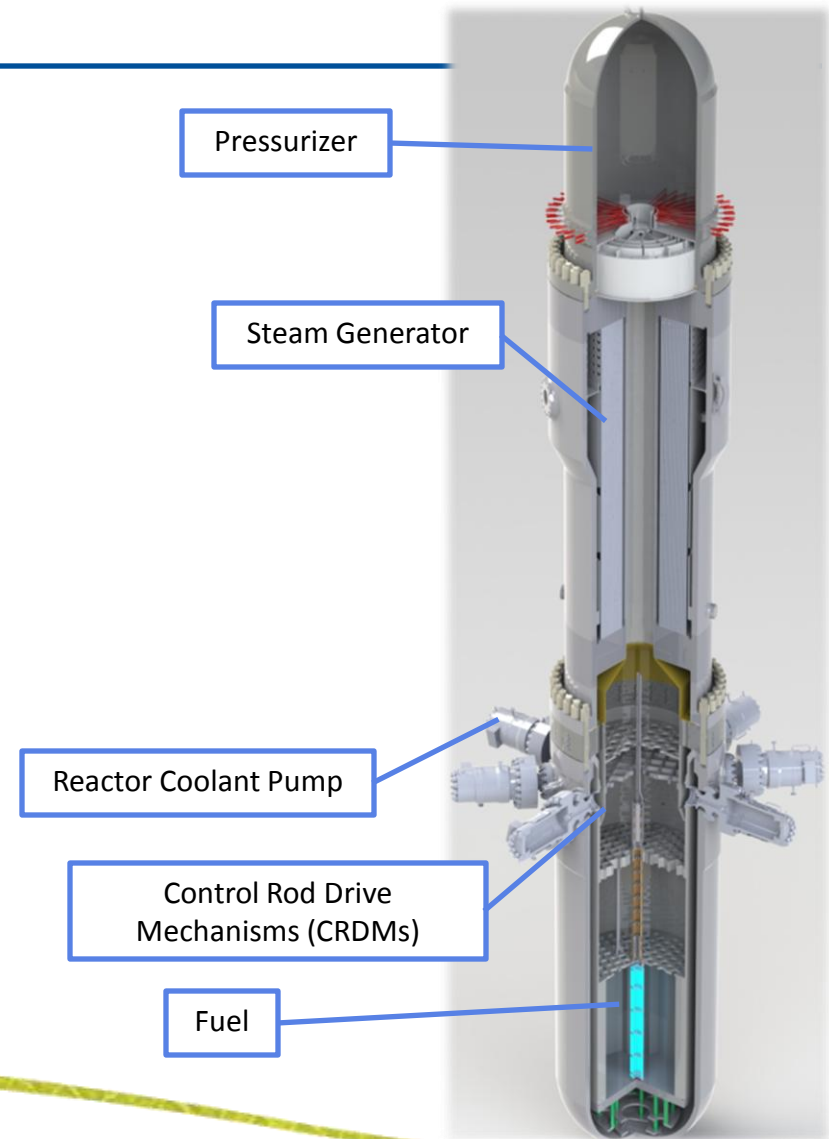
***New applications for nuclear...***

*Aging Fossil Plants  
District Heating  
Remote Markets  
Small Grid Markets  
Desalination  
Process Heat*

