Westinghouse Electric Company: Leading the Drive for Clean, Reliable Nuclear Energy Generation

October 2014

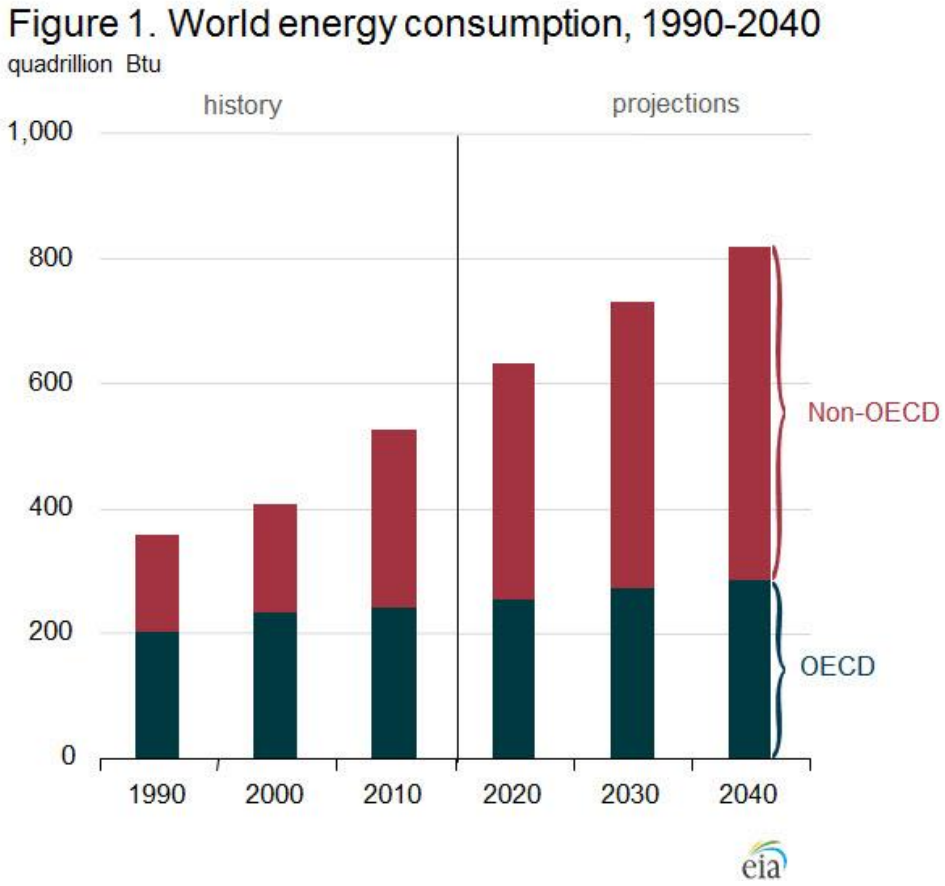
Carlos Leipner

Vice President, Latin America

Westinghouse

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

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For a Number of Reasons…

Nuclear Energy MUST be part of the future energy landscape

- Increasing energy demand
- Climate change
- Security of supply
- Insurance against future price exposure

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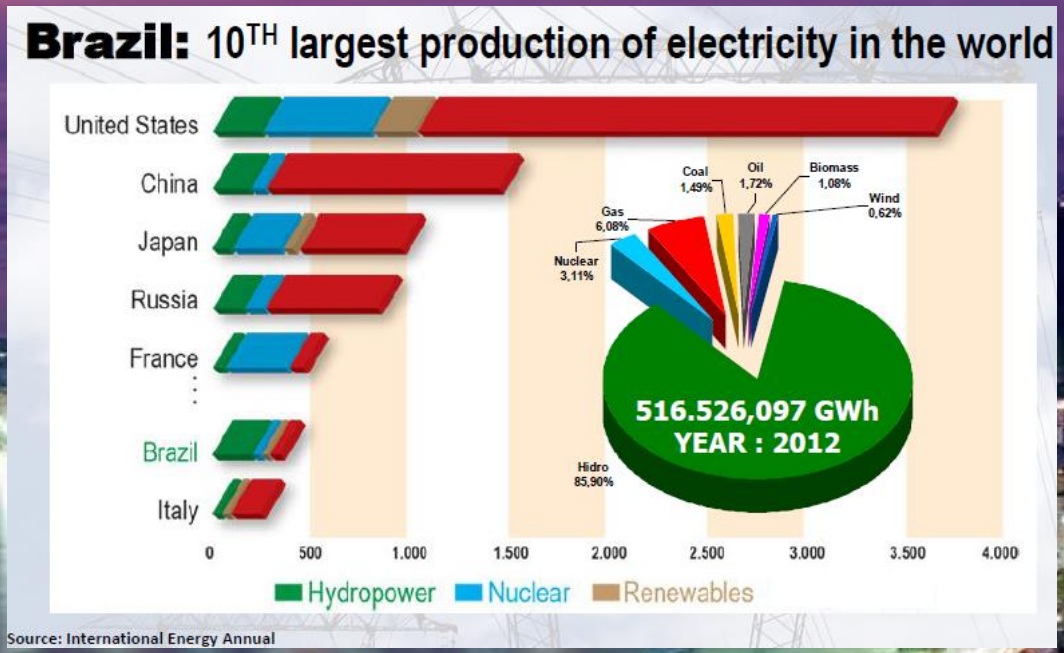
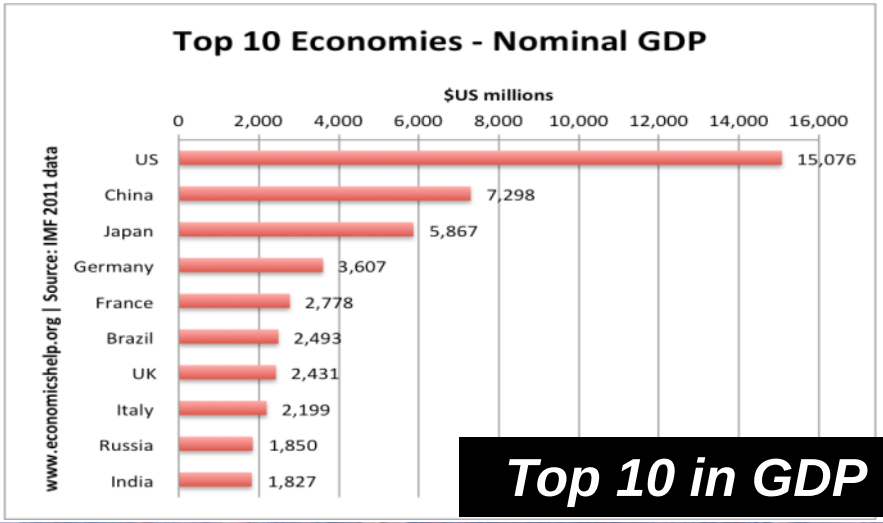
Brazil's Unique Position in the World Today

