BRAZIL

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1. GENERAL INFORMATION

1.1. General Overview

Brazil is a federal republic in South America, bounded on the north, west and south by every country of the continent except Chile and Ecuador, and on the east by the Atlantic Ocean, along 7,400 km (4,600 miles) of coastline. The country covers an area of 8,514,215,3 square kilometres, about half of all South America, and is the world's fifth largest country in area. Stretching for approximately 2,700 miles from north to south and from east to west, it contains no desert, high mountains, or Arctic environments that would limit the extent of human occupancy.

The population of Brazil, as of 2000, was about 170 million. Table 1 shows historical statistical data concerning population. Most Brazilians live in high-density areas of eastern Brazil or along the coast or the major rivers. Although urbanization does not show an actual decline in rural population, internal migration has caused cities to grow much faster than rural areas. Today, about 80% of the people live in urban areas. Many migrants to the cities take up residence in "favelas", or shantytowns, on the edge of urban areas. The urban poverty and unemployment that accompany swift urbanization are aggravated by a fast population growth rate.

The capital, Brasilia, whose construction started in 1957, was built in the highlands, in order to encourage development of the interior. According to the 2000 estimates, the largest cities of Brazil are: São Paulo, Rio de Janeiro, Belo Horizonte, Salvador, Recife, Brasilia and Porto Alegre.

TABLE 1. POPULATION INFORMATION

	1960	1970	1980	1990	2000	2001	Growth rate (%) 1980 To 2001
Population (millions)	72.7	96.0	121.6	148.0	170.4	172.6	1.7
Population density (inhabitants/km²)	8.5	11.3	14.3	17.4	20.0	20.3	

Predicted population growth rate (%) 2001 to 2010	10.9
Area (1000 km²)	8512.0
Urban population in 2001 as percent of total	

Source: IAEA Energy and Economic Data Base.

The single most important influence on Brazil's climate is its location on the equator. Temperatures seldom exceed 35°C in the tropics owing to the moderating effects of high atmospheric humidity. Most of Brazil receives a moderate rainfall of 1,000-1,500 mm (40-60 in.), although the Amazon lowlands and several other areas receive more than 2,030 mm (80 in.) of rainfall annually. The semi-arid northeastern interior, or 'Sertao', frequently suffers from very long droughts. Tropical rain forest, or 'Selva', is found in the wettest part of the Amazon Basin. Much of the south and southwest of Brazil is covered by savanna, or tropical grassland, and in the interior of the northeast, caatinga, a low and bushy scrub and thorn forest is characteristic.

Brazil's three major river systems are: the Parana-Paraguay-Plata in the south, the Sao Francisco in the east, and the Amazon in the north. The Amazon, the major river of South America, is the world's second longest river (6,440 km/4,000 miles), and most of its basin lies within Brazil. The Amazon river's major tributaries are the Tocantins-Araguaia, the Madeira, the Negro, the Xingu and the Tapajos. Brazil's mineral resources are superlative with many still unexplored. Sizeable deposits of iron and manganese ores have been discovered, but Brazil lacks the high-grade cooking coal needed to transform them into steel. Brazil is a leading exporter of iron. Discoveries of metals and minerals, including phosphates, uranium, manganese, titanium, copper, coal, and gemstones, are regularly made, particularly in the state of Minas Gerais and the Amazon area.

1.2. Economic Indicators

Table 2 provides the Brazilian Gross Domestic Product (GDP) statistics during the last two decades. Economy's average annual growth rate was only 2.0 % during the period 1980 to 1998.

TABLE 2. GROSS DOMESTIC PRODUCT

	1970	1980	1990	2000	2001	Growth rate (%) 1980 To 2001
GDP (millions of current US$)		236,995	479,147	595,414	567,042	4.2
GDP (millions of constant 1990 US$)	180,849	396,224	461,952	599,978	612,127	2
GDP per capita (current US$/capita)		1,949	3,238	3,494	3,286	2.5

Source: IAEA Energy and Economic Data Base

1.3. Energy Situation

Brazil has modest fossil energy resource and one of the largest hydroelectric potential in the world (Table 3). However, most of this potential has not yet been tapped. The hydro resources located in the north-east, south-east and south of the country have already been thoroughly surveyed. The hydroelectric potential of north and central west regions, which cover practically Brazil's Amazon area, is beginning to be tapped to partially meet both regional and national electric needs.