# What is the Westinghouse SMR?

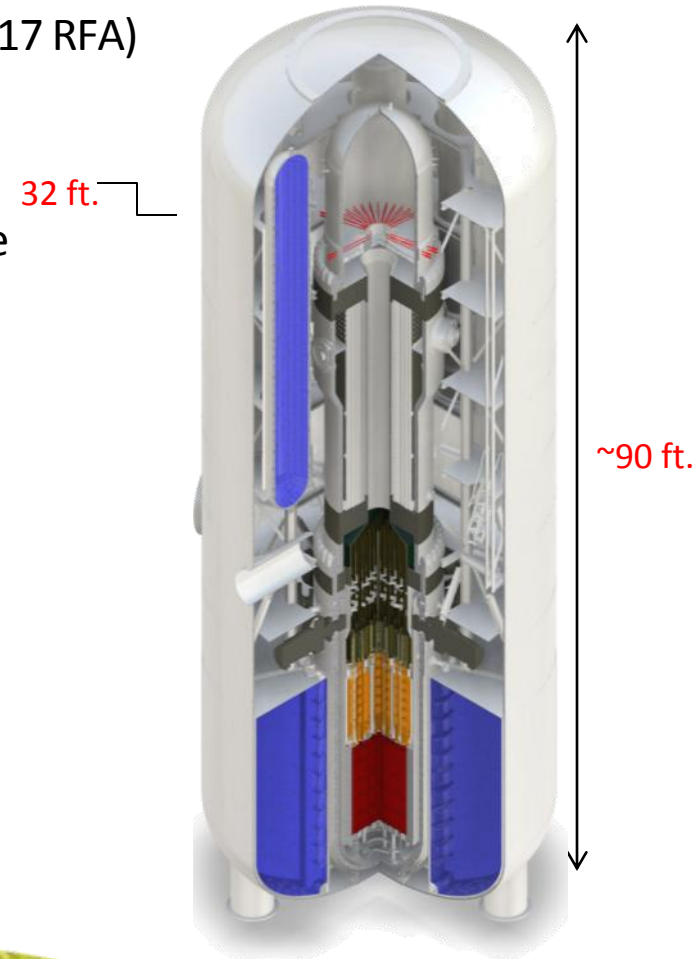
- An integral pressurized water reactor—single >225 MWe reactor
- Innovative packaging of proven components
- The highest levels of safety with fewer accident scenarios
- Industry-proven system designs
- Compact reactor coolant system and containment
- An engineered solution for today's clean energy challenges