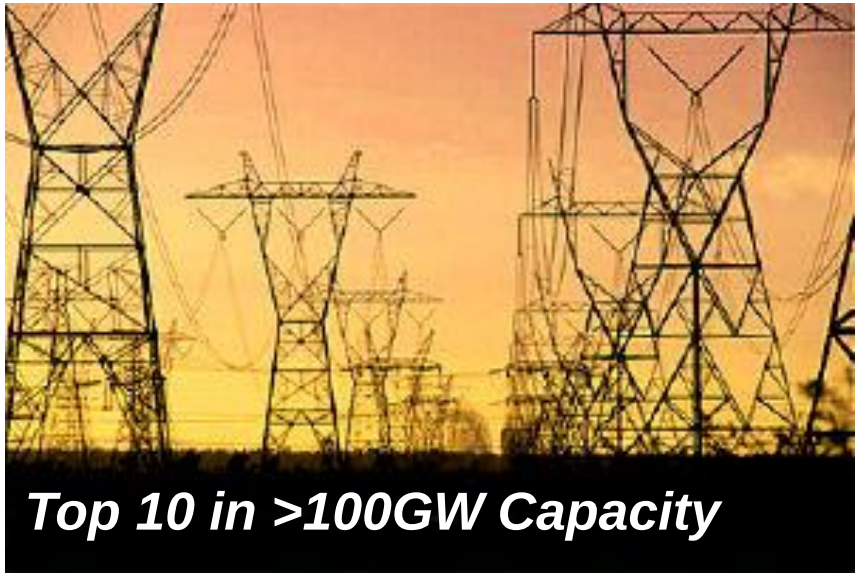


Brazil's Unique Position in the World Today

Top 10 in Population



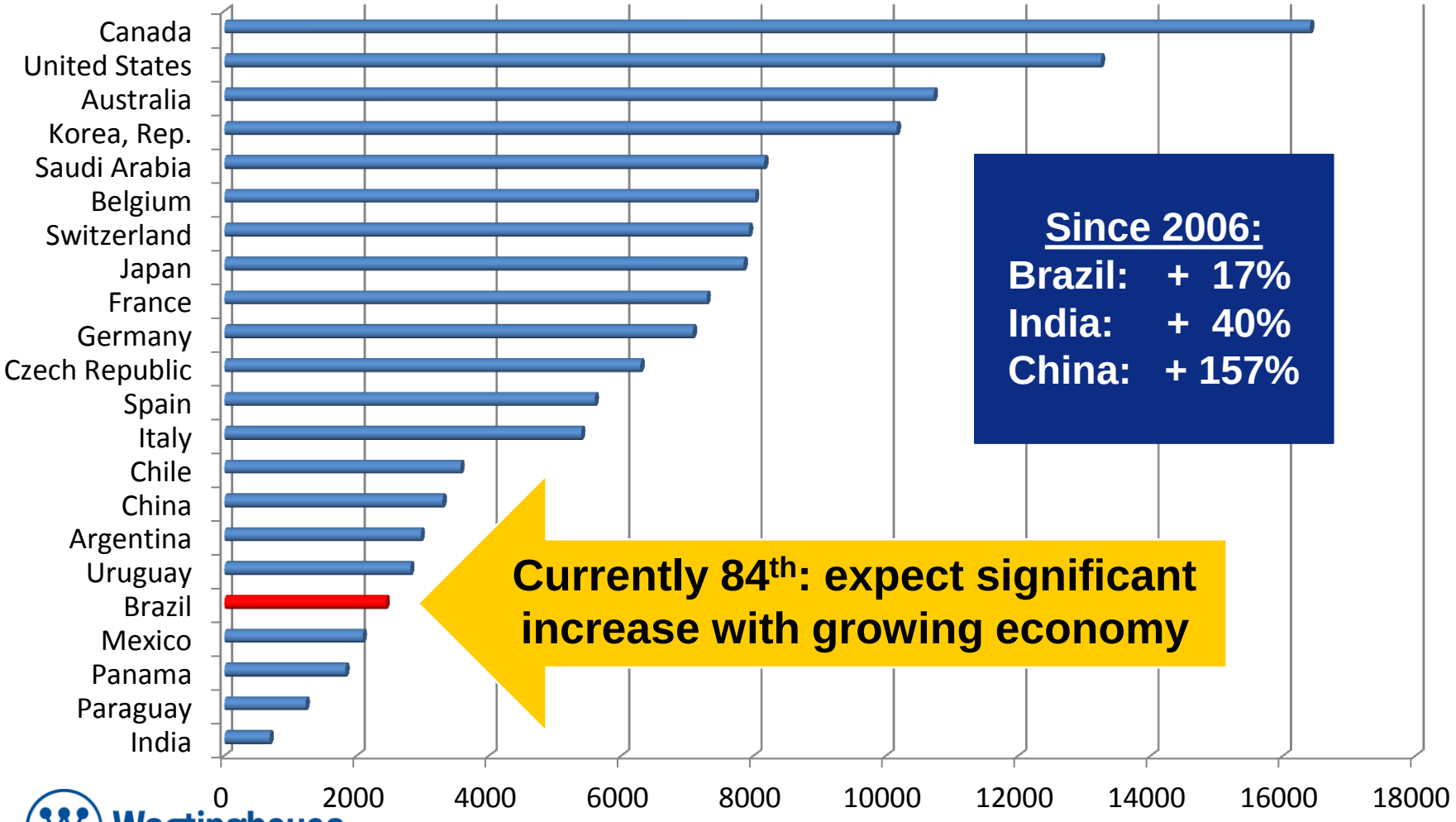
Top 10 in GDP



Top 10 in >100GW Capacity

Top 10 in Uranium Reserves

Electric Energy Consumption (kWh per Capita)



Source: World Bank 2011

Brazil's Rich and Diversified Energy Reserves

Hydro

100 yrs: 76.948

Wind

100 yrs: 19.102

Biomass

100 yrs: 122.040

Estimated National Energy Reserves

(equivalent in millions of barrels of oil)

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)

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35

822

17.8

35% – 2014 Hydro Reservoir Levels

R$822/MWh – Cap on Electricity Prices

R$17.8 B – Total 2014 Loans to Distributors

A New Energy Model Needs to Be Considered!

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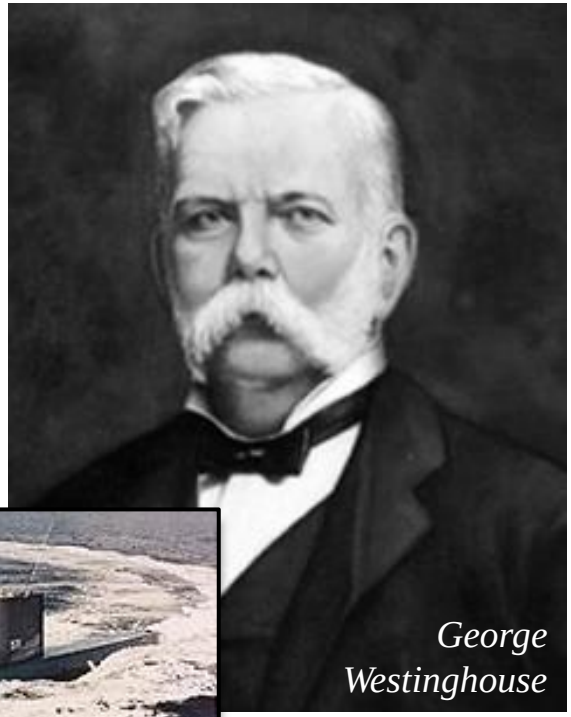
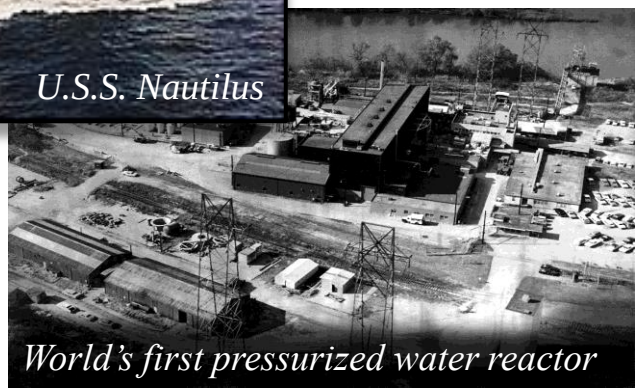
Westinghouse Electric Company

- Incorporated in 1886 by George Westinghouse
- Responsible for some of the world's most important achievements:
  - AC technology
  - 1st commercial radio broadcast
  - U.S.S. 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


George Westinghouse


U.S.S. Nautilus


World's first pressurized water reactor

Westinghouse

Westinghouse Is 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

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Westinghouse presence in Brazil

Angra 1
Eletronuclear (ETN)

- Angra 1 NSSS supplied in 70's
- Operations & Outage support
- Recently completed exchange of Steam Generators
- Nuclear Codes & Methods

INB
Indústrias Nucleares do Brasil (INB)

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

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Westinghouse 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

Engineering Capabilities

Gaining Regulatory Margins

- Advanced Safety Analysis Tools provide significant margin.
- Probabilistic Risk Assessment services provide insight.