TABLE 3. ESTIMATED ENERGY RESERVES

	Estimated energy reserves in 1999 (Exajoule)					
	Solid	**Liquid**	**Gas**	**Uranium (1)**	**Hydro (2)**	**Total**
Total amount in place	196.83	49.22	9.01	88.45	293.06	636.57

(1) This total represents essentially recoverable reserves.

(2) For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability (World Energy Council - 2002) by a factor of 10.

Source: IAEA Energy and Economic Data Base.

Historically, the expansion of the energy sector represented a dynamic aspect on the process of industrialization and modernization of economic and social structures in Brazil. This expansion has provided the energy needed for this process and has stimulated the development of productive sectors. During the last decades, Brazilian development was mainly induced by the State's direct action. The two large centralized energy systems, electricity and petroleum (state-owned) were consolidated. The consolidation bolstered the development of the country's main industries and engineering service infrastructure. Table 4 shows the historical energy statistics.

Since the 1940's, anhydrous alcohol extracted from the sugar cane has been added to gasoline, at first only in small quantities. During the first oil crisis in 1973, the percentage of anhydrous alcohol was increased, reaching approximately 14% in 1992. In order to carry out a National Alcohol Programme (1975), Brazil developed a technology for direct use of hydrous alcohol (containing about 4% water) in automobile engines. Since 1977, alcohol production and consumption have been rising rapidly. In 1991, about 43 per cent of the Brazilian cars were alcohol fuelled.

During the 1960's and 1970's the total energy production experienced a high average annual growth rate of 12%; however, during the 1980's and early 1990's energy production growth rate decreased considerably (3.3% per year). Primary electricity production had also a similar pattern; the annual growth rate decreased from 10% from 1960 to 1980 to about 3% during 1980 to 2000.

Final energy consumption in Brazil reached 9.6 exajoules in 2000, a nearly eleven-fold increase from the 1960 figure of 0.78 Exajoule. The share of liquid fuels in primary energy consumption decreased from 69% in the 1960's to 42% in 1998. Solid fuels, primary electricity (hydro and nuclear) and gas provided 17%, 37% and 3%, respectively, of primary energy consumption in 2000.

TABLE 4. BASIC ENERGY SITUATION(*)

	1960	1970	1980	1990	2000	2001	Average annual growth rate (%) 1960 To 1980	1980 To 2001
Energy consumption								
- Total (1)	0.78	2.88	5.51	6.89	9.62	9.82	10.28	2.79
- Solids (2)	0.05	1.40	1.89	1.69	1.57	1.58	19.36	-0.86
- Liquids	0.54	1.09	2.34	2.80	4.40	4.43	7.56	3.10
- Gases			0.04	0.15	0.28	0.29	15.03	10.11
- Primary electricity (3)	0.18	0.38	1.24	2.25	3.37	3.52	10.22	5.09
Energy production								
- Total	0.37	2.09	3.56	5.27	7.22	7.36	12.02	3.51
- Solids	0.03	1.35	1.78	1.38	1.15	1.17	23.35	-1.95
- Liquids	0.16	0.36	0.51	1.72	2.88	2.95	5.86	8.76
- Gases			0.04	0.15	0.26	0.28	15.03	9.87
- Primary electricity (3)	0.18	0.38	1.24	2.01	2.94	2.96	10.23	4.22
Net import (Import - Export)								
- Total	0.41	0.84	1.95	1.50	2.10	2.98	8.06	2.05
- Solids	0.03	0.05	0.13	0.31	0.44	0.47	7.86	6.41
- Liquids	0.39	0.78	1.82	1.19	1.64	2.47	8.07	1.47
- Gases					0.02	0.04		

(1) Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.
(2) Solid fuels include coal, lignite and commercial wood.
(3) Primary electricity = Hydro + Geothermal + Nuclear + Wind.
(*) Energy values are in Exajoule except where indicated.
Source: IAEA Energy and Economic Database.

