AP1000™ Technology: Passive & Proven
The Right Fit for Brazil

Jeff Benjamin
Senior Vice President
Nuclear Power Plants (NPP)

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Westinghouse Electric Company

• Incorporated in 1886 by George Westinghouse
• Responsible for some of the world’s most important achievements:
  – AC technology
  – 1st commercial radio broadcast
  – USS Nautilus
  – 1st camera on the moon
  – Commercial nuclear power

Vision: to be the customers’ choice in supplying leading-edge nuclear technology to satisfy the world’s growing demand for energy
Solely Focused on Commercial Nuclear Technology

Nearly **50 percent** of the nuclear power plants in operation worldwide are based on Westinghouse technology

- Our newest design – the AP1000® pressurized water reactor (PWR) – features innovative passive safety systems and proven technologies based on Westinghouse’s 50+ years of experience
Westinghouse Electric Company
Business Structure

**Engineering, Equipment and Major Projects**
Focused on ensuring new and operating plant success by providing technically superior engineering, hardware and services that enhance plant safety, ensure plant reliability, extend plant life and improve plant performance.

**Nuclear Power Plants**
Specializing in the development and delivery of new nuclear power plant projects.

**Nuclear Fuel**
A single-source fuel provider for PWR, BWR, VVER and AGR reactors worldwide.

**Automation and Field Services**
A global field services and instrumentation and control solutions provider, focused on delivering industry-leading operations solutions and better outage services worldwide.
Westinghouse Locations

60+ Sites Worldwide!
World Energy Demand Is Growing

- World population will increase 14 percent in the next 12 years
- Rising energy demand from economic output and improved standards of living will strain energy supplies
- World energy consumption is projected to grow 56% between 2010 and 2040

*Source: U.S. Energy Information Administration, July 2013*
Critical Decisions Must Be Made

• We need to address growing energy needs with environmentally responsible energy solutions that benefit our communities

• Multiple ways to achieve these goals:
  – Conservation
  – Balanced portfolio of “clean” energy technologies
  – Deployment of vehicles powered from clean energy sources
Nuclear Energy Has an Environmental Impact Comparable to Renewables

Life Cycle Emissions for Various Electricity Sources

- **Coal - Modern Plant**: 790 - 1182 gram equiv CO2/kWh
- **Solar Photovoltaic**: 13 - 731 gram equiv CO2/kWh
- **Natural Gas (Combined Cycle)**: 389 - 511 gram equiv CO2/kWh
- **Wind**: 7 - 124 gram equiv CO2/kWh
- **Biomass/forestry/waste combustion**: 15 - 101 gram equiv CO2/kWh
- **Nuclear**: 2 - 59 gram equiv CO2/kWh
- **Hydropower**: 2 - 48 gram equiv CO2/kWh

For a Number of Reasons...

Nuclear energy MUST be part of the future energy landscape

- Increasing energy demand
- Climate change
- Security of supply
- High-paying jobs
- Economic value for communities
Brazil’s Unique Position in the World Today

Brazil: 10th largest producer of electricity in the world

Source: International Energy Annual
Brazil’s Unique Position in the World Today

Top 10 in >100GW Capacity

Top 10 in Population

Top 10 in GDP

Top 10 in Uranium Reserves
Electric Energy Consumption (kWh per Capita)

Since 2006:
- Brazil: + 17%
- India: + 40%
- China: + 157%

Currently 84th: expect significant increase with growing economy

Source: World Bank 2011
Brazil’s Rich and Diversified Energy Reserves

Estimated National Energy Reserves (equivalent in millions of barrels of oil)

- **Hydro**: 100 yrs: 76.948
- **Wind**: 100 yrs: 19.102
- **Biomass**: 100 yrs: 122.040
- **Coal**: 63.560
- **Uranium**: 55.633
- **Oil**: 16.453
- **Natural Gas**: 3.249

Source: BEN 2007 (Note: does not account for recent O&G discoveries offshore)
Uranium Resources in Brazil

Today’s capability: > 300 million tons de U3O8

6th Reserve in the World
- with only 30% of the national territory explored
- allows for availability of material and stability of fuel prices
- existing capability of fuel technology

Estimate:
>800 million tons

Source: BEN 2007
Fuel Cycle Technology Established and Growing

Source: Industrias Nucleares do Brasil
Mature Nuclear Energy Generation Experience

Generation through 2012: 198,490,932 MWh

*Generation record 2012: 16 TWh*

2nd Best Availability Factor in the World in 2011
Angra 1&2: 95.7%
Sustainability of Brazilian Nuclear Industry

- Brazil has Competitive Edge for Supporting New Build
  - Capable, recognized nuclear operator
  - Fuel Cycle Capability
  - Mature Regulatory Body
  - Nuclear Construction Experience
  - Strong Engineering & Sciences Programs
  - Experienced Supply Chain