Increasing Engineering Efficiency

- Plant modifications with engineering design change packages, procurement and installation.
- Power Uprate Analysis
- Onsite teams supporting customer needs.

Dismantling and Decommissioning

- Westinghouse is the prime contractor on the reactor vessel segmentation for Chooz A in France.
- Cask welding and fuel handling for dry cask storage.

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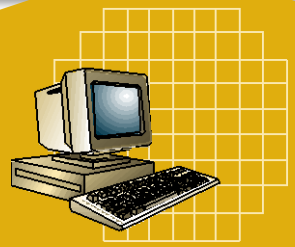
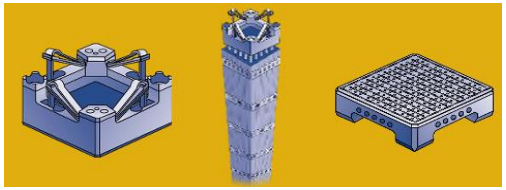
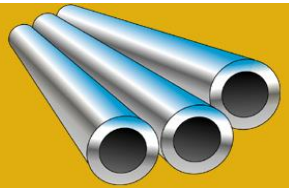
Nuclear Fuel Products and Services

Securing uranium resources through KAP*
Procurement through UAM**

KAP:Kazatomprom,
UAM:Uranium Asset Management

• Engineering Services & Technology		Pittsburgh Västerås Windsor
• Fuel Fabrication • Components • UF_6 Conversion		Columbia Västerås Windsor Springfields
• Tubing		Blairsville Specialty Metals
• Zirconium Products		Western Zirconium
• Uranium Supply • Transportation		UAM KAP

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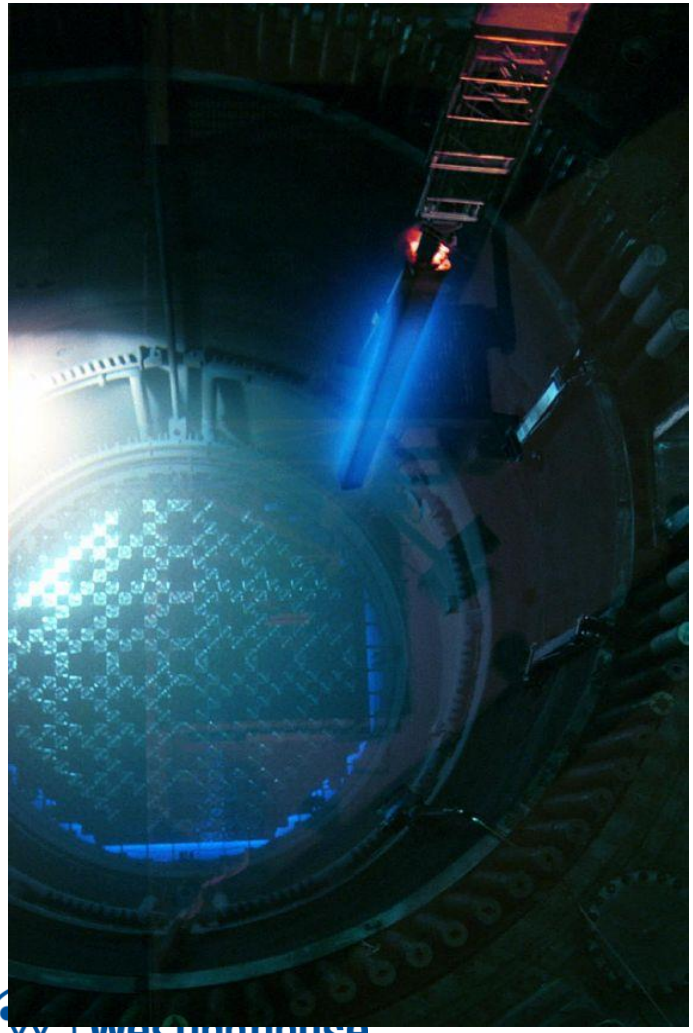
Loading Pattern (LP)



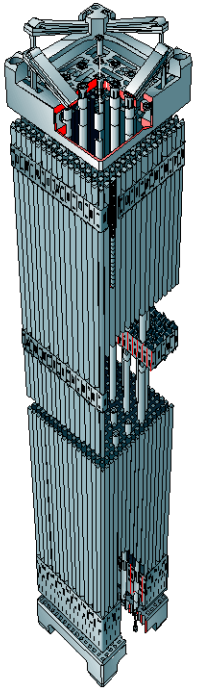
Detailed Description for Placement of Fuel

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
					K02 N-5	K36 H-15	AA52 F-7	AA45 M-7	K21 D-14	K32 J-15	K62 J-5					1
			K68 L-11	AA84 E-10	AB79 FEED	AB46 FEED	AB06 FEED	AB48 FEED	AB08 FEED	AB49 FEED	AB01 FEED	AA19 B-10	K71 H-10			2
		K66 F-8	AB74 FEED	AB67 FEED	AA80 H-5	AB31 FEED	AA23 B-8	AA72 K-13	AA50 G-6	AB34 FEED	AA10 C-3	AB69 FEED	AB75 FEED	K70 L-5		3
		AA22 F-2	AB70 FEED	AA39 P-9	AA36 G-2	AA18 D-13	AB22 FEED	AA51 L-4	AB24 FEED	AA71 N-10	AA14 N-4	AA34 J-2	AB71 FEED	AA85 K-11		4
	K64 L-9	AB82 FEED	AA09 N-3	AA27 M-13	AA46 D-7	AB14 FEED	AA07 P-11	AB57 FEED	AA01 B-11	AB16 FEED	AA43 G-12	AA33 B-9	AA88 E-8	AB83 FEED	K04 E-3	5
	K31 A-9	AB54 FEED	AB36 FEED	AA67 F-13	AB17 FEED	AA74 J-8	AB42 FEED	AA54 E-4	AB43 FEED	AA73 H-7	AB18 FEED	AA21 N-12	AB30 FEED	AB55 FEED	K33 R-8	6
	K22 B-4	AB09 FEED	AA64 K-7	AB25 FEED	AA04 E-2	AB44 FEED	AA83 F-11	AA15 K-2	AA79 L-10	AB32 FEED	AA02 L-2	AB26 FEED	AA31 H-14	AB10 FEED	AA58 G-10	7
90°	AA48 J-12	AB45 FEED	AA65 C-10	AA53 M-11	AB58 FEED	AA56 M-5	AA24 P-10	AB65 FEED	AA25 B-6	AA55 D-11	AB59 FEED	AA62 D-5	AA69 N-6	AB56 FEED	AA44 G-4	8
	AA63 J-6	AB11 FEED	AA20 H-2	AB27 FEED	AA03 E-14	AB39 FEED	AA87 E-6	AA30 F-14	AA78 K-5	AB40 FEED	AA08 L-14	AB21 FEED	AA60 F-9	AB05 FEED	K26 P-12	9
	K47 A-8	AB47 FEED	AB37 FEED	AA32 C-4	AB19 FEED	AA76 H-9	AB38 FEED	AA49 L-12	AB33 FEED	AA75 G-8	AB13 FEED	AA66 K-3	AB35 FEED	AB52 FEED	K30 R-7	10
	K01 L-13	AB84 FEED	AA77 L-8	AA37 P-7	AA42 J-4	AB20 FEED	AA05 P-5	AB60 FEED	AA06 B-5	AB15 FEED	AA47 M-9	AA29 D-3	AA12 C-13	AB78 FEED	K58 E-7	11
		AA81 F-5	AB72 FEED	AA35 G-14	AA13 C-12	AA70 C-6	AB28 FEED	AA61 E-12	AB23 FEED	AA28 M-3	AA40 J-14	AA38 B-7	AB66 FEED	AA17 K-14		12
		K67 E-11	AB76 FEED	AB73 FEED	AA11 N-13	AB29 FEED	AA57 J-10	AA68 F-3	AA26 P-8	AB41 FEED	AA02 H-11	AB68 FEED	AB77 FEED	K72 K-8		13
			K69 H-6	AA16 P-6	AB85 FEED	AB53 FEED	AB12 FEED	AB50 FEED	AB07 FEED	AB51 FEED	AB80 FEED	AA86 L-6	K73 E-5			14
	Y YY Z-ZZ	Assembly Identifier Previous Cycle Location			K65 G-11	K29 G-1	K27 M-2	AA41 D-9	AA59 K-9	K37 H-1	K03 C-11					15
								0°								