1.4. Energy Policy

In the last few years, a price and tariff policy not consistent with production costs and an inadequate return on investments led to higher energy costs and decreased reliability of supply. The effects were exacerbated by construction delays and rising construction costs in the 1980's. The Brazilian power sector is facing deep changes during the last four years evolving two different fronts: (i) the privatization of state owned electric companies (nuclear power generation is excluded); and (ii) the restructuring of electric sector as a whole (deregulation).

These changes have been designed to stabilize the currency, open markets to competition and reduce national indebtedness. The government has also decided to focus the role of the state on policy-making and regulation than as owner of economic agents, through the national privatization program (PND).

The main objectives of the national energy policy are orientated to: (i) conservation and efficient use of energy, (ii) expansion of oil production and electric power supply, (iii) realistic pricing policy, (iv) efficiency of energy production systems, (v) private enterprise participation, (vi) use of renewable energy resources; and (vii) technical innovation.

2. ELECTRICITY SECTOR

2.1. Structure of the Electricity Sector

Up until early 1960's, the Brazilian electric utilities had no central co-ordination. Operation and planning activities were limited to independent utility requirements, resulting in isolated or poorly integrated systems. Rapid growth in industrialization created expansion of inter-regional integration opportunities for the electric companies outside their geographical areas. This integration gave rise to increased supply reliability and provided economies of scale.

In 1962, the federal government established a holding company, ELETROBRÁS, with the objective of organizing, co-ordinating and planning all activities of the sector at the national level. ELETROBRÁS is attached to the Ministry of Mines and Energy. ELETROBRÁS is an open corporation with shares negotiated in the capital market. It co-ordinates the whole electricity sector concerning the technical, financial and administrative aspects. ELETROBRÁS is the major shareholder of the federal companies and is a minor shareholder in the state-owned companies. ELETROBRÁS is also the main shareholder of ELETRONUCLEAR, the nuclear utility of Brazil.

A large utility company, Itaipu Binacional, was founded in 1973 by Brazil and Paraguay to manage the Itaipu hydropower plant of 12,600 MW capacity located at the border of both countries. Due to the difference in the frequencies used in both countries, the energy share sent to Brazil has to be transformed in direct current, transmitted to a conversion centre and then reconverted to alternate current in 60 Hz. According to the treaty that gave rise to Itaipu Binational, Brazil has to buy the excess energy produced and not consumed by Paraguay (27,560 GW·h in 1993).

Electricity generation and transmission are run by ELETROBRÁS subsidiaries, which are being privatized and some of the state-owned utilities within the geographical limits of the states. The states have a mix of state and privately owned companies for the distribution of electricity. The exception is the state of Tocantins, recently founded, where electricity is supplied by a private utility. The national electrical transmission grid has 61,539 km of 230 kV lines and 91,000 km of lines lower than 230 and higher than 34 kV.

As of December 1996, the Brazilian electricity sector comprises 62 organizations: four companies of the ELETROBRÁS System (ELETRONORTE, CHESF, FURNAS and ELETROSUL), 27 state utilities associated to ELETROBRÁS and 31 public and private utilities (see Table 5). The federal government is responsible for electricity generation in the north and northeast regions through two federal monopolies: ELETRONORTE and CHESF. In the remaining regions, the ELETROBRÁS System competes in the generation activities with state-owned utilities.

The current government programme for privatisation of the power sector is leading ELETROBRÁS to divest itself of its utilities with the exemption of ELETRONUCLEAR as, by the Brazilian Constitution, nuclear power activities should belong to the state. During the privatization process, there were 35 state & municipal distribution companies/utilities responsible for distribution under public service concessions, covering all 26 states and the Federal District of the country. Almost all used to be state-owned companies but now according to the new process 80% of them have been privatized and others are in preparation to be sold. Four vertically integrated state-owned utilities are responsible for 30% of the available energy. During year 2000, four regional generation/transmission subsidiaries of ELETROBRÁS account for 40.5% of the available energy. The most important of these state-owned companies are Companhia Energética de Minas Gerais (CEMIG) in the Minas Gerais State; Companhia Energética de São Paulo (CESP) in São Paulo; Companhia Paranaense de Eletricidade (COPEL) in Paraná and Companhia Estadual de Energia Elétrica (CEEE) in Rio Grande do Sul.

