Nuclear Power Plant Programme in Brazil

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ELETRONUCLEAR

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Power Generation in Brazil

BRAZIL

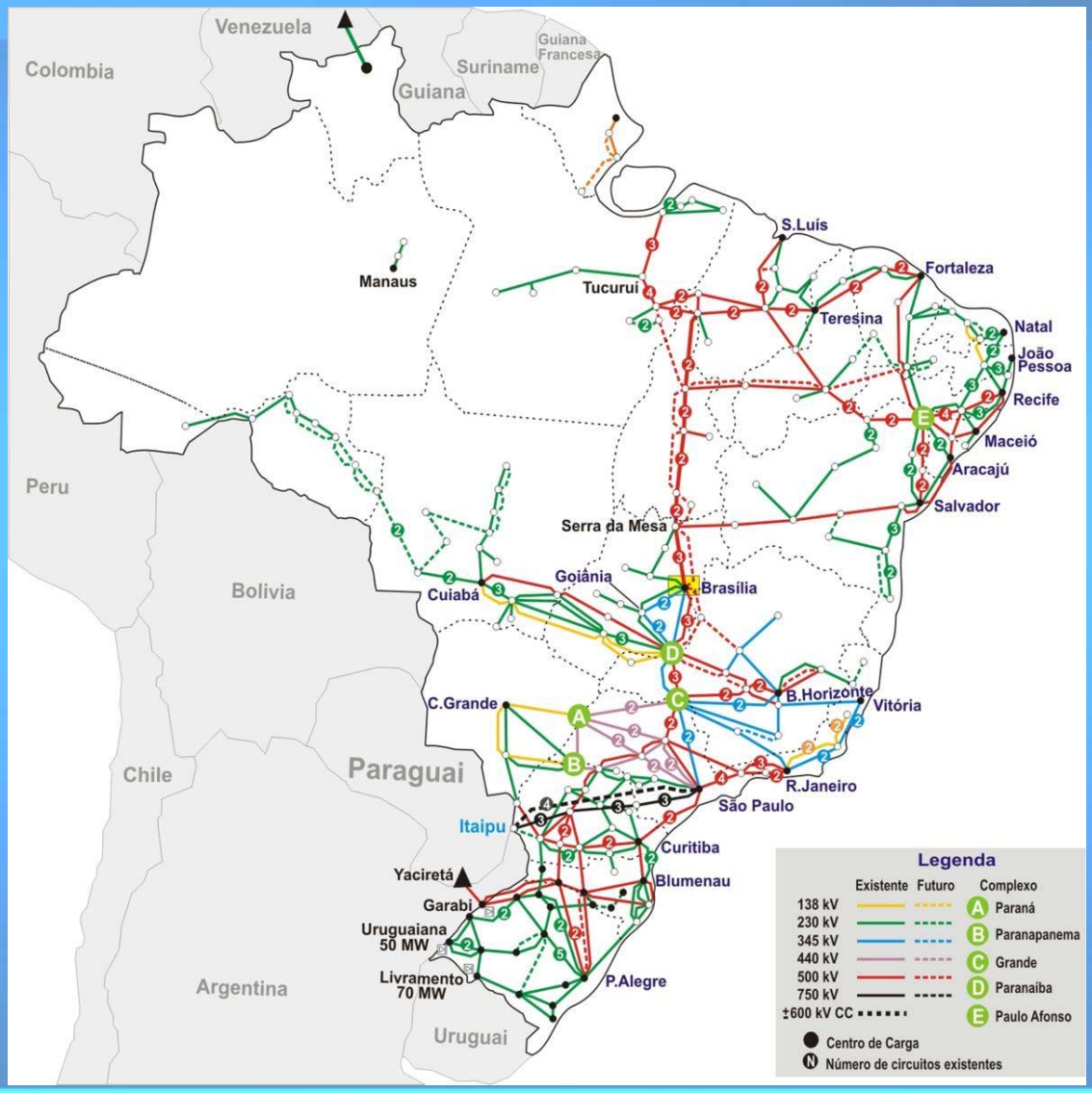
- Area: 8.5 million km^2
- Population: 190 million
- Total installed capacity: 104.8 GW
- Total electric power consumption: 390 TWh
- Electricity per capita consumption: 2 MWh/inh