K REGION 10A (4.102 w/o)	AA REGION 11A (4.597 w/o)	AB REGION 12B (4.600 w/o)
K REGION 10B (4.404 w/o)	AB REGION 12A (4.200 w/o)	

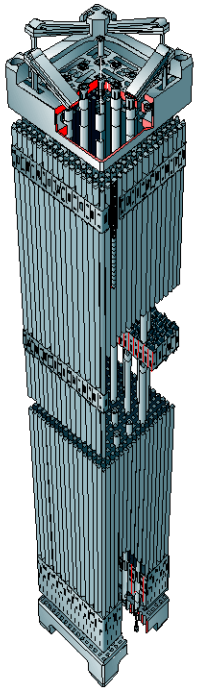
Westinghouse LWR Product Lines

Westinghouse PWRs



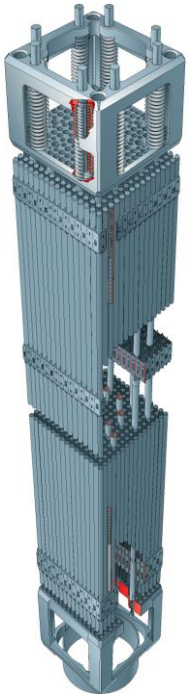
- 17x17 and 17x17XL
- 16x16
- 15x15
- 14x14

French PWRs



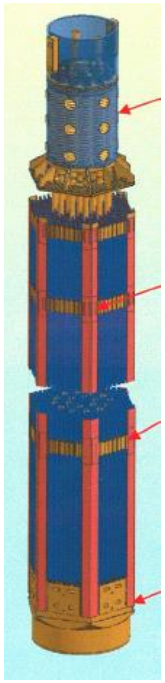
- 17 RFA2 (12'/14')
  - without P-Grid
  - with P-Grid
- EDF

German PWRs



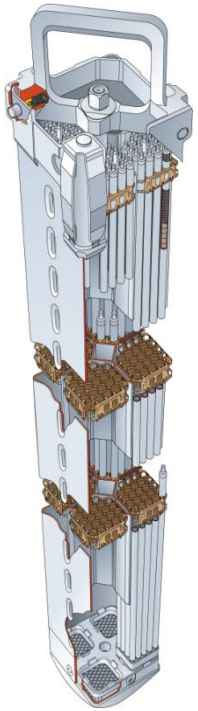
- 16x16 – E.ON, EnBW
- 18x18 – E.ON, RWE

Russian PWR



- VVER-1000
  - 9 Grid
- CEZ
  -16 Grid
- Energoatom

BWRs



- SVEA-96 Optima2 – TVO, Forsmark, OKG, KKB, KKK, RWE, KKL, Iberdrola
- SVEA-96 Optima3 intro
- ongoing
- partial reloads: OKG, RWE

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Fuel Cycle Management

- Leading single-source/integrated supplier of nuclear fuel products and services for PWRs, BWRs, VVERs, and AGRs
- More than 5000 employees supporting fuel business in:
  - United States
  - Sweden
  - United Kingdom
  - Japan
  - China
- Licensed Codes & Methods

Nuclear Automation Services

- Cyber Security tools, assessments & solutions
- Engineering, Operator and I&C Training
- Turnkey Services for I&C upgrades
- Seismic, environmental and qualification testing
- Lifecycle testing and predictive maintenance

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Nuclear Automation Solutions

Safety Systems

FPGA-based ALS and CommonQ (qualified) platforms and applications for safety systems solutions

- ALS provides non-software-based safety system solutions.
- CommonQ, based on an ABB platform, is used for the full suite of safety systems for AP1000 and APR1400 plant designs
- Full safety system replacement at Sweden's Ringhals 2 with CommonQ

Vintage Systems

Obsolescence Engineering Services
System Improvements, I&C Field Services
Replacement Parts & Components

- Vintage systems such as 7300 and SSPS
- Lifecycle management services
- Asset management strategies

Westinghouse

Nuclear Automation Solutions

Control Systems

Ovation® platform

Engineering for Nuclear Applications

Plant Information Systems, NSSS, Turbine and BOP

- Emerson's Ovation® is the leading process automation platform in the power generation industry
- Full-plant control & information solutions for AP1000 & APR1400
- Recently completed control system upgrades at Duke Catawba & McGuire, SONGS, and ANAV plants.
- Full replacements at Ringhals 2 and Kozloduy 5&6.

Control Rooms & Simulators

Human Factors Engineering, Human-Machine Interface Design, Custom Applications

Digital and Hybrid Control Room Solutions

- New plant control room solutions
- Partial upgrades or full control room replacements
- Simulators for modifications from upgrades to full system replacements

Waltz Mill: Home of Westinghouse's Global Field Services Business

- U.S. Center for radiological equipment, maintenance and storage
- Pump and Motor repair center
- Steam Generator advanced technology development

50-year history
26 buildings on 850 acres
750 employees

- Reactor cavity maintenance and fuel handling training, testing
- WesDyne headquarters (nondestructive examination leadership)
- Also home to Installation and Modification Services for plants: design basis maintenance, improvement, aging management and life extensions

Main Mission: Hub for global nuclear field dispatching, development, and maintenance processes

Westinghouse

Advanced Field Service Robotics

Refueling Machines, Critical Cranes

Design, Fabrication and Maintenance

- NuCrane Manufacturing (new joint venture company) fabricates polar cranes, cask-handling cranes and turbine/reactor building cranes.
- Refueling Machine asset management.

Nondestructive Testing

- Submersible Inspection Platform for in-service inspections
- Phased array inspections of critical welds.

Field Welding and Machining

- Structural Weld Overlay
- Specialty Machining
- Specialty Welding Tools
- Welder Certification
- Development of underwater laser beam welding and peening.

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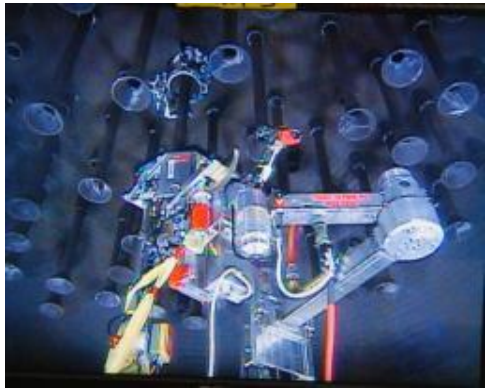
WesDyne International

- Global supplier of state-of-the-art nondestructive examination services
- Provides component and piping inspection services to nuclear facilities worldwide
- Automated turbine generator inspection services for nuclear and fossil power generators.



