

Westinghouse Nuclear Technology: Energizing the World

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November 2018
IV SENCIR
Belo Horizonte, MG, Brazil



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Back in 2011...



Agenda

- My Background
- Westinghouse
 - History
 - New Plants Technologies
 - Research and Development
 - Presence in Brazil
- My Experience at Westinghouse
 - Intern experience
 - Projects
- Tips for success



Internship Process

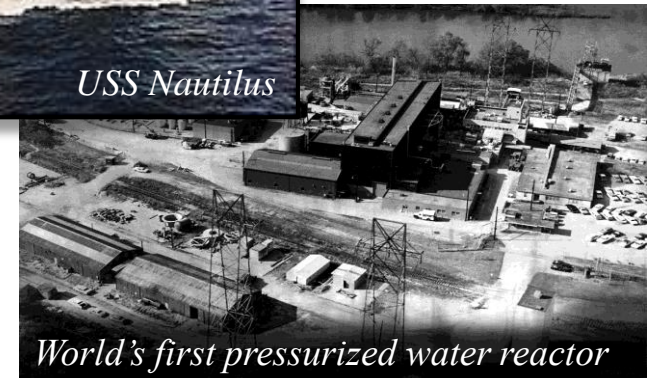
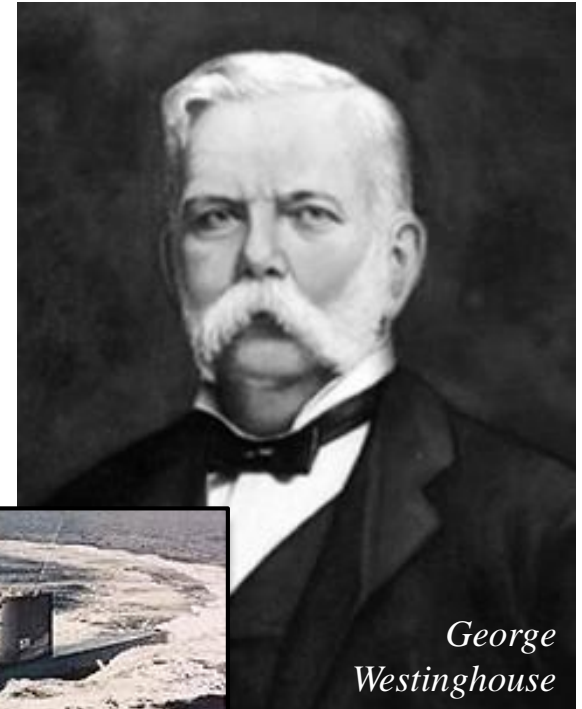
- Brazilian Mobility Program - Science Without Borders-2014
- Pennsylvania State University

Undergraduate Brazilian's Students
At Pennsylvania State University



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



Brookfield



Brookfield Place, New York, NY

- Approximately **\$250 billion** under management globally
- **70,000** operating employees
- **700** investment professionals
- Over **30** countries
- **115** years investing in real assets

www.brookfield.com



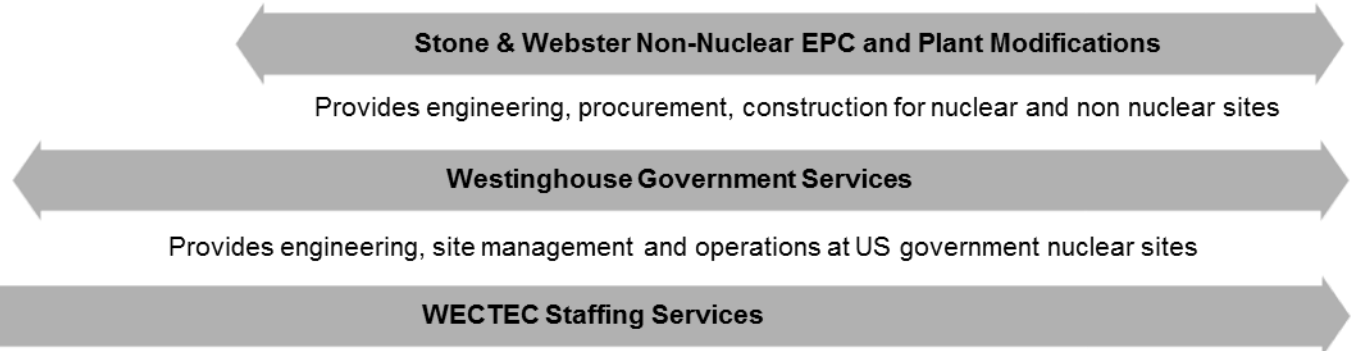
Westinghouse Today: A Leading Position Across the Nuclear Value Chain