**The most power, with the least amount of material**



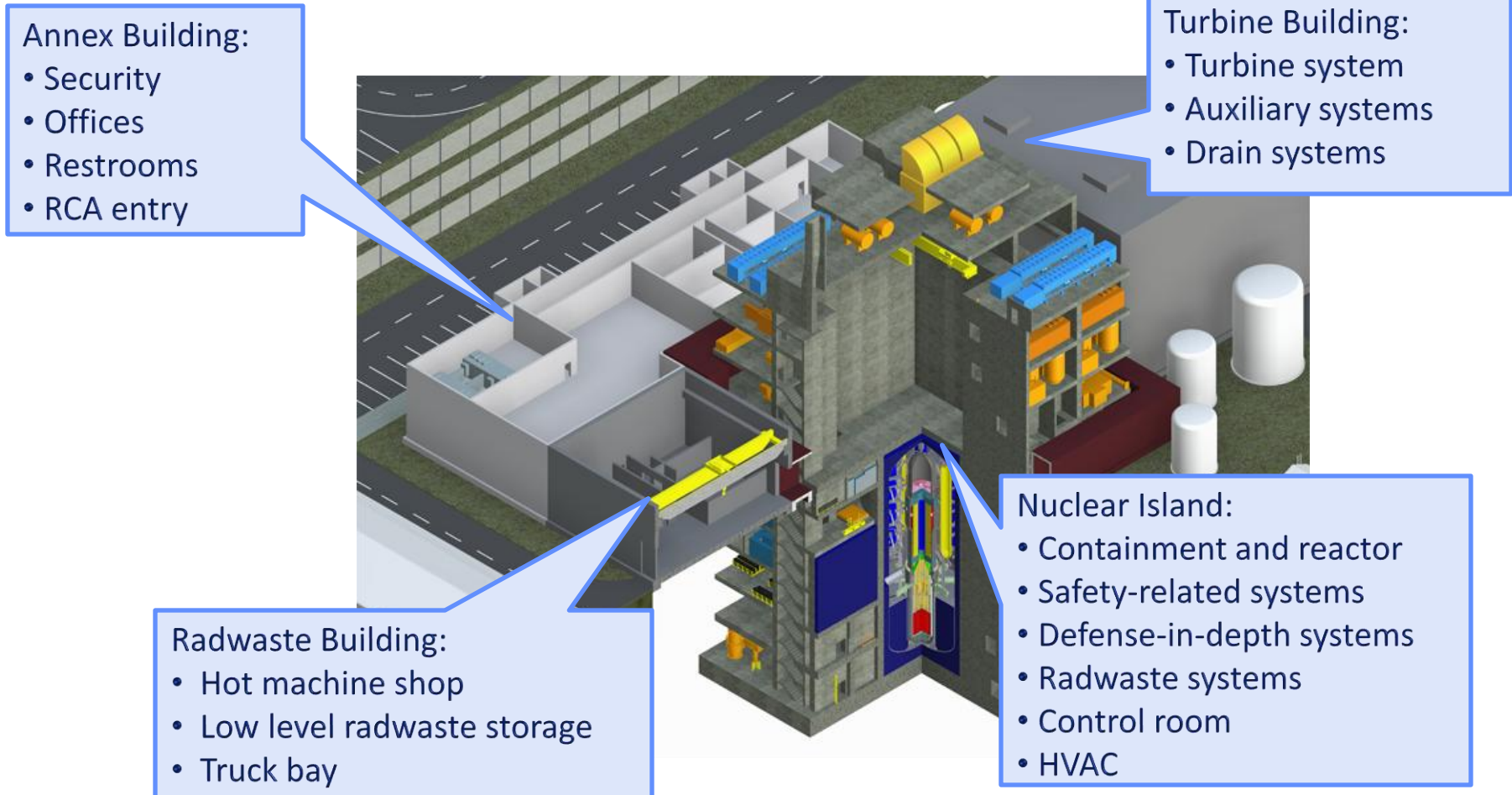
# Westinghouse Plant Design

- Single reactor site (standalone)
- Fuel – Modification of standard Westinghouse product (17x17 RFA)
- Forced flow with 8 reactor coolant pumps
- Internal control rod drive mechanisms
- Compact/high pressure containment vessel below grade
- Recirculating straight tube steam generator with steam drum location outside containment vessel
- Nuclear Island is 110'x110'
- Embedment is 105' deep
- 24-month cycle length
- Load follow capability
- Total site area: ~15 acres
- Instrumentation and Control:  
Ovation®-based Digital Control System