WesDyne DERI Manipulator

SQUID Scanner

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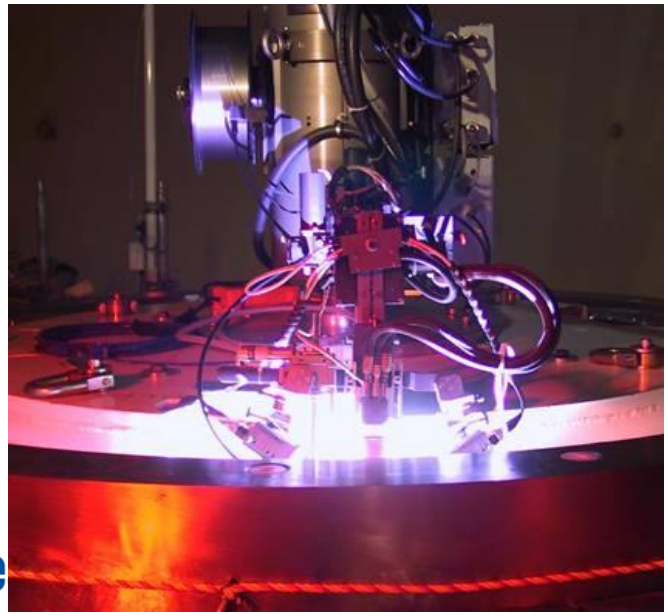
Fuel Handling Technology - PaR

- PaR Nuclear is a wholly owned subsidiary of Westinghouse
- Refueling machine manufacturer
- Single failure proof crane manufacturer
- Ability to provide engineering support for cask handling equipment
- Recent cask crane upgrade at Ft. Calhoun

Westinghouse

Welding Technology - PCI

- PCI Energy Services is a wholly owned subsidiary of WEC Welding & Machining, LLC, a Westinghouse Electric Company
- The industry leader in Canister Seal Welding and Dry Cask Storage (DCS) support
- The only company in the industry that is capable of full turn-key DCS services within one organization without subcontractors



Westinghouse Locations

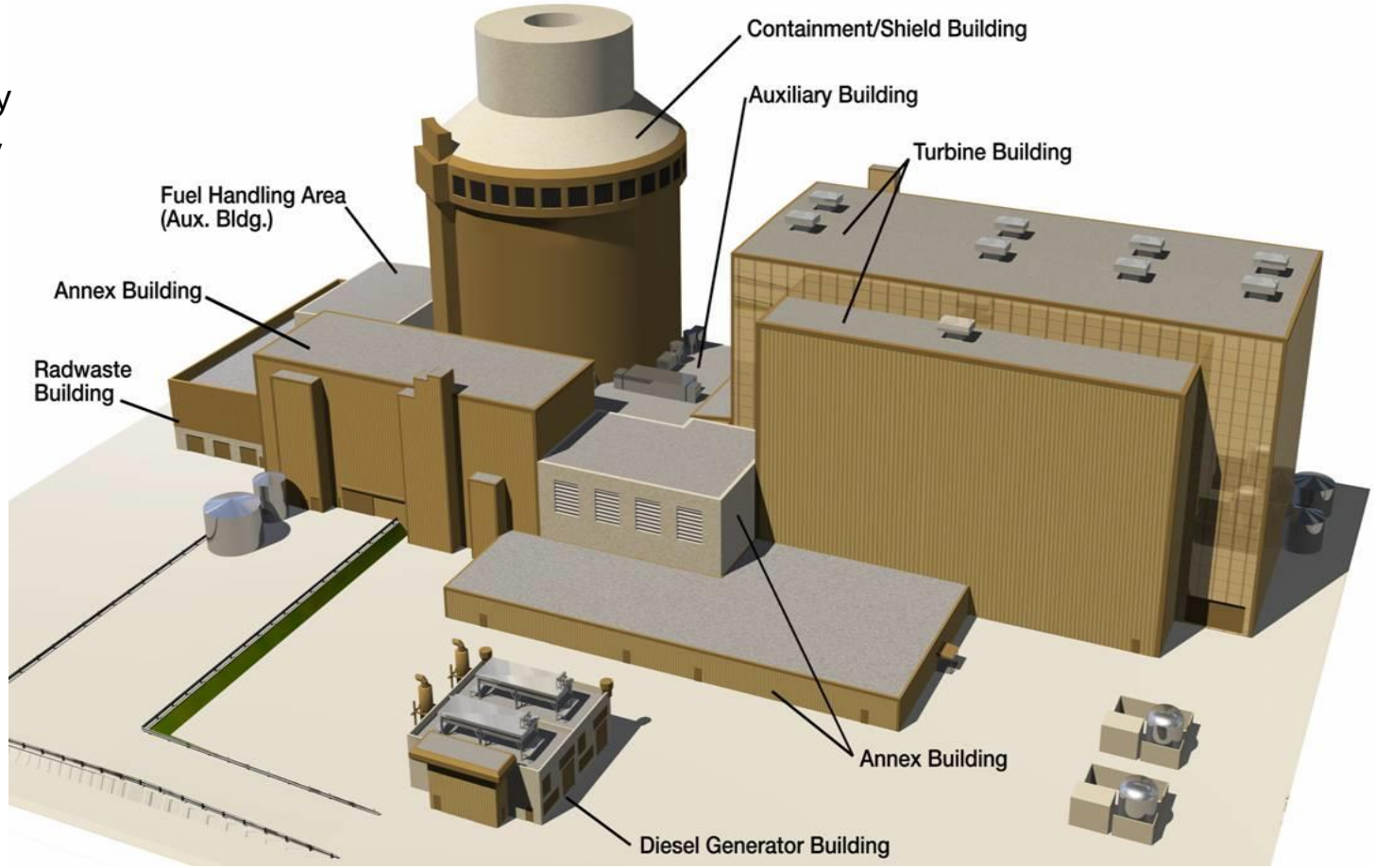
60+ sites worldwide!

*Westinghouse joint venture operations

Westinghouse AP1000®

A Compact Station

- Gen III+ technology
- 3415 MWt, primary system
- 1117 MWe
- Two-loops, two steam generators



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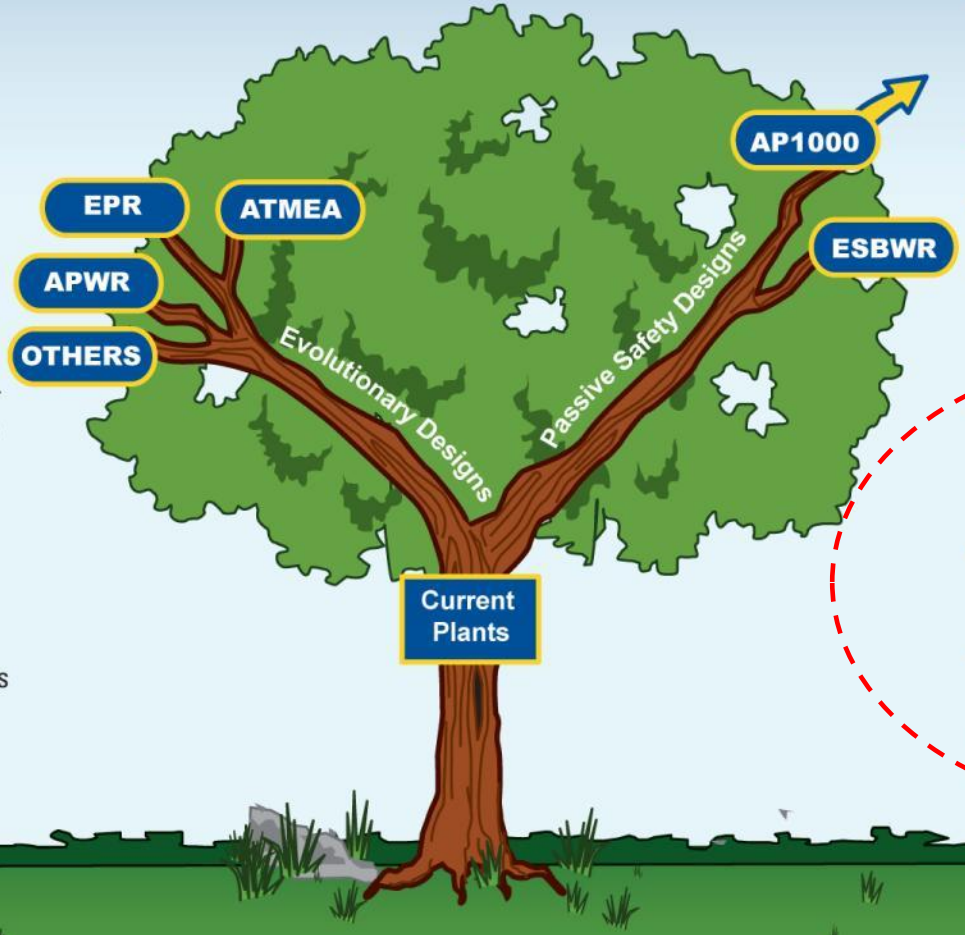
Evolutionary PWRs

- Updates of current 3 & 4-loop designs
- Extensive, safety-grade support systems
- Off-site ac for safety action and safety diesel or turbine -driven generators as backup
- Greater reliance on operator action
- Ultimate heat sink: heat exchangers/water systems



Why AP1000 passive designs?