Description

| | | | | | | |
|--|--|--|---|--|---|---|
| Designs, develops, procures equipment for new plant projects | Designs, manufactures, delivers PWR, BWR, AGR and VVER fuel globally | Provides critical engineering design and analysis to enhance the safety, availability, and reliability of operating plants | Delivers advanced products and services for complete outage support | Manufactures specialized components for new and operating plants | Engineers safety and non-safety, state-of-the-art instrumentation and control products and services | Provides characterization, decontamination, segmentation, and production of waste treatment systems |
|--|--|--|---|--|---|---|

Adjacent Businesses



New Plant Technologies

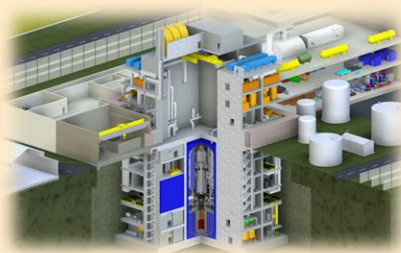
AP1000®



1100MWe

- Gen III+ loop PWR
- Active Deployment

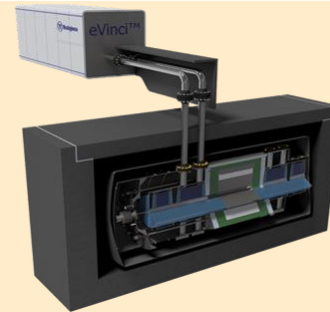
W-SMR



>240MWe

- Integral PWR
- AP1000 derivative
- Development program paused

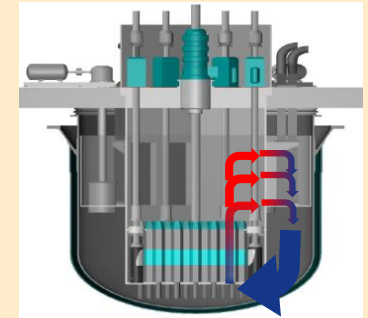
eVinci™



0.2 to 15MWe

- Transportable CHP
- Factory built
- 5-10 year operations
- Deployment in 2020s
- Targeted micro grid applications