- Demographics Challenging Industry
- New Projects Attracting Limited Amount of New Talent
- Maintaining the Key Skills Needs to be part of Debate

Scale of Industry is KEY to Sustaining Brazil Nuclear Sector
Westinghouse Presence in Brazil

Angra 1
Eletronuclear (ETN)

- Angra 1 NSSS supplied in 70’s
- Operations support
- Outage support
- Codes & Methods

Instituto Nacional de Pesquisas Energéticas (INB)

- Provided technology for manufacturing of Angra 1 reload fuel
- Joint Development of 16x16 Next Generation Fuel Program
- Codes & Methods

A long partner with the nuclear industry in Brazil
AP1000 Plant: Safe, Simple and Standardized

- **Passive safety** replaces mechanical and electrical systems – harnesses natural forces like gravity, convection and condensation to achieve safe shutdown

- **Strong licensing pedigree** based on reviews in multiple countries; first and only Generation III+ reactor to receive design certification from the U.S. NRC

- **Simplified design and modular construction** provides a plant that is easier and less expensive to build, operate and maintain
Major Safety Advancements of the AP1000 Plant

**Passive Safety-Related Systems**
- Use “passive” processes only, no active pumps, diesels, ….  
- One-time alignment of valves  
- No support systems required after actuation  
- Greatly reduced dependency on operator actions

**Active Defense in Depth-Related Systems**
- Reliably support normal operation  
- Redundant equipment powered by onsite diesels  
- Minimize challenges to passive safety systems  
- Not necessary to mitigate design basis accidents  

*Severe accident scenario effects are mitigated by in-vessel retention of the melted fuel*
Regulatory Certainty

- EUR confirms the AP1000 plant can be **successfully deployed** in Europe (May 2007)
- AP1000 plant amended design **unanimously approved** by NRC (December 2011)
- UK regulators grant **Interim Design Approval** (December 2011)
- China licensing activities on-track, with **Final Safety Analysis Report** (FSAR) submitted to customer (2012).
- Combined construction and operating licenses (COL) approved for **Vogtle 3&4** site (February 2012) and **V.C. Summer 2&3** site (March 2012)
Summary of Key Conclusions

AP1000 Plant Response to Extreme Events

- Westinghouse assessment concluded that AP1000 Plant maintains all safety limits
- The AP1000 Plant passive design assures
  - Containment integrity
  - No fuel damage (both spent fuel and reactor)
  - No radiological release as a result of the event

AP1000 achieves and maintains Safe Shutdown, protects public health and safety, and prevents loss of utility investment.

[...] as has been pointed out to me by Japanese colleagues as they reflect upon Fukushima, had the plant been operating AP1000 reactors, it is likely that the outcome would have been very different. The AP1000’s passive safety systems provide the ability to maintain core cooling for at least 72 hours with little human intervention. 72 hours to make repairs, transport emergency equipment, and take other actions in response to the earthquake and tsunami that assaulted the Fukushima site would have made a very significant difference.

US NRC Commissioner William D Magwood
AP1000 Plant Focus on Simplicity

- 50% Fewer Valves
- 35% Fewer Pumps
- 80% Less Pipe*
- 80% Fewer Heating, Ventilating & Cooling Units
- 45% Less Seismic Building Volume
- 70% Less Cable
Modular Construction Allows More To Be Done in Parallel

Result: Shorter Construction Schedule
AP1000 Plant Modular Construction
An Innovative Approach Unique in our Industry

Improved Quality Control and Efficiency
Reduced Construction Schedule and Optimized Costs
Long lead orders placed

Typical AP1000 Construction Schedule

<table>
<thead>
<tr>
<th>Pre-Construction</th>
<th>Construction</th>
<th>Start-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 Months</td>
<td>48 months, then 36 months later units</td>
<td>6 Months</td>
</tr>
</tbody>
</table>

- Plant Order
- First Structural Concrete
- Nuclear Island Basemat
- Lower Ring
- Mid-Ring
- Mid-Ring
- Upper Ring
- Polar Crane
- Top Head
- Fuel Load
- Commercial Operation
- Set Primary Equipment
- Set Turbine Generator
- Cold Hydro
- Hot
- Turbine Island Basemat/Pedestal
- Internal Concrete/Steel Modules
Localized Supply Base as a partner with Westinghouse in the AP1000 Integrated Global Supply Chain network

1. Localization & horizontal integration – We Buy Where We Build™
2. Progression of Localization

- **Minimum Development/Investment:** Construction labor and construction commodities.
- **Medium:** Localization of equipment by qualified local industries. Mainly Commercial off the shelf, build-to-spec, non-safety, but need to be commercially competitive.
- **Maximum:** Qualified safety-related, Tech Transfer (TT). TT develops local industries, licensed technology. Usually viable only for national fleet program aspirations.
• Eight AP1000 units under construction worldwide
  - Four units in China
  - Four units in the United States
China AP1000 Plant Progress: Sanmen

Unit 1 First Concrete – March 2009

Unit 2 SG/Refueling Canal Module – December 2010

Unit 1 Reactor Vessel – August 2011

Unit 1 CVTH Set – January 2013

Photos © Sanmen Nuclear Power Company, Ltd. All rights reserved.
Sanmen 1 Reactor Vessel Internals (RVI)

Manufacturing Progress (cont.)