Following an auction in 1999, the control of the generating company Centrais Elétricas Geradoras do Sul S.A.(Gerasul) was sold for an amount of US$ 800 million in cash. In February 1999, shares of Eletricidade e Serviços S.A. (Elektro) were offered to the public. This company resulted from the separation of the distribution part of CESP. Enron International, the controlling stockholder in Elektro, purchased the shares for about US$ 216 million, a premium of 98.9% over the minimum set auction price. Controlling stakes in the generation companies, resulting from the separation of Companhia Energética de São Paulo (CESP), Paranapanema and Tietê, were also sold.

In 1999, the U.S. Duke Energy Corporation acquired the company Cia. de Geração de Energia Elétrica Paranapanema for the sum of R$ 1.239, a premium of 90.2% over the minimum auction price. In the same year, the U.S. company AES (Applied Energy Services, Inc.) acquired the company Cia. de Geração de Energia Elétrica Tietê for R$ 938.6 million, a premium of 30% over the minimum set auction price.

The Power National Operator (ONS) is a private company of utilities, transmission and distribution companies, importers and exporters of power, and power consumers, responsible for the co-ordination and operation control of generating and transmission facilities using the interconnected grid. The Ministry of Mines and Energy participates in NOS and has veto power in matters conflicting with national policy.

TABLE 5. PARTICIPATION OF PRIVATE AND STATE-OWNED COMPANIES IN THE ELECTRICITY GENERATION

COMPANY TYPE	PARTICIPATION (%) 1996	PARTICIPATION (%) 1998	PARTICIPATION (%) 2000
ELETROBRÁS system	40.0	38.0	40.5
State-owned Utilities	36.0	34.0	31.3
ITAIPU - Brazil's share	9.5	9.5	9.6
ITAIPU - Brazil's import	9.5	9.5	9.6
Auto-Producers	4.7	5.7	4.1
Private/Municipal	0.3	3.3	4.9

Source: ELETROBRÁS - 2001

2.2. Decision Making Process

The institutional organization of the Brazilian electricity sector includes the Ministry of Mining and Energy (MME) as the highest political instance, the National Electric Power Agency (ANEEL), created in 1996 replacing the Department of Water and Electrical Energy (DNAEE) as a normative body, and ELETROBRÁS as a planning and system expansion co-ordinator. Policy and decision making tasks are accomplished by ELETROBRÁS mainly through three committees: GCOI - Network Operation Co-ordination Group, GCPS - Electrical Systems' Planning Co-ordination Group, and SINTREL - National Electric Energy Transmission System.

GCOI, created in 1969, is a co-ordinating group formed by ELETROBRÁS and the utilities, that optimizes the operation of the hydrothermal system by using to a maximum extent water resources and providing for fossil and nuclear fuel economy.

GCPS, created in 1992, is a committee in which the utilities are integrated, under the co-ordination of ELETROBRÁS. GCPS develops and updates the system's ten-year expansion plan. This Decennial Plan is the main instrument used by the Ministry of Mining and Energy for planning the expansion of the electric sector.

SINTREL was created in 1993, as a result of deregulation, for improving competitiveness and increasing the participation of private capital in the sector. The utilities are in charge of the expansion, operation and maintenance of the SINTREL's network.

In order to adapt the Government structure to the new market trends of deregulation, competitiveness and privatization, the National Electric System Operator (ONS), was created in December 1997. It has the responsibility to operate, control and co-ordinate the electric energy generation and transmission in the interconnected systems, assuring to the agents of the area a free access to the transmission network and an equanimous treatment, through the use of impartial, predictable and transparency operational rules.