W-LFR



400-500 MWe

- Gen IV high temp
- Deployment in 2030s
- Long term LWR replacement

Key Advantages of Westinghouse AP1000 Plant

Proven Technology and Innovative Passive Safety Systems

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



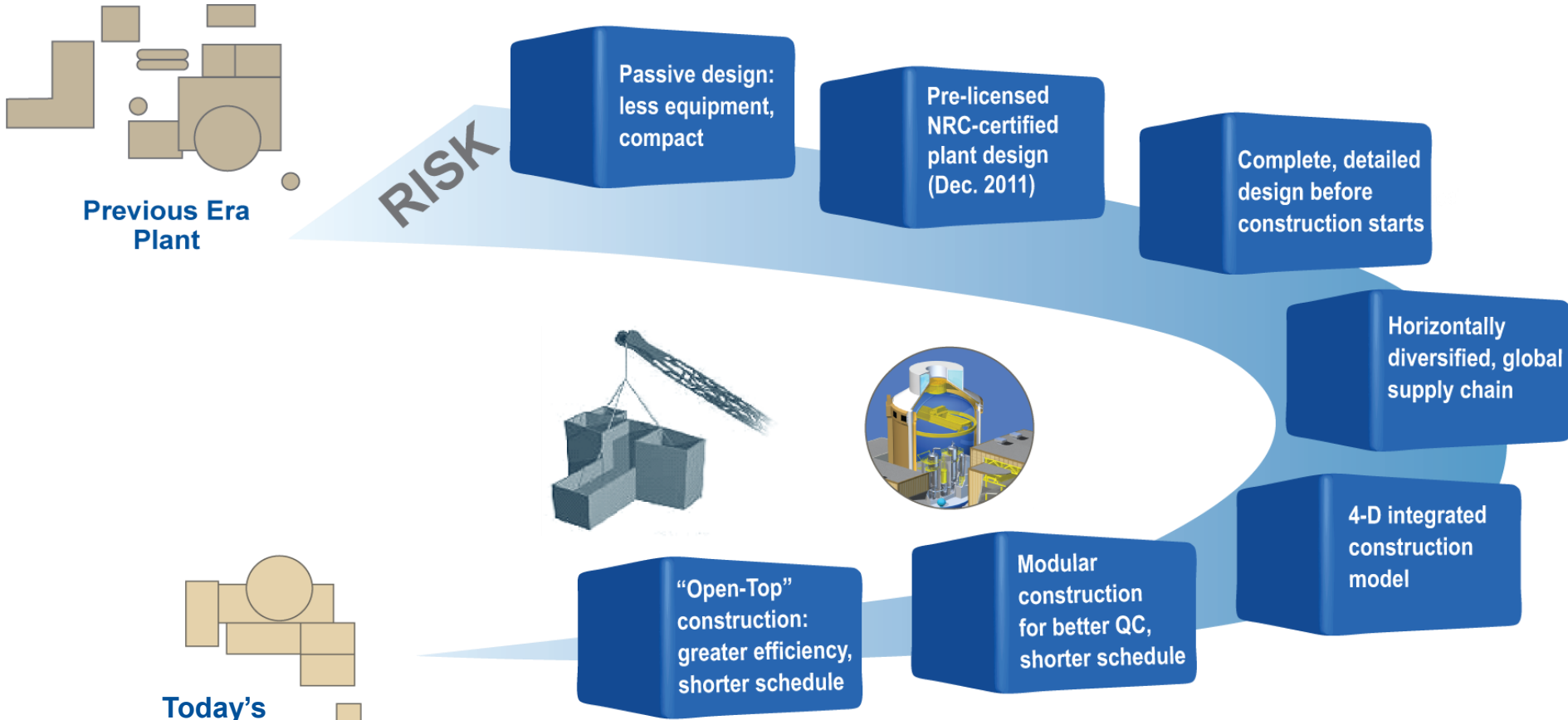
Delivery Certainty

Standard design, experience from current projects and modular construction enable “nth of a kind” delivery performance

Regulatory Certainty

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

AP1000 Plant Design Reduces Project Risks



AP1000 Plant Global Project Sites

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



VOGTLE



HAIYANG

SANMEN



Gen III+ AP1000 Nuclear Power Plant Deployment Key Milestones Reached

Vogtle 3&4

- Westinghouse is continuing to deliver its scope under the services agreement
- Schedule is currently holding to a Unit 3 fuel load date of October 2020; Unit 4 will follow 12 months after



Vogtle Site

China Projects

- Haiyang 2 commenced initial fuel load on Aug. 8
- On Aug. 14, Sanmen 1 successfully reached 100 percent rated thermal power (RTP), Commercial Operation reached on October 1, 2018
- Haiyang 1 initially synchronized to the electrical grid on Aug. 17
- Sanmen 2 safely and successfully connected to the electrical grid on Friday, Aug. 24



Sanmen Plant

Sanmen Site Progress: Time Lapse View

2009 to 2018



Sanmen Unit 1 Nuclear Fuel Loading Complete

SANMEN 1 FUEL LOAD #BYTHENUMBERS

Operation of Sanmen 1 will avoid burning the equivalent of **16 million** tons of coal in China during each 18-month operating cycle



Sanmen 1 is comprised of **157** fuel assemblies with **264** fuel rods in each, totaling over **41,000** fuel rods overall



Regulatory reviews of the AP1000® unit took more than **700 person-years**



Each of the 157 fuel assemblies contain energy equivalent to burning more than **100,000 tons of coal**



Fuel load completed in **four days**



The successful loading of the fuel assemblies into the reactor was the result of a **total Westinghouse team effort**, across the globe



Sanmen 1 will be the **first plant in the world** to utilize **passive safety technology** while providing **more than 100,000 homes** with safe, reliable and clean energy