Power Generation in Brazil

Power Generation	Installed Capacity (2006) [GW]	Plants	[%]
Hydro	74	638	71
Gas	10.8	101	10
Oil	4.5	566	4.3
Renewable	3.7	269	3.5
Nuclear	2	2	1.9
Coal	1.4	7	1,3
Wind	0.2	15	0.2
Imported	8.2	*	7.8
Total	**104.8**		**100**

* Paraguai 5650 MW, Argentina 2250 MW, Venezuela 200 MW, Uruguai 70 MW

Transmission System



Electrical Subsystems

Electrical System

SUBSYSTEM	Average Load [MW]		%
	2005	2006	2006 / 2005
SE / Center	28355	29355	3.5
South	7557	7851	3.9
NE	6695	6913	3.3
North	3102	3353	8.1
TOTAL	45709	47473	3.9

Electrical System

SUBSYSTEM	Peek Load [MW]				
	MW 2005	Month	MW 2006	Month	% 2006 / 2005
SE / Center	38426	Apr	39433	Apr	2.6
South	11056	Apr	10983	Mar	-0.7
NE	8609	Oct	9047	Dec	5.1
North	3702	Nov	3977	Dec	7.4
TOTAL GRID	60918	Apr	61782	Apr	1.4

Electrical System

POWER OF THE NEW PLANTS

• Average Load Increase		4%/year
• SE/C	Average Load	30 GW
	Peek Load	40 GW
• S, NE, N	Average Load	< 8 GW
	Peek Load	< 12 GW

➢ Power of the new NPP 1 to 1.2 GW

Energy Planning

STRATEGIC ASPECTS

- **Reduction of large regional differences**. Some regions have not enough installed power plants resulting in high transmission costs.
- **Diversity of power plant type.** Reduction of the high dependency on hydro-electric plants. (Some regions depends only on hydro-electric power.)

➢ NE (today only hydro-electric power)

➢ SE/C (no more hydro-electric power possible)

Energy Planning

NUCLEAR POWER PLANTS

10 Years Energy Planning (2007-2016)

- 2014 SE/C 1.4 GW NPP Angra 3

National Energy Planning (2030)

- 2019 NE 1 GW
- 2021 NE 1 GW
- 2023 SE/C 1 GW
- 2025 SE/C 1 GW

4 NPP's

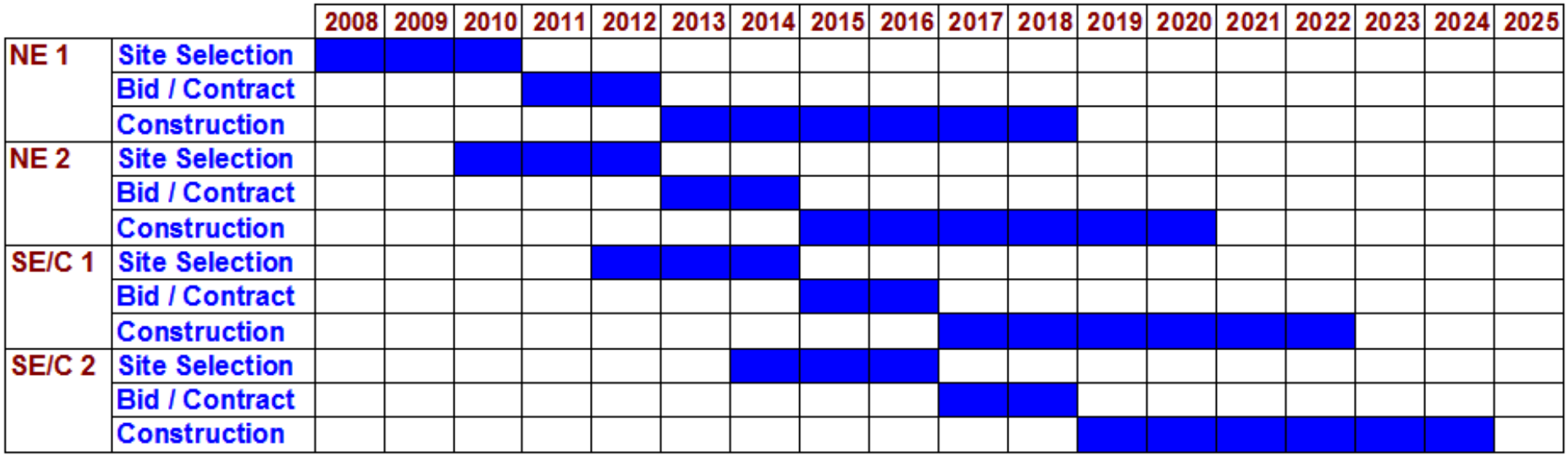
Economic and Financial Aspects

	New NPP in USA	Future Brazilian NPP
Overnight capital costs	US$ 1200 / kW	US$ 2000 / kW
Overnight capital costs (FOAKE)	US$ 1500 / kW	US$ 2400 / kW
Plant life	60 years	60 years
Construction	< 5 years	< 6 years
Load capacity	90 %	85 %