2.3. Main Indicators

Brazil's electricity output in 2000 amounted to 357 TW·h, of which 89.4% originated from hydroelectric sources, 8.9% from fossil fuelled plants, and 1.7% from nuclear plants (Table 6). In 2000, the electricity/energy production rate was about 45%. Per capita electricity consumption increased from 1,653 kW·h in 1990 to 2,268 kW·h in 1999 (Table 7).

TABLE 6. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

							Average annual growth rate (%)	
	1960	1970	1980	1990	2000	2001	1960 To 1980	1980 To 2001
Electricity production (TW.h)								
- Total (1)	22.87	45.46	139.49	222.82	322.46	330.42	9.46	4.19
- Thermal	4.48	5.60	10.58	14.06	17.97	23.18	4.39	3.81
- Hydro	18.38	39.86	128.91	206.71	298.44	292.88	10.23	3.99
- Nuclear				2.06	6.05	14.35		
- Geothermal								
Capacity of electrical plants (GWe)								
- Total	4.80	11.23	33.37	53.05	71.67	74.00	10.18	3.87
- Thermal	1.16	2.41	5.87	6.87	9.00	9.61	8.45	2.38
- Hydro	3.64	8.83	27.50	45.56	60.77	62.49	10.64	3.99
- Nuclear				0.63	1.90	1.90		
- Geothermal								
- Wind								

(1) Electricity losses are not deducted.

Source: IAEA Energy and Economic Database.

2.4 Impact of Open Electricity Market in the Nuclear Sector

The Brazilian electric sector is facing a restructuring that comprises the following institutional aspects (i) the creation of the Wholesale Energy Market (WEM), with the definition of new agents, their relationships, commercialization rules at the supply level and measures to ensure competition to be followed by companies operating in more than one of these segments: generation, transmission, commercialization and distribution. All generators with installed capacity above 50 MW and all distribution/ retailers with annual sales in excess of 100 GW·h would be required to join the WEM. Free consumers would be entitled to join. Large consumers over 10 MW are free to choose their suppliers;

TABLE 7. ENERGY RELATED RATIOS

	1960	1970	1980	1990	2000	2001
Energy consumption per capita (GJ/capita)	11	30	45	47	56	57
Electricity per capita (kW.h/capita)	314	458	1,125	1,653	2,172	2,389
Electricity production/Energy production (%)	60	21	38	41	43	43
Nuclear/Total electricity (%)				1	2	4
Ratio of external dependency (%) (1)	53	29	35	22	22	30
Load factor of electricity plants						
- Total (%)	54	46	48	48	51	51
- Thermal	44	27	21	23	23	28
- Hydro	58	52	54	52	56	54
- Nuclear				37	36	86

(1) Net import / Total energy consumption.

Source: IAEA Energy and Economic Database.

(ii) implementation of the open access to the transmission and distribution networks including of non captive consumers to their suppliers and the remaining systems agents; (iii) the implementation of a new regulatory agency – National Electric Energy Agency (ANEEL); (iv) the creation of the National Electric System Operator (ONS), and the definition of responsibilities in regard to generation supply and basic transmission networks; and (v) the restructuring of ELETROBRÁS Post-privatization, ELETROBRÁS will retain a minority interest in the privatized companies, its 50% in Itaipu and ownership of the nuclear power plants.

The central feature of the new trading market model was the creation of the independent system operator (ISO), an independent company responsible for the operational planning, scheduling, dispatch and market price calculation. The trading market model was implemented in 2000, when the functions of GCOI and CCON were transferred to ISO and the WEM was established.

At the beginning the relationship between generators and consumers/distributors will be mostly controlled by bilateral contracts, 90% of the whole market, and just 10% will be sold on free conditions, due to institutional restrictions. Nuclear is included at this form of contract at the same way of Itaipu. From 2003 on, energy will be free to be trade in a competitive market, without tariffs regulation. ELETROBRÁS will commercialize the energy from Itaipu and Eletronuclear.