New Plant Technologies

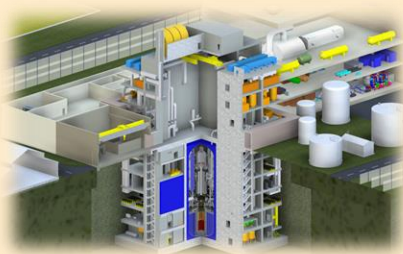
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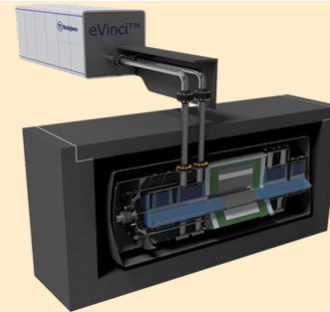
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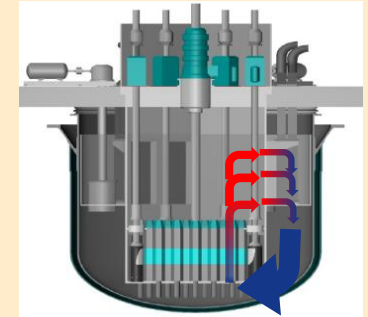
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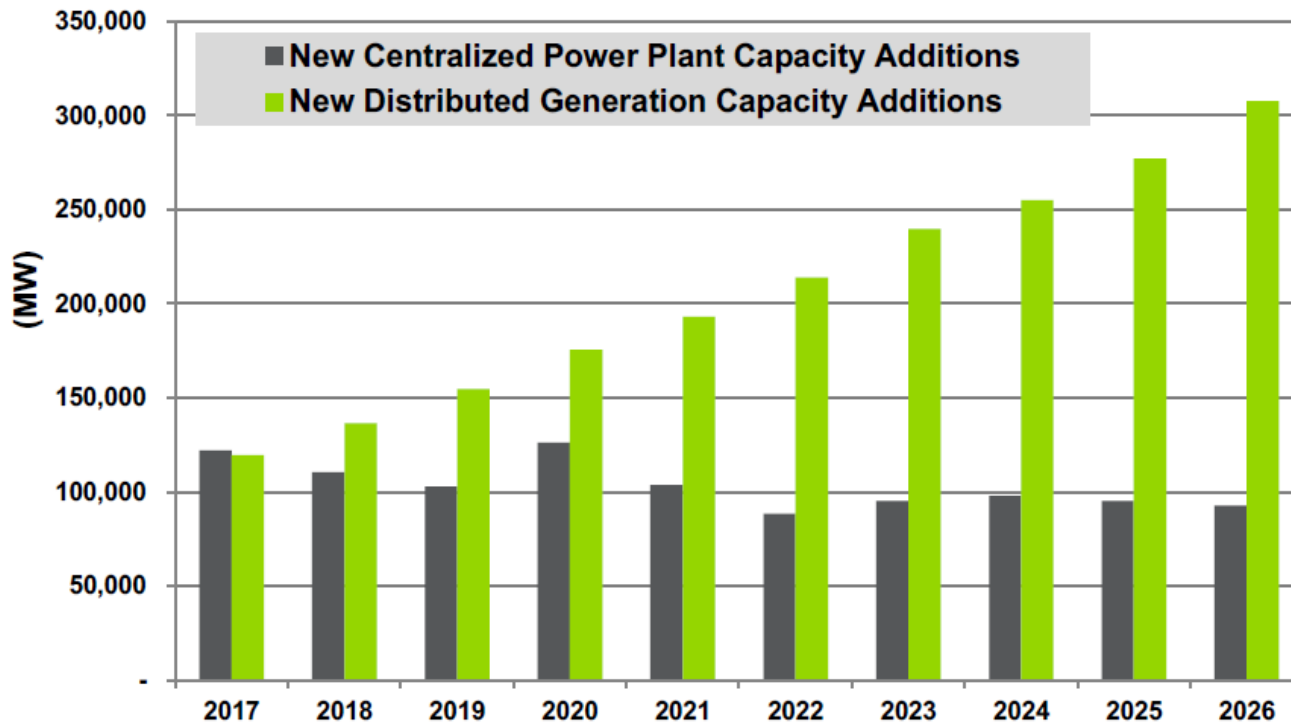


400-500 MWe

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Evolving Energy Market

A turning point: In 2018, new distributed generation (DG) power capacity will overtake new centralized generation