Preliminary evaluation for planning

Energy Planning

NPP Time Schedule



- **Each site will have a infrastructure for 6 plants (future expansion)**

Site Selection

Preliminary Site Selection

NE

SE/C

Site Selection

NE

Site Selection

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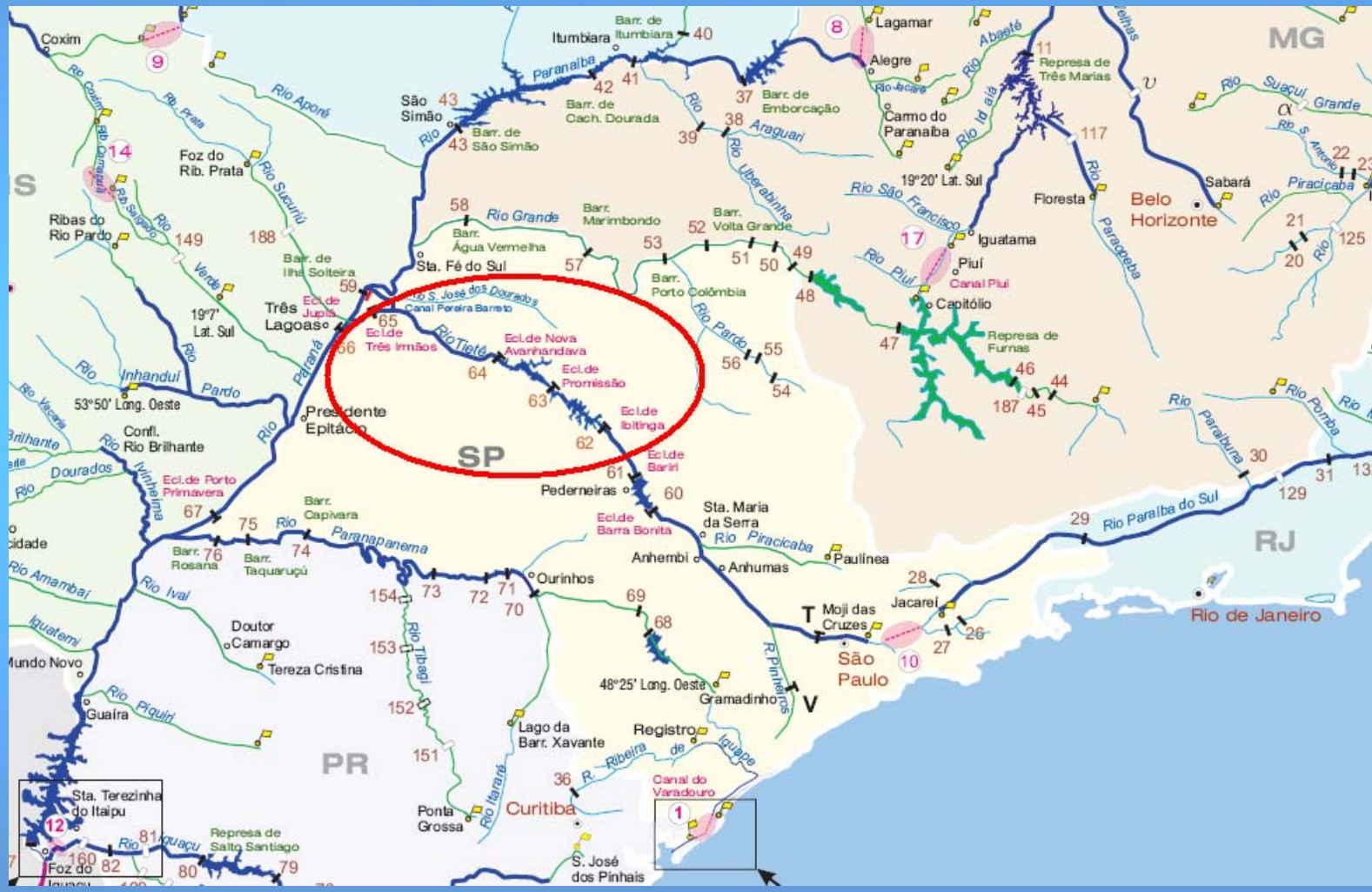
SE/C



