Drivers and Impediments for Regional Cooperation on the Way to Sustainable NES

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INPRO Dialogue Forum, IAEA Headquarters, Vienna, Austria
30 July – 03 August, 2012
Overview of the Presentation

1. Nuclear Power Program in Brazil: Status and Prospects
2. Drivers and Impediments for Expansion
3. Nuclear Energy System in Brazil (2030 and 2050)
4. Nuclear Power by Foreigners Suppliers
5. Back-End Fuel Cycle Services
6. Sustainable Nuclear Energy System
7. Energy Independence and Security of Supply
8. Cooperation in Energy Projects
9. Cooperation in Nuclear Power Projects
10. Indicators of Cooperation in Nuclear Energy Projects
1. NP Program in Brazil – Status & Prospectus

Electricity generation
- Eletrobrás Thermonuclear S/A – Eletronuclear
- A government-controlled company that in-charged of operating and building thermal nuclear power plants in Brazil

Fuel Cycle
- Brazilian Nuclear Industries (INB)
- INB act on the uranium productive chain, from mining to the production of the fuel that powers the reactors in the NNPs

National Nuclear Authority
- National Nuclear Energy Commission of Brazil (CNEN)
- Formulation of the national energy policy
- R&D, services in nuclear technology applications
- Regulation, licensing, authorization, controlling and supervision
1. NP Program in Brazil – Status & Prospectus

Electricity generation

- Admiral Álvaro Alberto Nuclear Power Station

- Angra 1 NPP: 657 MWe PWR, Westinghouse, 1985
- Angra 2 NPP: 1350 MWe PWR, Siemens/KWU, 2002
1. NP Program in Brazil – Status & Prospectus

Electricity generation

- Nuclear Power Station Almirante Álvaro Alberto

- Angra 3 NPP: 1350 MWe PWR, Siemens/KWU, 2015 (a replica of Angra 2 NPP; it incorporates the technological advances since construction of the latter)
Electricity generation

- National Energy Plan 2030 (PNE 2030)
  - Expansion of 130.1 GWe of installed electricity capacity
  - Hydropower energy shall contribute with 87.7 GWe
  - Nuclear energy shall contribute with 5.3 GWe
1. NP Program in Brazil – Status & Prospectus

Electricity generation

- 2030
  - 2 NPPs in the Northeast (2000 MWe)

- 2 NPPs in the Southeast (2000 MWe)
1. NP Program in Brazil – Status & Prospectus

Fuel Cycle

- Mining (Brazil)

- Milling (Brazil)
1. NP Program in Brazil – Status & Prospectus

Fuel Cycle

- Uranium concentrate ($\text{U}_3\text{O}_8$) production:
  - Caetité (State of Bahia)
    - Current production: 400 ton/year
    - 2013 production: 900 ton/year
  - Santa Quitéria (State of Ceará)
    - 2015 production: 600 ton/year
1. NP Program in Brazil – Status & Prospectus

Fuel Cycle

- Uranium conversion $U_3O_8$ / $UF_6$:
  - Currently: Canada
  - 2013 start production: 1200 ton/year
  - 2018 increase production to 2400 ton/year
1. NP Program in Brazil – Status & Prospectus

Fuel Cycle

- Enrichment (Brazil and Europe)
1. NP Program in Brazil – Status & Prospectus

Fuel Cycle

- Uranium Enrichment in Brazil
  - Started in 2006

- At the moment
  - 730 kg of 4% enriched uranium/year
  - Current capacity: 115,000 SWU/yr (separative work unit/year)

- Full stage 1
  - 60% of the fuel needs for Angra 1 & 2 NPPs
  - Capacity for 200,000 SWU/yr
1. NP Program in Brazil – Status & Prospectus

Fuel Cycle

- Reconversion (Brazil)

- Pellets (Brazil)
1. NP Program in Brazil – Status & Prospectus

Fuel Cycle

- Fuel element (Brazil)
2. Drivers and Impediments

Main Driving forces

• Reserve of uranium
• Reliable supply
• Reduction of greenhouse gases emission
• Price of petroleum and natural gas are increasing
• Nuclear power is considered a strategic technology (industry, medicine, materials, navy and research)
• Income distribution in Brazil has improved and the demand for electricity is increasing
2. Drivers and Impediments

Major Impediments

- Public acceptance
- Governmental policies
- Lack of definition of the national deposit for LLW (Low Level Waste) and ILW (Intermediate Level Waste)
- Lack of definition of the national deposit for SNF (Spent Nuclear Fuel) and HLW (High Level Waste)
3. NE system in Brazil (2030 and 2050)

2030 Scenario - PNE 2030

- Reactors: 7 NPPs in operation
  PWR technology
  Installed capacity of 7357 MWe
  (share of ~ 5% of total capacity)

- Fuel Cycle: Domestic once-through (industrial scale)
  Deposit for LLW & ILW
  Intermediate deposit for SNF & HLW

2050 Scenario: Not yet defined
4. Nuclear Power by Foreigner Suppliers

- Angra 1, 2 and 3 NPPs were built with foreign technology.

- Next 2 NPPs in the northeast (by 2022) shall be supplied by foreign vendors (EPR and AP1000 under consideration).

- Technology transfer expected from suppliers.
5. Back-End Fuel Cycle Services

- Brazil masters the open fuel cycle
  - CNEN plans an intermediate deposit for the SNF and HLW storage
    - Final geological repository is not currently under consideration (*wait and see policy*)
  - National deposit for the LLW and ILW is an ongoing government project
    - No legal provision regarding transit of return of SNF and HLW to other countries
6. Sustainable Nuclear Energy System

- Brazil adopts the Brundtland report (1987): “The development that meets the needs of the present without compromising the ability of future generations to meet their own needs”

- National on-going activities of analysis and assessment of NE system:
  - Long-term NE planning studies conducted by the Company of Energetic Planning of the Ministry of Mines and Energy
  - Application of INPRO methodology for Innovative Nuclear Energy systems (INSs)
6. Sustainable Nuclear Energy System

Priority areas regarding nuclear energy system sustainability:

1. Economics
2. Safety
3. Waste management
4. Environment
5. Infrastructure
6. Physical protection
7. Proliferation resistance

Belmonte Hydroelectric

- State of Pará (Altamira)
- Capability: 11200 MW
- Average/year: 4500 MW
- Public opinion: against

Wind energy
- Low average power per year
8. Cooperation in Energy Projects

- Itaipu Bi-national Co. (Brazil – Paraguay)
  - Hydropower – 14000 MWe installed capacity
9. Cooperation in Nuclear Power Projects

- Brazil – United States: Angra 1 NPP
- Brazil – Germany: Angra 2 & Angra 3 NPPs
- Brazil – Argentine: ABBAC, research reactor

Licensing

Research
- The intermediate deposit for the SNF and HLW
- National deposit for LLW and ILW
10. Indicators of Cooperation in NP projects

- Number of bi-lateral and multi-lateral agreements for transference of nuclear power technology (reactor and fuel cycle technologies)

- Number of participation in international initiatives for development of nuclear energy systems (Gen IV Intnl Forum and INPRO/IAEA)

- Number of bi-lateral and multi-lateral agreements for R&D on nuclear power technology
Thank you for your attention

- CNEN
- National Nuclear Energy Commission