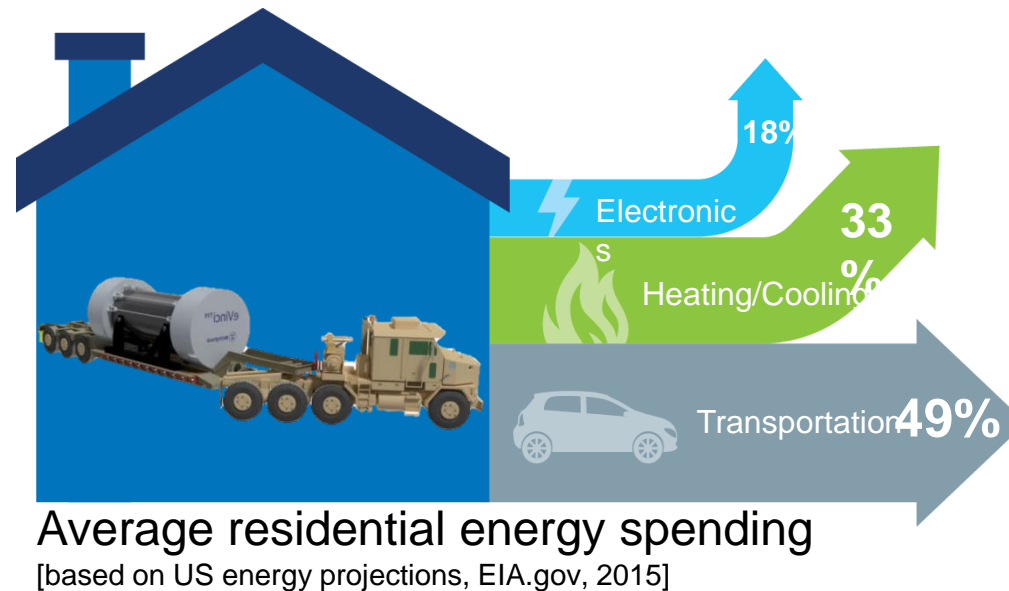


Source: Navigant Research

Forecast:
DG may displace
300 gigawatts of
new large-scale
power plants by
2026

Vision

Disrupt the decentralized energy market with an **autonomous** nuclear micro reactor – for **distributed generation** – that meets **complete energy needs** of the consumer



eVinci's location to the customer can provide them with complete energy needs

A Reactor For A New Age

eVinci™ Micro Reactor

Ultimate Energy Solution for the Off-grid Customer



Long-life nuclear battery **eliminates fuel supply**



Affordable energy for remote communities and mines



Enables Economic Development with abundant power



Clean energy with low environmental impact



Scalable power for complete energy needs



eVinci Product Attributes

Nuclear Battery

- Combined Heat & Power: 0.2 - 15 MWe, up to 600°C
- Transportable energy generator
- Fully factory built, fueled and assembled
- Up to 10 year life
- < 1 month onsite installation

Safety & Security

- “Inherent” safety
 - Physics-based with no “computer signals” or mechanical actuations
- High proliferation resistance

Solid State Technology

- Autonomous load-follow capability
- Heat pipe technology
- Solid Monolithic core block
- Minimal moving parts
- Greenfield-like decommissioning



Manufacturability Goals

- No Welding
- No inspection & maintenance
- Automated Manufacturing
- Scalable and Repeatable
- Robust: Shock & Vibration proof

Accident Tolerant Fuel – The Future of Nuclear Fuel



| | | | | |
|--|---|---|---|---|
|  |  |  |  |  |
| <p>Provides significantly increased safety margins in severe accident scenarios</p> | <p>The suite of EnCore Fuel products offers economic benefits of up to hundreds of millions of dollars</p> | <p>Accelerated delivery timeline</p> | <p>Superior design provides enhanced fuel cycle and plant economics</p> | <p>World's largest supplier of nuclear fuel with world-class partner network</p> |

Westinghouse is Actively Present in all Nuclear Markets in Latin America



Argentina

- Atucha 1 inspection equipment
- Embalse Life Extension Program
- INVAP Engagement

Brazil

- Angra 1 OEM Services, I&C Modernization, Plant Life Extension Program
- Angra 2 Inspection Services
- INB Fuel Technology Transfer
- MOA Signed with UFRJ

Mexico

- Laguna Verde 1 and 2 Outage Support
- Steam Dryer Services
- SFPIS, etc.



What are the key challenges?