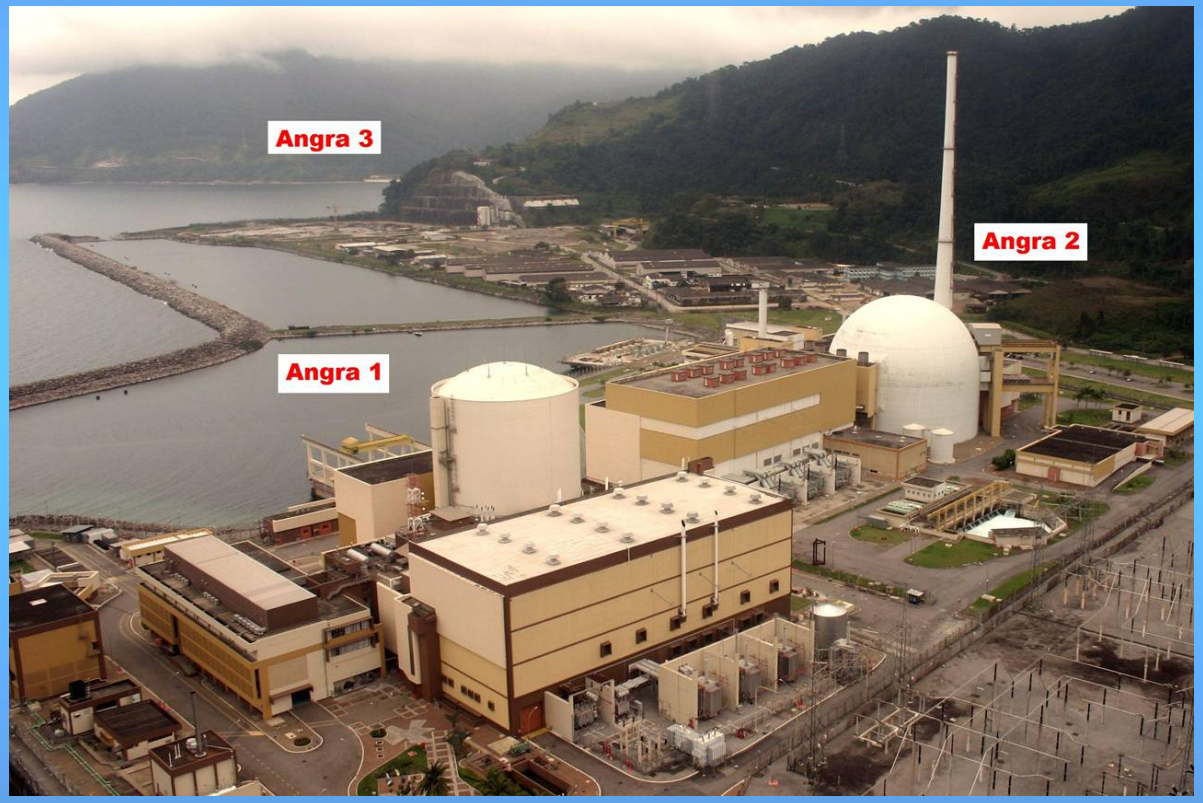
Energy Planning

Definitions of the future Brazilian NPP based on the energy planning:

- NPP size → 1000 to 1200 MWe
- Site with 6 NPP's for future expansion
- 4 NPP's planned until 2030
- Site region → NE and SE/C

Nuclear Power Plants in Brazil

- **Angra 1** - 657 MW
  Westinghouse PWR
  Operation since 1985
- **Angra 2** - 1350 MW
  KWU/SIEMENS PWR
  Operation since 2000
- **Angra 3** - 1405 MW
  KWU/SIEMENS PWR
  Construction