Now the challenge of nuclear energy in Brazil is to compete in the new market, in which tariffs of the four federal suppliers companies in 2000 stay in the range of about 18.7 US$/MW·h for the generation services. The actual generation costs of hydro plants are currently about 15.3 US$/MW·h and nuclear 26.38 US$/MW·h. It is a question of competitiveness. In the long term, nuclear energy will be necessary in the Brazilian energy mix. It is not known, how long this period will be and whether Brazil will be able to implement the nuclear power programme in the future to survive.

3. NUCLEAR POWER SITUATION

3.1. Historical Development

In 1970, a decision was made to build Brazil's first nuclear power station through an international bid. The contract of a turn-key project for a 626 MW(e) PWR reactor (ANGRA 1) was awarded to Westinghouse Electric Corporation of the United States of America. ANGRA 1 construction started in 1971, and the first criticality was achieved ten years later.

In 1975, in an effort to become self-sufficient in nuclear power generation, Brazil signed an agreement with the Federal Republic of Germany to build eight 1,300 MW(e) reactors (PWR Biblis B type) over the period of 15 years. Under this agreement, two of these units (ANGRA 2 and ANGRA 3) were scheduled for construction on the following year with most of their components imported from Kraftwerk Union's (KWU) shops in Germany. According to this agreement, the rest of the plants were to contain 90% Brazilian-made components. The Brazil-Germany agreement created the Empresas Nucleares Brasileiras (NUCLEBRAS) and a Brazilian stated-owned nuclear holding company. Additionally, several subsidiaries (joint companies) were established to achieve nuclear technology transfer from Germany (see Table 8).

The Brazilian nuclear regulatory body is the National Nuclear Energy Commission (CNEN), responsible for conducting the national research programme; licensing nuclear power plants and nuclear facilities; performing regulatory activities; and training and organizing personnel, according to the Law 4,118 of 1962. In the early 1980's, the Brazilian Navy started a nuclear propulsion programme. Backed by CNEN, the Navy's main activity was the development of uranium enrichment by using ultracentrifuge process. Relatively good success was achieved by the end of the decade, which has continued through the 1990's.

TABLE 8. NUCLEBRAS SUBSIDIARIES

COMPANY	ACTIVITY
NUCLEP*	Heavy Components Manufacture
NUCLEI*	Enrichment by Jet-Nozzle Process
NUCLEN*	Nuclear Power Plant Architect and Engineering
NUCLAM*	Uranium Prospection
FEC	Fuel Elements Manufacture
CDTN	Nuclear Technology R&D Centre
NUCON	Nuclear Power Plant Construction
NUCLEMON	Rare Earth's Production
CIPC	Mining and Yellow Cake Production

*Joint Brazilian-German Companies

Due to several factors (especially financial problems) the Brazilian-German technology transfer programme was forestalled. ANGRA 2 and ANGRA 3 construction was interrupted several times, resulting in further delay in Brazilian nuclear programme. Due to Brazil's foreign debt and high inflation with added pressures from privatization programme and budget cuts, the Brazilian nuclear programme was reorganized at the end of the 1980's.

In 1988, a new company, Industrias Nucleares Brasileiras SA (INB) replaced NUCLEBRAS and its subsidiaries, with limited authority. INB became responsible for rare earth's, mining of nuclear minerals and yellow cake and nuclear fuel production assuming FEC, NUCLEMON and CIPC activities. FEC, renamed as Nuclear Complex of Rezende, was transformed in an INB Directorate. Both INB and NUCLEP, responsible for heavy equipment fabrication, became CNEN's subsidiaries. Responsibility for the construction of nuclear power stations was transferred to the state-owned utility, FURNAS/ELETROBRÁS, incorporating NUCON activities. NUCLEN was maintained responsible for nuclear power plant architect and engineering.

In 1997, the architect engineering company Nuclen, merged with the nuclear directorate of Furnas, an utility responsible for the bulk supply of electricity of the most developed region of Brazil. (included in the privatization programme) The new company named Eletronuclear - ELETROBRÁS Termonuclear S/A. is responsible for design, procurement & follow up of Brazilian and foreign equipment's, management of construction, erection and commissioning of nuclear power plants and is the sole owner and operator of nuclear power plants in the country. Siemens sold its 25% holding in Nuclen to ELETROBRÁS when Eletronuclear was formed. NUCLEI and NUCLAM were disbanded.