- Political stability
 - Needed for decisions to be made, Elections 2018
- Uncertainties in NPP program (business model, regulatory reform)
 - Needed to be addressed to attract private investment
- Human Resources Development
 - Students need clarity of potential jobs
- Communication
 - Sector needs to improve

Working Group

Ministério de

Minas e Energia

Dados Abertos | Legislação | Área de imprensa | Comunidade MME

Minas e Energia > Página Inicial > Outras Notícias > CNPE cria grupo para estudos de viabilidade da Usina Nuclear Angra 3

ASSUNTOS

↳ Página Inicial

Consultas Públicas

Agendamento
Usina Solar

Acesso a
Informação

Agenda de
Autoridades

Conselhos e
Comitês

CNPE cria grupo para estudos de viabilidade da Usina Nuclear Angra 3

Publicação: 18/07/2018 | 17:34
Última modificação: 18/07/2018 | 17:36

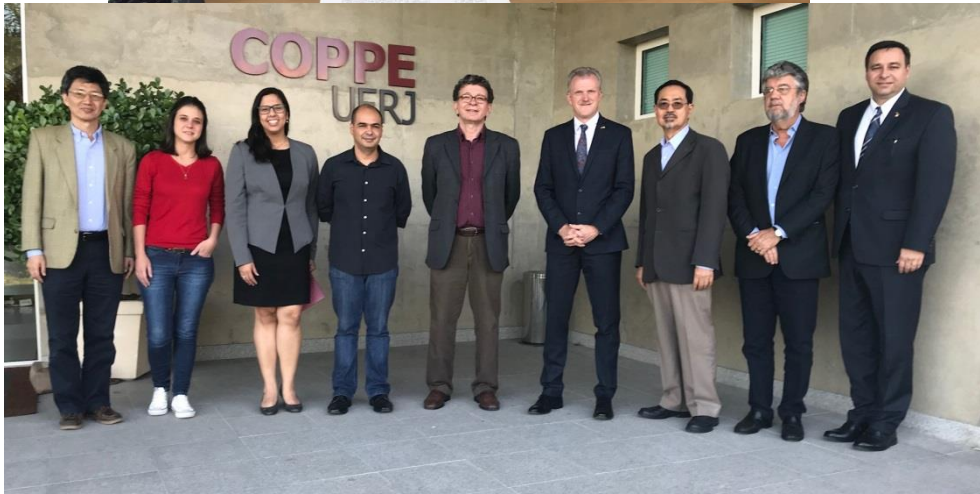
Tweetar



O Conselho Nacional de Política Energética (CNPE) instituiu um grupo de trabalho para realizar estudos e analisar a viabilidade da Usina Nuclear Angra 3. A Resolução foi publicada no Diário Oficial da União desta quarta-feira (18).

O grupo é formado pelos Ministérios de Minas e Energia, Fazenda e Planejamento, além do Gabinete de Segurança Institucional e Secretaria Especial do Programa de Parceria de Investimentos (PPI), vinculados à Presidência da República. Empresa de Pesquisa Energética, Eletrobras e Eletronuclear também participam do GT. O colegiado se reunirá a cada 15 dias e terá o prazo de 60 dias para concluir suas atividades, com possibilidade de prorrogação.

Talent from UFRJ Nuclear Engineering Program



Investing in the next generation of nuclear professionals in Brazil

Interning at Westinghouse is not only just about the technical projects.

- Orientation day
- Mentoring relationship
- Breakfast with the CEO
- Intern competition within the Core Engineering group
- Wrap-up
- Barbecue with the Young Generation group from Pittsburgh

We need to study Fast Transients when performing a BWR reload analysis (2014)

3D Steady-State Core Simulator



1D Fast Transient Code

Intern social events



Westinghouse Brazilians having lunch in Downtown Pittsburgh



Brazilian interns at a Pirates game

Core Engineering interns at the Pirates game



June 2016 – We got hired!