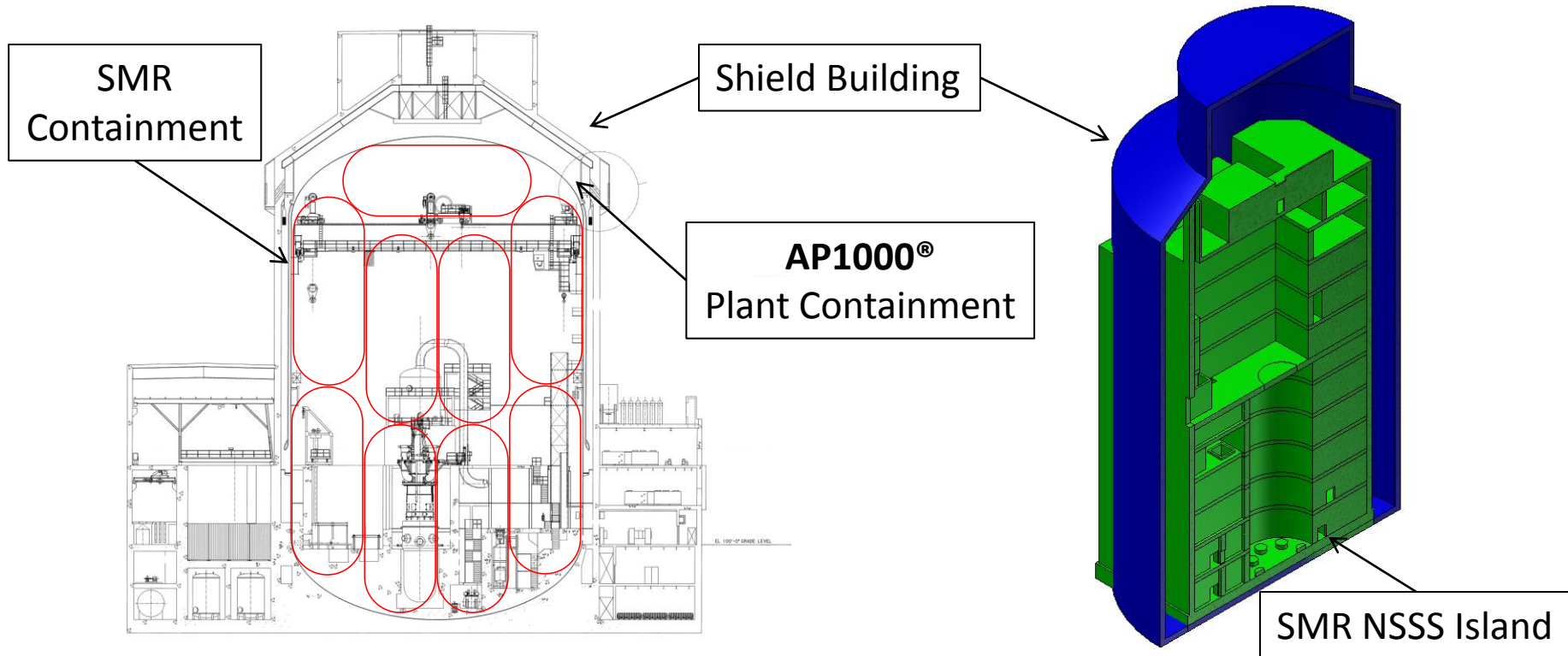


# SMR Plant Layout





# How Small is Small?



**25 Westinghouse SMR containment vessels fit in a single AP1000 plant containment vessel**

**Westinghouse SMR NSSS island fits in the AP1000 plant shield building**

# SMR Safety Overview

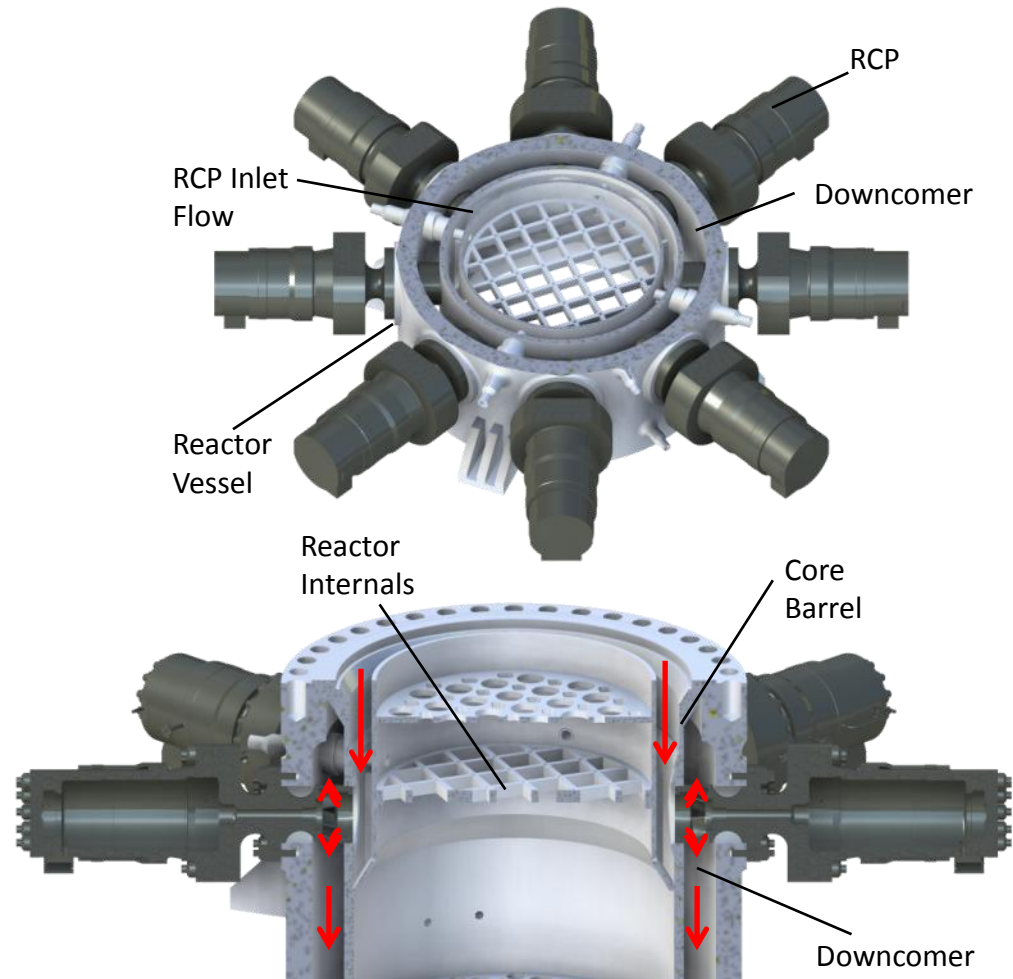
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- **7 Days of Passive Heat Removal with Onsite Inventory**