- Less concrete & steel/MWe
- Simpler, less equipment, less safety-grade equipment, no safety-grade pumps
- Fewer Seismic 1 structures
- Shorter construction schedules
- Less maintenance, maintenance-free canned reactor coolant pumps, simpler Tech Specs
- Much less reliance on operator action to mitigate accidents (72 hours)
- Independent of off-site ac power to operate safety systems
- Ultimate heat sink: ambient air

The preferred technology in the US and China

Major Safety Advancements of the **AP1000** Plant

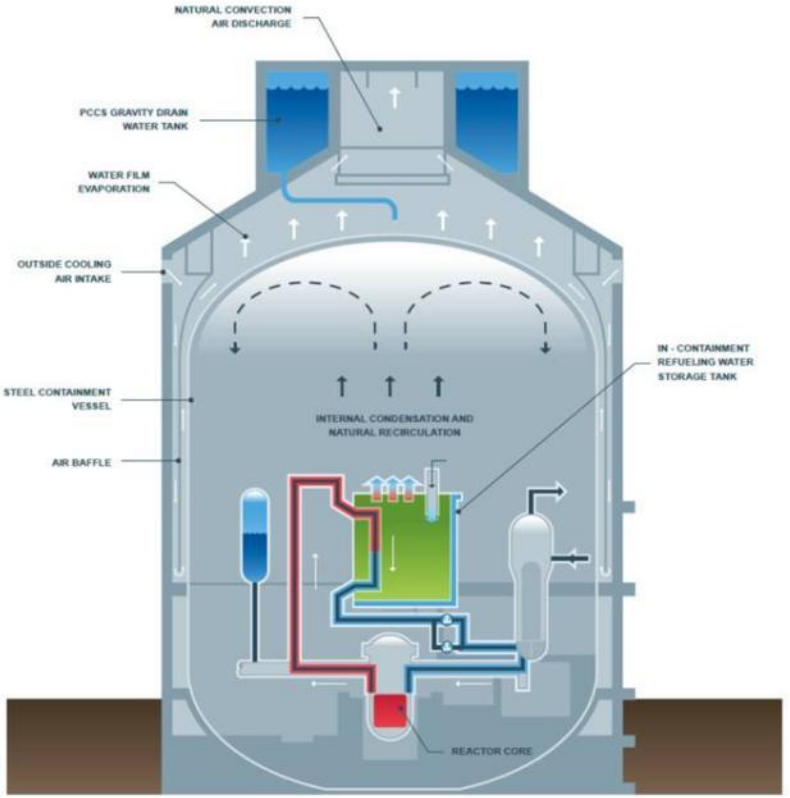
Passive Safety-Related Systems

- 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



If the operating plant at Fukushima had been an **AP1000** plant, there would have been no core melt and no explosions

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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 the 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

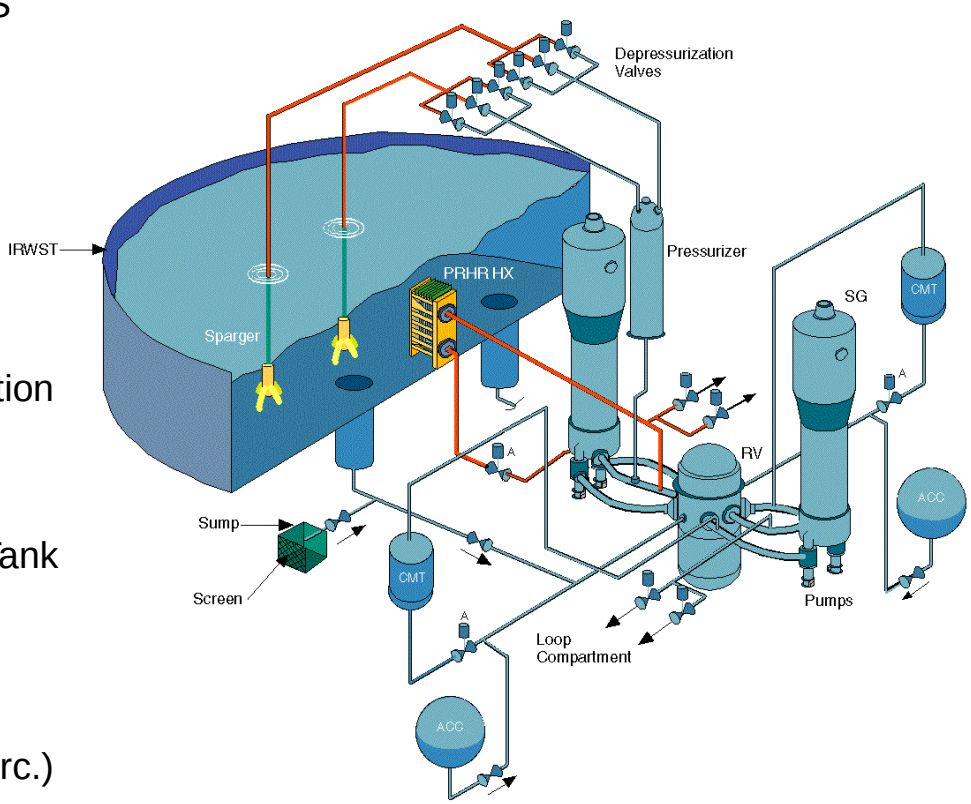
"AP1000 achieves and maintains Safe Shutdown, protects public health and safety, and prevents loss of utility investment."