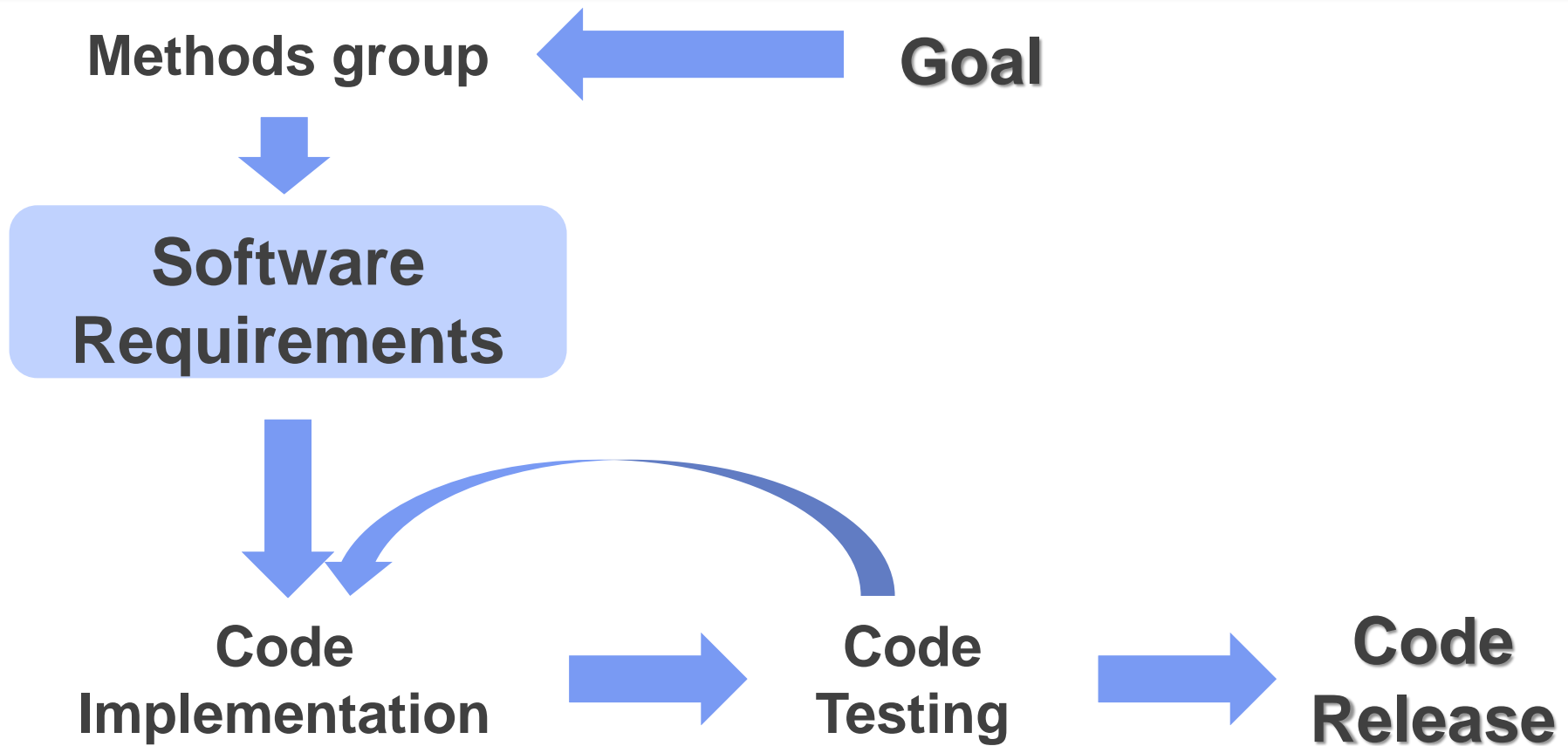


Reduced Reload Safety Analysis Checklist – Core Engineering Group (2015)

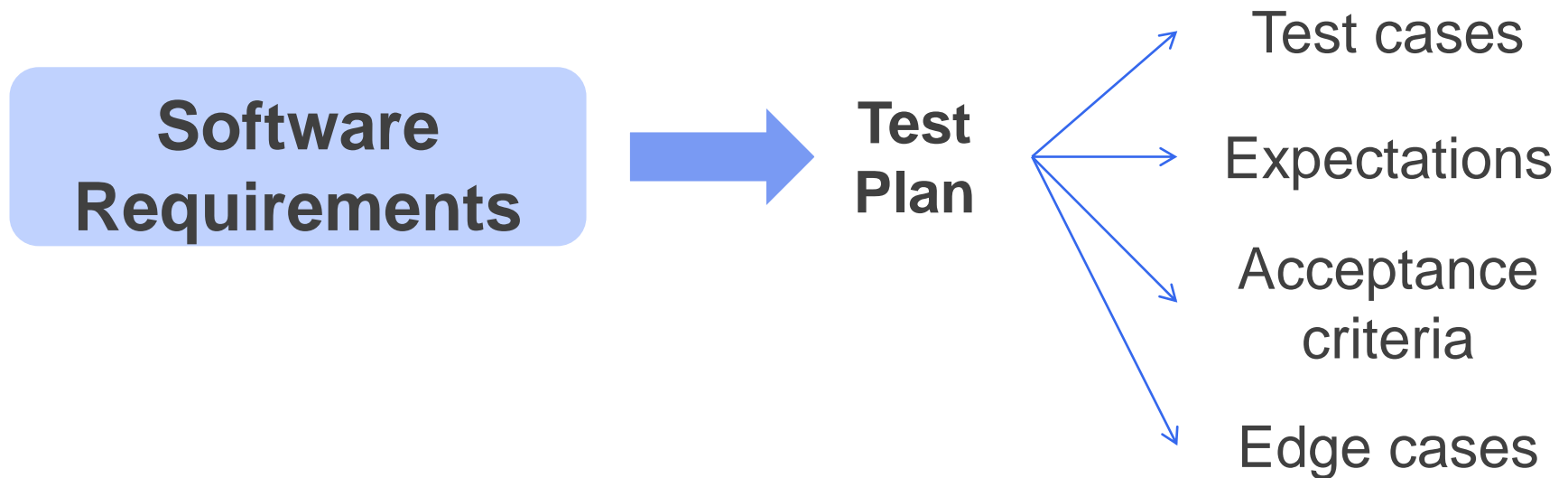
- The RSAC is issued each reload and is a selectively edited list of limiting values for those parameters that are reload sensitive and can affect the accident analysis of a plant.
- The “Reduced RSAC” (RRSAC) approach provides one method of reducing the reload safety analysis and emergency core redesign cycle time.