  - Capability to add additional inventory to UHS tanks for indefinite cooling
- **100% reliance on natural forces**
  - Evaporation, condensation, gravity

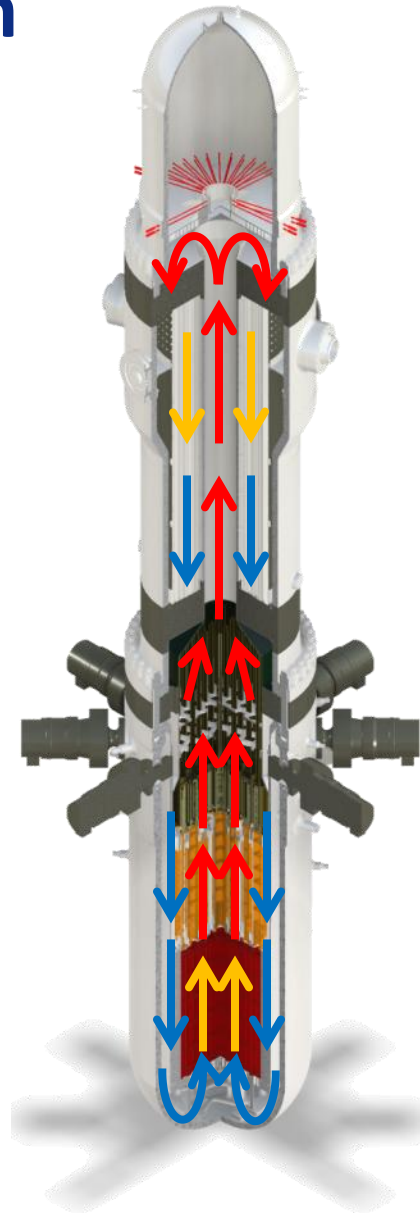


# Reactor Coolant Pumps Overview

- Seal-less pump design
- Driven with variable frequency drives (VFD)
- Mounted horizontally to reactor vessel below closure flange
- Internally circulating reactor coolant removes pump heat via heat exchanger to plant component cooling water system