[…], ***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.*

Former US NRC Commissioner William D Magwood

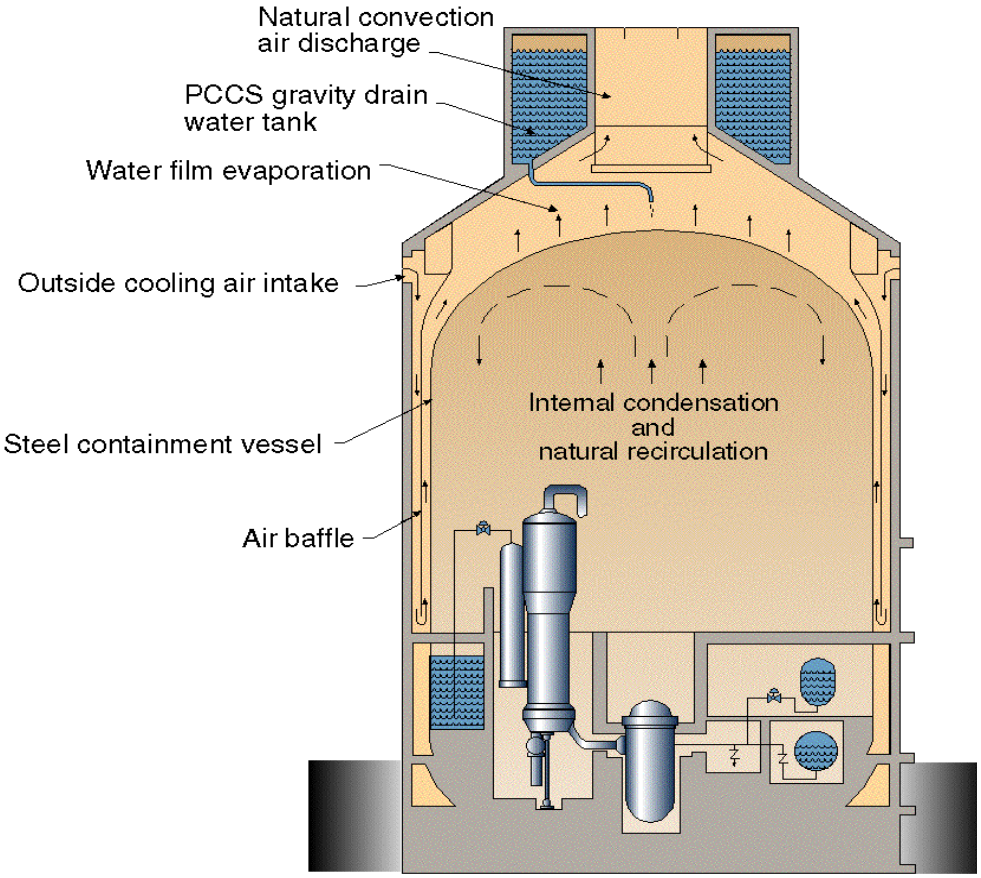
Passive Core Cooling System

- Passive Residual Heat Removal Heat Exchanger (PRHR HX)
  - Natural circ. heat removal (replaces AFWS pumps)
- Passive Safety Injection
  - Core makeup tanks (CMTs)
    - Full RCS pres, natural circ. inject
    - Replaces HHSI pumps
  - Automatic RCS depressurization (ADS)
    - Four stages, controlled depressurization
  - Accumulators
    - Similar to current plants
  - In-containment Refueling Water Storage Tank (IRWST) Injection
    - Low pres (replaces LHSI pumps)
  - Containment recirculation
    - Gravity recirc. (replaces pumped recirc.)



Passive Containment Cooling

- Provides air flow over the outside of the containment vessel by a natural circulation air flow path from the air intake to the air discharge structure.
- Delivers water by gravity from the Passive Containment Cooling Water Storage Tank (PCCWST) to the outside, top of the containment vessel for 72 hours.
- Provides connections for alternate water supplies for post-72 hours.



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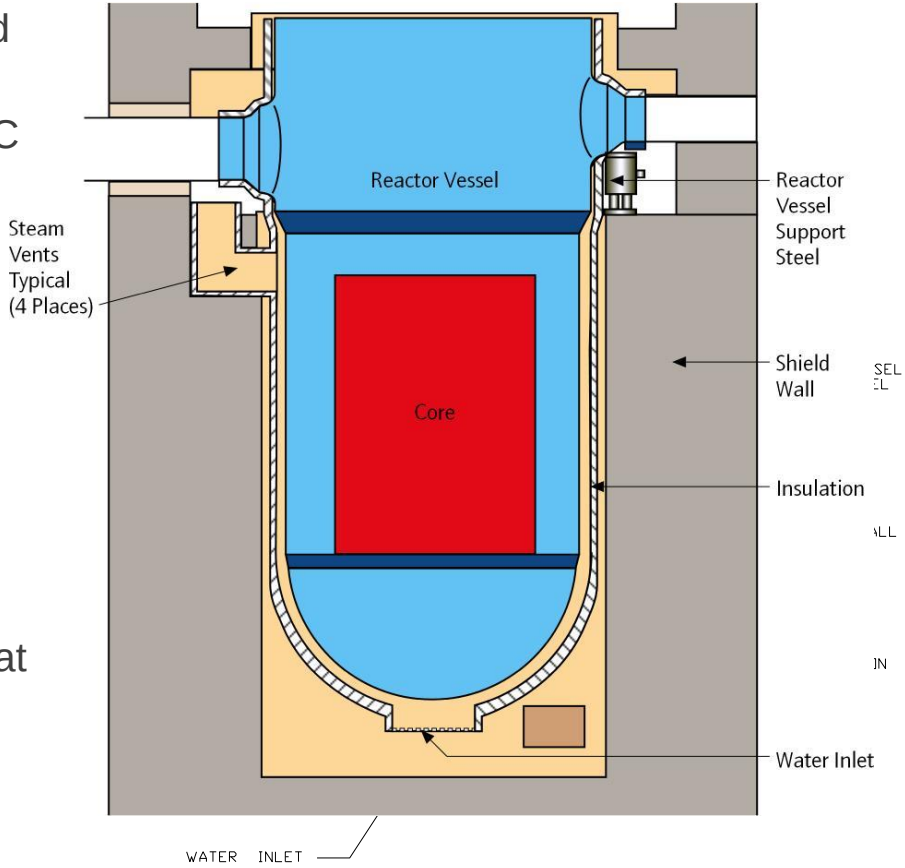
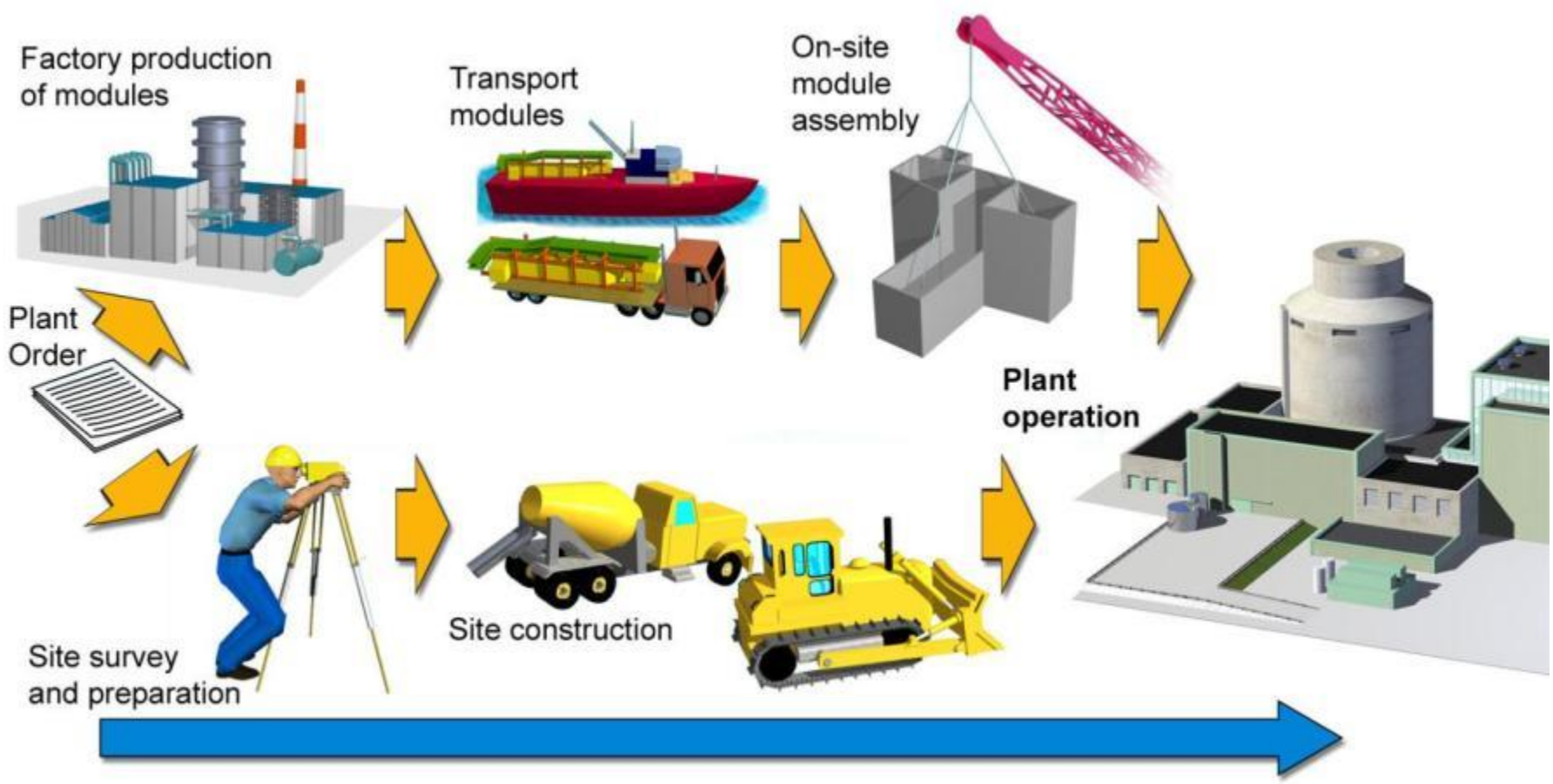
Simple Severe Accident In-Vessel Retention (IVR)