The software development process involves several steps, including Testing (2015)

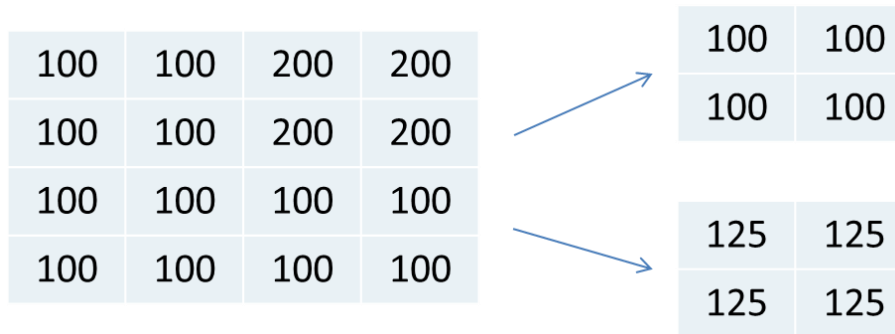


When code testing, we develop a test plan based on software requirements (2015)

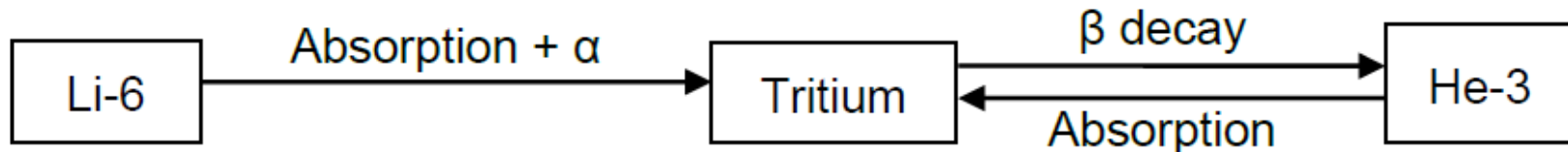


Major Testing Projects

- Quarter-Core Solution



- Tritium-Producing Burnable Absorber Rod



- Generic Inserts Methodology

Highlights

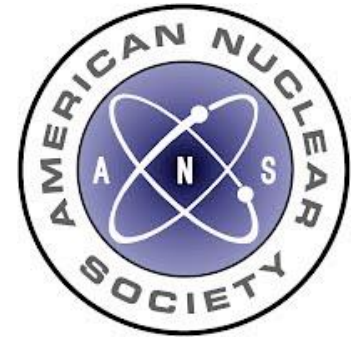
- Networking
- We are always learning new things
- Concern with employees' welfare
- Friendly environment to raise concerns
- Great mentoring

Recommendations to students

- Language
- Dedication
- Be eager to learn
- Proactivity
- Networking

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!



Summary

- **Westinghouse** continues to be ***committed*** to the successful and safe reactor operations in Latin America
 - Capable of Supporting all Reactor Designs in the Region
- The ***AP1000 plant technology*** is the right size, it is passive, standardized and licensed . . . in commercial operation!
- Investing in ***innovation*** to drive future nuclear technologies



THANK YOU

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