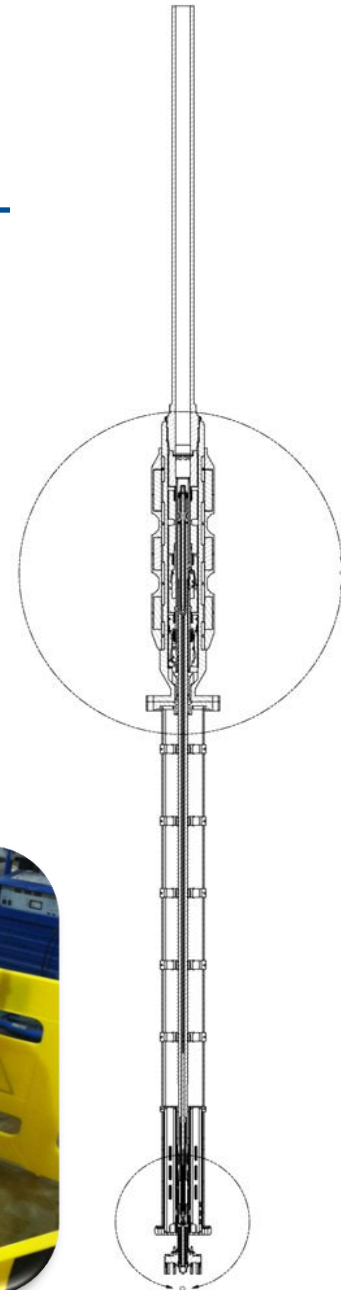


# Coolant Flow Path



# Internal CRDM Design

- Latch assemblies, controls, and interfaces with fuel are all based on existing, proven designs
- Three-coil magnetic jack based **AP1000** plant design with modifications
  - *High-temperature* coil winding design
  - Sealed, stainless steel coil stack housing
  - Sealed power conduit with leak detection
- Testing program under way