- Provides Reliable Means of Cooling Damaged Core
  - Tests and analyses reviewed by U.S. NRC
- In PRA Core Damage Sequences
  - Cooling flow driven by natural circulation
  - Cooling water flow path in vessel/ insulation annulus
  - Core heat transferred through RV wall
  - Water in containment removes heat from RV
  - ADS valves keep RCS pres low
  - Passive containment cooling transfers heat out of containment
  - Core debris retained inside reactor vessel



Modular Construction Allows More To Be Done in Parallel Result: Shorter Construction Schedule



Placement of Unit 3 Containment Vessel Bottom Head

Placement of Unit 2 Module CA-20

CA 20 Unit Topic 2 2014 v2 prompt

Placement of Unit 2 Containment Vessel Ring 1

AP1000 Plant Global Project Delivery

- Eight **AP1000** units under construction worldwide
  - Four units in China
  - Four units in the United States

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Sanmen Site Progress: Time Lapse View

2009 to 2014

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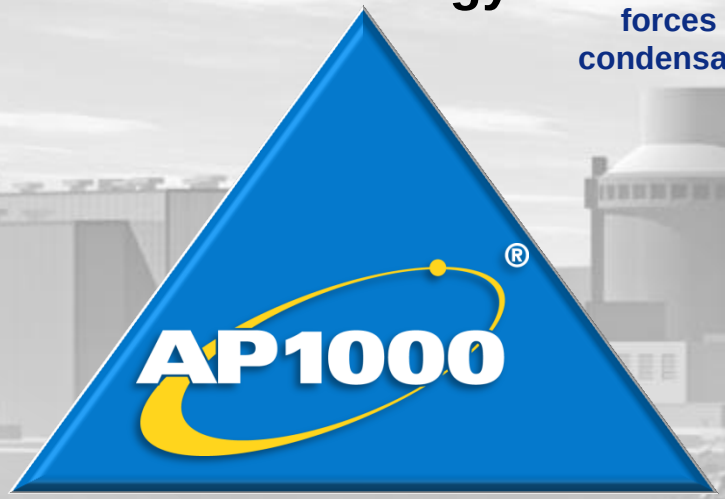
Westinghouse **AP1000™** New Plant Value Drivers

Passive Safety, through Proven Technology

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



Delivery Certainty, through Experience

Provides a plant that is easier and less expensive to Build, Operate and Maintain

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Regulatory Certainty

Reviewed by multiple countries; First Generation III+ reactor to receive design certification from the U.S. NRC

Active Global Partner in Education and Training

- Westinghouse is committed to developing the next generation of engineers and other technical professionals
- UFRJ students participated in Westinghouse internships in 2014 through the “Ciência Sem Fronteiras” program

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UFRJ

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How can you prepare for the future?

- **Build a strong academic record**
  - Learn the basic science and fundamentals of engineering
  - Explore across technical disciplines
- **Get involved in projects**
  - Develop leadership and experience
  - Practice teamwork
- **Get involved in professional organizations**
  - Build a network
  - Learn about industry trends, challenges and opportunities
- **Get involved in community service and activities**
  - Make a difference . . . Even in social networks
- **Maintain a balanced personal and professional life**
  - Focus on Excellence!
  - Have fun!

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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

Come and join us on this journey!

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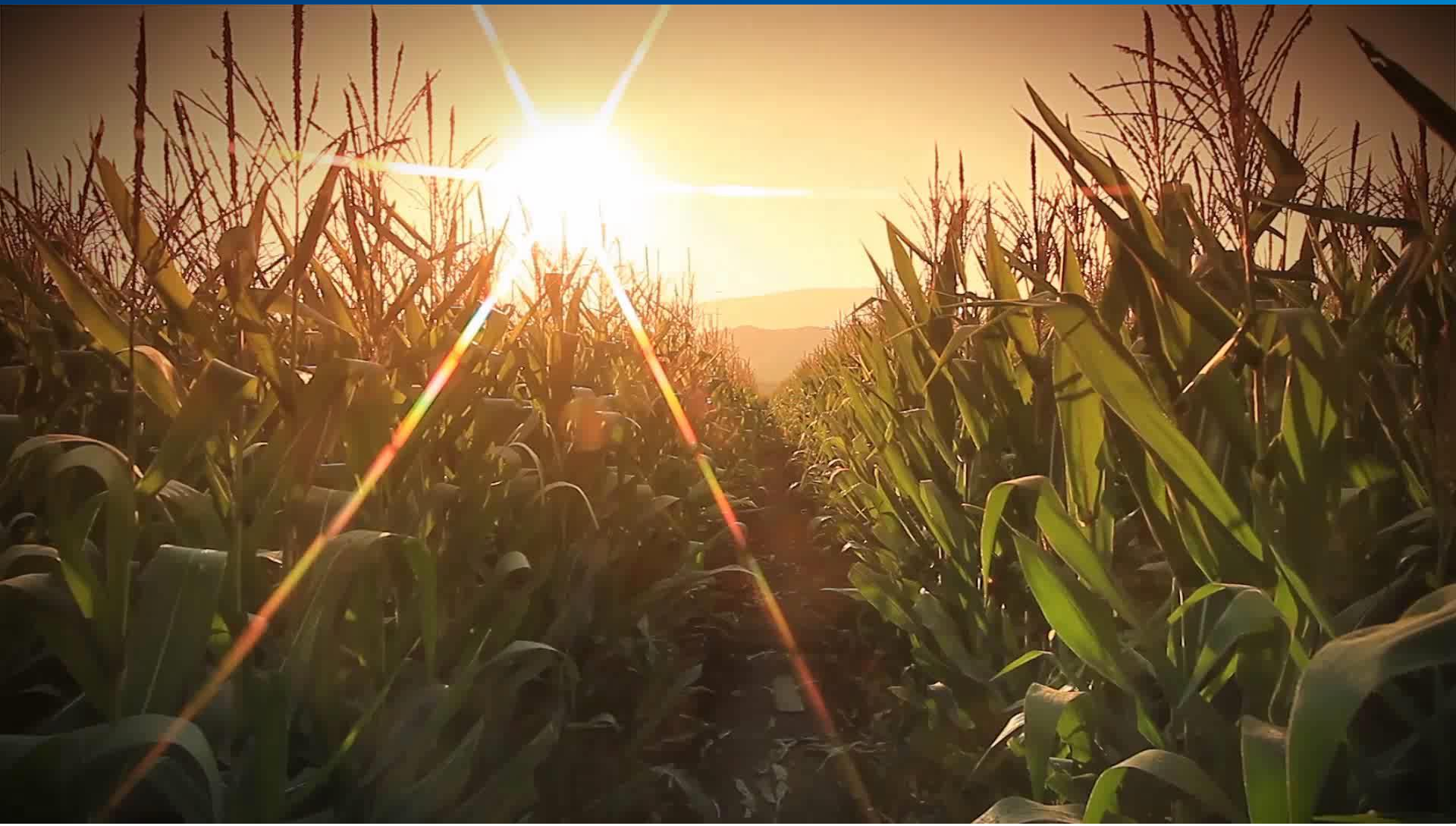

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Obrigado! Questions?

Please visit us at http://www.westinghousenuclear.com/

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