Westinghouse SMR & Nuclear Fuel Overview

Carlos Leipner, Westinghouse VP Latin America
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Market Drivers for Nuclear & SMRs

The energy industry demands versatility

The Westinghouse SMR delivers:

- A replacement for aging fossil fuel plants
- A solution for the needs of small utilities
- A solution for remote and grid limited applications
- A design with the ability to load follow and adjust to varying grid load swings
- An economic and clean generation solution for the industry
- A balanced energy portfolio
Design Philosophy

• **Enhanced safety and security**
  – Based on tested & licensed passive safety systems
  – Reactor & safety systems below ground

• **Best opportunity for cost competitiveness**
  – Most power with the least amount of material
  – Entirely modular design
  – Rail, truck and barge transportable

• **Speed to market**
  – Proven ability to design, license and deploy reactors
  – Existing technical skills, licensed technologies and fuel supply
  – Designing to eliminate supply chain bottlenecks

**The most economic SMR**
AP600™ Plant → AP1000® Plant PWR Design Changes

- Increased core length & number of assemblies
- Increased size of key NSSS components
  - Increased height of Reactor Vessel
  - Steam Generators
  - Larger canned RCPs
  - Larger Pressurizer
- Increased Containment Height
- Capacity increases in passive system pipe size and in passive safety system components
- Turbine Island sized to increase power rating - 3 LP Turbines

AP1000® Plant Retained the AP600™ Plant Nuclear Island Footprint
AP1000® Plant ➔ SMR Design Changes

- Eliminated Reactor Coolant Loop Piping – SMR – Integral Reactor
- Large, Free Standing, Steel & Concrete Containment Changed to Small Diameter High Pressure Steel Containment
- Relocated CRDMs Inside Reactor Vessel
- Integrated PRHR Heat Exchanger into Core Makeup Tanks
- Complete Revision to Nuclear Island layout with Containment Located Underground – Tiny Footprint
- Dramatic Increase in the use of Large Structural Modules
- Eliminated accumulators. Provides 4 Core Makeup Tanks

SMR Retains the AP600™ Plant and AP1000® Plant Passive Safety Approach
The Westinghouse SMR
Design Features Overview

- Packages Existing Technology Developed for the AP600™ Plant and AP1000® Plant PWR to meet the Demands of the SMR Market
  - Less than 300MWe
  - Rail Shippable Components
  - Integral PWR
  - CV and Rx Below Grade
  - Extended Coping for SBO – 7 Days
  - 10 year Deployment

- Westinghouse Advantage
  - Employ Compact Containment to address Economy of Scale Challenge
  - Most Power for the Least Amount of Buildings & Equipment
  - Shortest Development Cycle/Reduced Licensing Risk
  - Modular Construction – <30 Month Construction Schedule
The Westinghouse SMR
Integral Reactor Vessel

• Integral pressurized water reactor—single >225 MWe reactor
• Standalone unit; no shared systems
• Innovative packaging of proven components
• The highest levels of safety with fewer accident scenarios
• Leverages AP1000® plant passive safety system designs
• Compact reactor coolant system and containment
• 100% Modular Nuclear Power Plant

An Engineered, Economic Solution for Today’s Clean Energy Challenges
## The Westinghouse SMR
High Pressure Containment Vessel