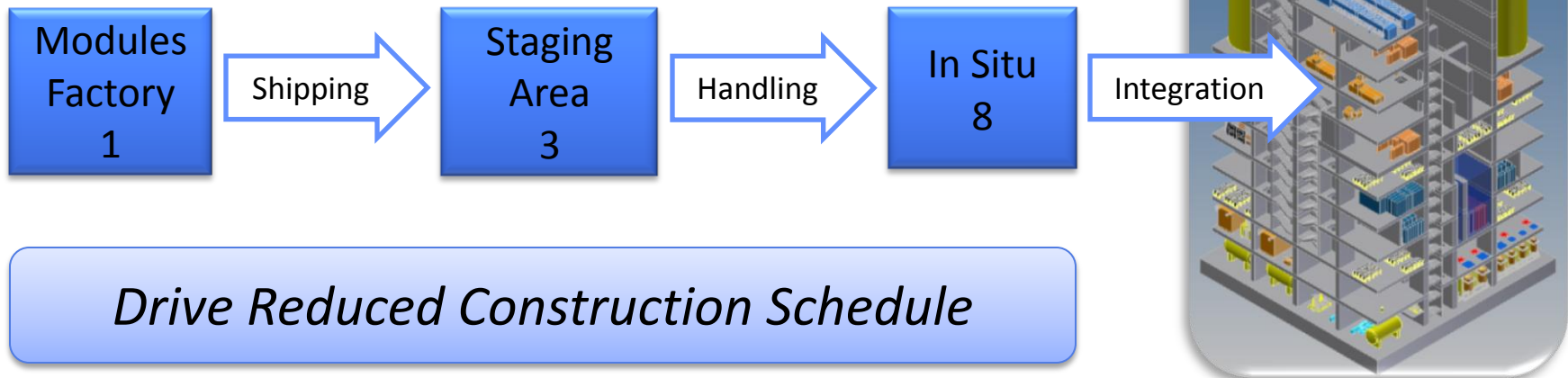




# Modular Design Goal:

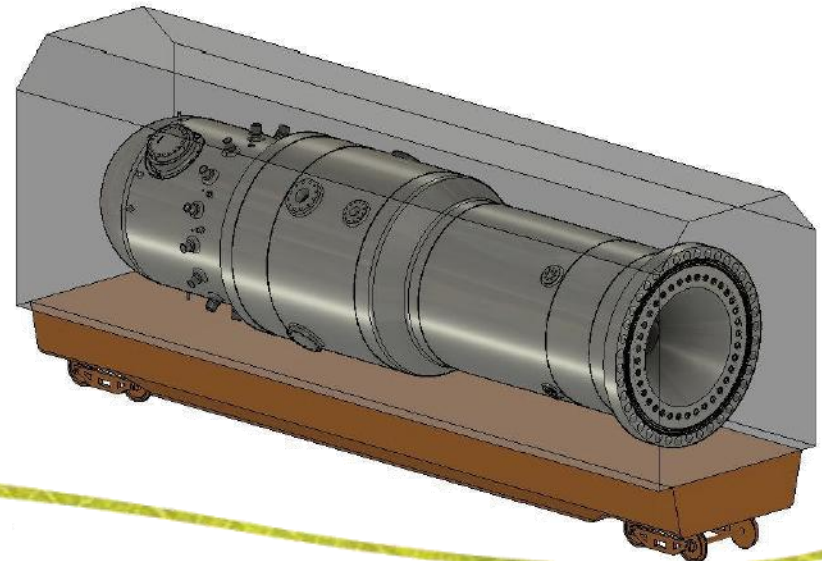
## Increase Factory Fabrication and Reduce Schedule

- Target for SMR is to have 90% modularity (**AP1000** plant is approximately 30% modularized)
- Use industry best practices for modularity
  - Shipbuilding and airline industry benchmarks
  - Modularization 1:3:8 rule



# Modular Construction

- Traditional large scale reactor economies of scale can be countered through application of modular construction techniques
- SMR maximizes modular design in all aspects of plant
- Modular design drives work normally completed at the construction site to the factory where quality is increased and overall cost are reduced
- Modules are designed for road and rail transport to site and scalable to other forms of transport



# Modular Construction



- SMR uses the **AP1000** plant licensed modular wall and joint design
- All SMR structures, systems and components are considered for modular assembly
- On-site assembly of larger modules will reduce work in the hole
- Outfitted modules enable early testing before installation
- Modular construction reduces the onsite construction time and resources
- Modular construction is critical to the success of SMR

# Westinghouse SMR Program Team

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- Westinghouse is the only SMR vendor with a dedicated customer, Ameren Missouri
  - Callaway site in Missouri to be the site of the first Westinghouse SMR
- Ameren Missouri and Westinghouse formed the NexStart Alliance
  - NexStart Alliance design reviews have involved customers early in the design phase
- Westinghouse has teamed up with universities
  - Missouri System
  - Carnegie Mellon University, University of Pittsburgh
  - National Labs; ANL, Idaho National Lab, Oak Ridge
- Burns and McDonnell will have engineers working alongside Westinghouse engineers in Spring 2013

# NexStart SMR Alliance



- Multiple seriously interested customers and suppliers
- NexStart SMR Alliance **will ensure that a license moves forward**





# SMR Websites and Recent Articles

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- [Official Westinghouse SMR Website](#)
- [Nuclear Energy Institute \(NEI\) Web Page on Small Reactors](#)
- [EnergyBiz Magazine - "Going Modular: The Promise and Untapped Markets"](#)  
(by Dr. Kate Jackson, Westinghouse Chief Technology Officer & SVP, Research & Technology)
- [NexStart Alliance Website](#)
- [Ameren Missouri Website](#)
- [Modern Power Systems - BRICS Edition Article - "Small, but perfectly formed"](#)  
(interview with Dr. Kate Jackson)

# Questions?

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