Nuclear Power Plants in Brazil

- **First NPP**
  - **Angra 1** - 657 MW - Westinghouse PWR
    Operation since 1985
- **Past Nuclear Power Programme (1975)**
  - 8 NPP 1300 MW - Technology Transfer
  - **Angra 2** - 1350 MW - KWU/SIEMENS PWR
    Operation since 2000
    Power increase to 1405 MW scheduled to 2010
    Studies for power increase to 1445 MW (Turbine changes)
  - **Angra 3** - 1405 MW - KWU/SIEMENS PWR (AREVA)
    In construction (Operation scheduled to 2014)
- **Future Nuclear Power Programme**
  - First phase (2019 - 2030): 4 NPP's 1000 MW

Brazilian Structure in Nuclear Power

ELETRONUCLEAR – Design and Operation

- design, procurement and follow up of Brazilian and foreign equipments for NPPs
- management of construction, erection and commissioning of NPPs
- operation of NPPs
- Transfer technology contract with KWU/SIEMENS, ELETRONUCLEAR for the design of a great part of Angra 2 and 3.

➢ **Experience: PWR**

Brazilian Structure in Nuclear Power

ELETRONUCLEAR

INB – Fuel element production

- Uranium concentrate (yellow cake)
- Uranium dioxide powder
- Uranium pellets
- Uranium enrichment (pilot plant)
- Fuel elements for the Angra 1 and 2

Uranium reserves in Brazil (2006)

- Measured: 66,000 t U_3O_8 (< 40 US$/kg U)
- Measured: 111,000 t U_3O_8 (< 80 US$/kg U)
- Inferred: 132,000 t U_3O_8 (< 80 US$/kg U)
- Total: 309,000 t U_3O_8
  This amount covers the supply of domestic needs on the long run and the oversupply will be available for the international market.

Brazilian Structure in Nuclear Power

NUCLEP – Heavy Components Production

- Through a transfer technology contract with German and Austrian companies, the NUCLEP participated in the production of the heavy components for Angra 2 and 3.
- NUCLEP fabricated in 2008 the replacement steam generators for Angra 1.
  - AREVA design.
  - Replacement in March 2009.

Brazilian Structure in Nuclear Power

CNEN – Licensing Authority

- ***Licensing of the Angra 1 NPP (Operation)***
  Final Safety Analysis Report (FSAR) according to the U.S. NRC (United States Nuclear Regulatory Commission) standard format.
- ***Licensing of the Angra 2 NPP (Operation)***
  Final Safety Analysis Report (FSAR) adapted to the NRC format, as far as possible, to meet the requirements of the CNEN. German standards.
- ***Licensing of the Angra 3 NPP (Construction)***
  Preliminary Safety Analysis Report (PSAR) is based on the reference plant Angra 2. Digital I&C and other improvements.

➢ **Experience: PWR, US-NRC, German standards**

Strategic Aspects

- **Development of the Brazilian industry**
  Reduction of import dependency.
  Availability of spare parts.
  Adaptation of the water-steam cycle and auxiliary systems.
  (NSSS supplied by the NPP designer)
- **Fuel cycle industry**
  Reduction of the costs of the existing Brazilian fuel cycle industry.
  (Experience in PWR fuel elements)

Definition of the characteristics of the NPP

Past steps:

- Definition of type and size of the NPP → PWR 1 to 1.2 GW.
- ELETRONUCLEAR made several basic designs of the water-steam cycle of a PWR, starting from a single secondary circuit with one turbine up to two fully separated secondary circuits with two turbines (common steam and feed water header) to identify Brazilian suppliers of components.

Present steps:

- Identification of the possible NSSS suppliers
- Identification of the possible Brazilian suppliers of components for water-steam cycle and auxiliary systems.
- Economic and financial analysis.
- Site regions. Possible site locations (6 NPP's).

Definition of the characteristics of the NPP

Future steps:

- Site location in the selected region.
- Selection of the NSSS supplier.
  - Joint work between ELETRONUCLEAR and the NSSS supplier to define the overall project.
  - Decision about passive safety systems (remote locations).
- The possibility to incorporate, in the NPP project, a plant for Seawater Desalination.

Definition of the characteristics of the NPP

Status of the definition of the future Brazilian NPP

- Experience → PWR
- Experience → Licensed by US-NRC
- Standardization → Site with 6 NPP's
- Standardization → Same type of NPP
- NPP size (grid size) → 1000 to 1200 MWe
- Site selection → NE and SE/C

Next Steps

- Definition of the NSSS supplier
- Site location

Nuclear Power Plant Programme in Brazil

Thank you for your attention!