Upper Support Cylinder

Upper Cylinder Assembly

Core Shroud
China AP1000 Plant Progress: Haiyang

- Unit 1 First Concrete – September 2009
- Unit 2 Auxiliary Building – December 2010
- Unit 1 Reactor Vessel – January 2012
- Unit 1 CVTH Set – March 2013

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Progress of China Projects: Summary

- Major equipment delivered and installed at Sanmen Unit 1 and Haiyang Unit 1 includes:
  - Reactor Vessel
  - Steam Generators
  - Reactor Vessel Internals
  - Polar Crane
  - Integrated Head Package
- Containment Vessel Top Head (CVTH) set at Sanmen Unit 1 in January 2013 and Haiyang Unit 1 in March 2013
- Digital I&C turnover to Startup staff in progress
- Potential Sanmen operators have completed simulator training; Haiyang operators started simulator training in July
- Technology transfer well advanced
U.S. AP1000 Plant Projects

Vogtle 3&4
Waynesboro, Georgia

V.C. Summer 2&3
Jenkinsville, South Carolina
U.S. AP1000 Plant Progress: Vogtle Site

Unit 3 CVBH Set – June 2013

Unit 3 Accumulator Tank Delivery – October 2013

Unit 3 CA20 Module Assembly – October 2013

Unit 3 Turbine Building – September 2013
U.S. AP1000 Plant Progress: V.C. Summer Site

Unit 3 First Concrete Pour – November 2013

Unit 2 Reactor Vessel Delivery – June 2013

Unit 2 CVBH Set – May 2013

CH80 Module Lift – September 2013

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Progress of U.S. Projects: Summary

- Nuclear island basemat concrete pours completed for V.C. Summer Units 2&3; Vogtle Unit 3
- Containment Vessel Bottom Head (CVBH) set in nuclear island for initial units at each site
- CV ring fabrication underway
- Component and module fabrication proceeding
- Reactor vessels delivered for initial units at each site; additional equipment and component deliveries continue to proceed
Benefits of AP1000 Technology and Westinghouse Approach to New-Build Business

- **AP1000** plant combines proven technologies and innovative passive safety systems
  - 5,000 man-years of design work
- Eight units under construction worldwide; more are planned
  - First nuclear concrete placed for first eight
- Regulatory certainty
  - Almost 300 man-years of licensing review in US and UK alone
- We Buy Where We Build™ approach provides rich opportunities for local suppliers
- Committed to developing the next generation of engineers and other technical professionals in Brazil
Lessons Learned: Requirements for a Successful New-Build Program

- **Strong reference plant**
- Leverage “Country of Origin” Licensing
- Utilize Modern Construction Methods
- Defined Approach to Sustainable Localization
- Avoid First-of-a-Kind Deployment Issues
- Take Advantage of Nth-of-a-Kind Experience
AP1000 Plant Value Proposition

Proven Technology with Passive Safety Systems

Simplified Design with Modular Construction

Reviewed in Multiple Countries by Independent, Technically Rigorous and Transparent Regulators – Using a Well Defined Safety Standard
Westinghouse Technology and Brazil: The Right Fit

- Westinghouse Looks Forward to Continuing our Long Nuclear Partnership with Brazil
- Our Approach Helps Achieve
  ...a balanced energy supply
  ...safe, clean electricity generation
  ...sustainable economic growth
Obrigado! Questions?

Por mais de 125 anos, a Westinghouse tem demonstrado liderança em inovação e tecnologia para melhorar o nível de vida do mundo. Hoje, aproximadamente 50% das centrais nucleares do mundo são baseadas na tecnologia da Westinghouse.

Westinghouse continua liderando a tecnologia de geração de potência de maneira segura, confiável e com sustentabilidade ambiental através da central AP1000 que é a líder dos reatores avançados de próxima geração. Através da incorporação de sistemas de segurança passivos e um modelo de construção modular, o projeto AP1000 garante proteção de segurança, desempenho de projeto e localização de fornecedores que resultam em redução de riscos de cronograma e investimento. O projeto AP1000 — uma escolha inteligente para o mundo, uma escolha inteligente para o Brasil.

Consulte-nos na www.westinghousenuclear.com

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