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Details</th>
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</thead>
<tbody>
<tr>
<td>Thermal Output</td>
<td>800 MWt</td>
</tr>
<tr>
<td>Electrical Output</td>
<td>&gt;225 MWe</td>
</tr>
<tr>
<td>Passive Safety Systems</td>
<td>No operator intervention required for 7 days</td>
</tr>
<tr>
<td>Core Design</td>
<td>17x17 Robust Fuel Assembly</td>
</tr>
<tr>
<td></td>
<td>8.0 ft. Active Length</td>
</tr>
<tr>
<td></td>
<td>&lt; 5% Enriched U235</td>
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<tr>
<td></td>
<td>89 Assemblies</td>
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<tr>
<td></td>
<td>Soluble Boron and 37 Internal CRDMs</td>
</tr>
<tr>
<td></td>
<td>24-Month Refueling Interval</td>
</tr>
<tr>
<td>Reactor Vessel Size</td>
<td>Outer Diameter: 12 ft.</td>
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<tr>
<td></td>
<td>Height: 81 ft.</td>
</tr>
<tr>
<td>Upper Vessel Package</td>
<td>280 Tons</td>
</tr>
<tr>
<td>Containment Vessel Size</td>
<td>Outer Diameter: 32 ft.</td>
</tr>
<tr>
<td></td>
<td>Height: 91 ft.</td>
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<tr>
<td></td>
<td>Fully Modular Construction</td>
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<tr>
<td>Reactor Coolant Pumps</td>
<td>8 External, Horizontally-Mounted Pumps</td>
</tr>
<tr>
<td></td>
<td>Sealless Configuration</td>
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<tr>
<td>Steam Generator</td>
<td>Recirculating, Once-Through, Straight-Tube</td>
</tr>
<tr>
<td>Pressurizer</td>
<td>Integral to Vessel</td>
</tr>
<tr>
<td>Instrumentation and Control</td>
<td>Ovation®-based Digital Control System</td>
</tr>
</tbody>
</table>
The Westinghouse SMR
How Small is Small?

25 Westinghouse SMR Containment Vessels fit inside a single AP1000® Plant Containment Vessel

A Compact Containment Addresses the Economy of Scale Issue for Lower Output Power of SMR
Westinghouse SMR
Modularity Approach

Aggressive Modular Approach
Reduces Construction Duration and
Allows Flexibility in the Schedule

Leverages AP600™ Plant/AP1000®
Plant Structural Module Designs
AP1000 Plant Modular Construction
An Innovative Approach Unique in our Industry

Improved Quality Control and Efficiency
Reduced Construction Schedule and Optimized Costs
Sanmen Site Progress: Time Lapse View

2009 to 2014
Refuel Concepts

- Complete core off-load
- 24-month operating cycle
- Limits refueling outage duration
- Uses traditional refueling methods
- Transfers single fuel assemblies
- Derived handling equipment from existing designs
- Leverage experience of operating fleet and AP1000® Plant
- Uses spent fuel storage with transition to dry storage

Use Existing Technology and Proven Licensing Basis to Reduce Development Time and Licensing Risk
Load Follow Capability

- The Westinghouse SMR is designed to respond to various load change transients
  - Daily and weekend load follow operations
  - Extended reduced power operation
  - Grid frequency response (load regulation)
- Load follow operations utilize MSHIM™ operating strategy
  - Power maneuvers accomplished without cycling of boron systems

The Westinghouse SMR is flexible and responsive to frequent changes in electrical demands
SMR Fuel Design: Proven Features, Ease of Licensing

- Westinghouse Integral Nozzle (WIN)
  - No potential for loose parts
  - One piece casting

- Skeleton structure
  - Enhanced dimensional stability
  - ZIRLO™ thimble tubes
  - Thick thimble tubes
  - Tube-in-tube dashpot design
  - Anti-bowing design prevents IRI

- Based on proven 17x17 RFA design
Westinghouse SMR Fuel

- Westinghouse Columbia Fuel Fabrication Facility (CFFF)
  - Located in Columbia, SC, and in operation since 1969
  - Current fuel manufactured at CFFF provides 10% of all U.S. electricity
  - CFFF has manufactured fuel assemblies for 8-foot cores
  - Hydraulic and mechanical testing completed successfully
AP1000 Plant
• 157 Fuel Assemblies
• 17 x 17 RFA
• 14 ft. (~4.25 m) Active Length
• 18 Month Fuel Cycle

SMR
• 89 Fuel Assemblies
• 17 x 17 RFA
• 8 Ft. (2.4 m) Active Length
• 24 Month Fuel Cycle
Benefits of the Westinghouse SMR

Proven Technology Basis

- Passive safety systems are conceptually similar to AP1000® plant (proven design)
- Digital I&C systems based on AP1000® plant design (proven design)
- Only SMR designer with an approved fuel design
- One reactor with no shared systems (less operating risk)
- Large, predictable thermal margin of safety
- Pump-Driven RCS flow at power results in increased plant efficiency and increased core cooling certainty during power operations
- Yields the most power with the least amount of material and equipment
- Fully-modular nuclear generating station design

The result is a small, affordable, nuclear package that can be competitive with and complimentary to other generating sources around the world.
Obrigado!

Questions?