Safety Brief
Webinar Overview

- 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
Current Need for Nuclear Energy, including SMRs

Small Greenhouse Gas Footprint                Scalable Electricity

Source: 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

West
Number of Units: 88
Average Nameplate Capacity: 187 MW
Average Age of Units: 40 years

Midwest
Number of Units: 583
Average Nameplate Capacity: 195 MW
Average Age of Units: 44 years

Northeast
Number of Units: 131
Average Nameplate Capacity: 216 MW
Average Age of Units: 43 years

Southwest
Number of Units: 95
Average Nameplate Capacity: 365 MW
Average Age of Units: 33 years

Southeast
Number of Units: 458
Average Nameplate Capacity: 267 MW
Average Age of Units: 44 years

SMR Global Market Perspective

- Cogeneration (Heat and Power)
- Credible Base Load Replacement
- Base Load Renewable Integration
- Low Cost and Price Certainty
Competitive Landscape

Commerically 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

~90 ft.
32 ft.
SMR Plant Layout

Annex Building:
- Security
- Offices
- Restrooms
- RCA entry

Turbine Building:
- Turbine system
- Auxiliary systems
- Drain systems

Radwaste Building:
- Hot machine shop
- Low level radwaste storage
- Truck bay

Nuclear Island:
- Containment and reactor
- Safety-related systems
- Defense-in-depth systems
- Radwaste systems
- Control room
- HVAC
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

• **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
Reactors 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

Drive Reduced Construction Schedule
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

- 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

• **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)

Feel free to email with any questions: tavridel@westinghouse.com
Questions?
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