3.2. Current Policy Issues

Hydroelectric power plays a paramount role in the Brazilian electricity system while thermal power plants (conventional and nuclear) are meagre contributors to electricity supply. Considering the country's huge hydroelectric potential along with social and economical uncertainties, it is very difficult to forecast further nuclear power development in Brazil. However, according to the "Plan 2015" (i.e. ELETROBRÁS' National Plan for Electrical Sector Expansion to 2015), an additional nuclear capacity of 1,300 MW(e) was planned for 2001 (commissioning of Angra 2). The construction of the ANGRA 3 power station is being studied.

3.3. Status and Trends of Nuclear Power

The status of the Brazilian NPP is shown in Table 9. The ANGRA 1 nuclear power plant located between Sao Paulo and Rio de Janeiro, has a net capacity of 626 MW(e). It started commercial operation in December 1984. During the period of 1985-1989, the plant experienced two long unscheduled outages due to problems on the main condenser and emergency diesel electric generator. From 1990 on, the plant operated with a limited capacity factor of 55% due to preference given to hydroelectric generation. Nevertheless, ANGRA 1 has operated at full capacity, in several occasions, when it was necessary. In March 1993, the plant experienced problems with some fuel rods. It resumed energy production in December 1994. From 1994 on, the performance of ANGRA 1 followed a more reliable path, reaching its generation record in 1999, 3,976.9 GWh, with an availability factor of 96%. ANGRA 1 plays an important role in the reliability of the southeast electric system (predominantly of hydro origin) assuring continuous electric power supply to the states of Rio de Janeiro and Espírito Santo where local water resources are virtually exhausted and power supply depends on long transmission lines. The operating experience is given in Table 10.

TABLE 9. STATUS OF NUCLEAR POWER PLANTS

Station	Type	Net Capacity	Operator	Status	Reactor Supplier
ANGRA-1	PWR	626	ELETRONU	Operational	WEST
ANGRA-2	PWR	1270	ELETRONU	Operational	KWU
ANGRA-3	PWR	1224	ELETRONU	Suspended	KWU

Station	Construction Date	Criticality Date	Grid Date	Commercial Date	Shutdown Date
ANGRA-1	01-May-71	13-Mar-82	02-Apr-82	01-Dec-84	
ANGRA-2	01-Jan-76	05-Nov-99	21-Jul-2000	01-02-2001	
ANGRA-3					

Source: IAEA Power Reactor Information System as of 31 Dec. 2001.

Construction of ANGRA 2 began in January 1976, but due to financial problems the construction of the unit has slowed down and was several times halted. The economic recovery of the second half of the 90's led to the acceleration of the unit's construction. On 21 July 2000, at 10:16 pm, ANGRA 2 was synchronized for the first time to the Brazilian interconnected electrical grid.

The reactor became critical on 14 July at 11:50 pm, after being licensed for this procedure on the previous day by the Brazilian nuclear regulatory authority, CNEN (National Commission of Nuclear Energy). ANGRA 2 trial operation (a test phase of continuous operation at a 100% power level) was successfully completed on 21 December 2000 and, since then, the plant has been operating above 90% of its nominal capacity. In 2001, ANGRA 2 generated 10,498.4 GWh, with an availability factor of 93.9%. In July, 2002, the National Agency of Electric Energy approved the new installed capacity value of 1,350 MW for ANGRA 2.

TABLE 10. OPERATING EXPERIENCE OF ANGRA 1

Year	Energy GW·h	Average Load Factor (%)	Year	Energy GW·h	Average Load Factor (%)
1982	54.1	0.9	1992	1752.3	30.4
1983	183.7	3.2	1993	441.8	7.7
1984	1642.1	28.5	1994	54.9	1.0
1985	3412.1	59.3	1995	2520.7	43.8
1986	145.6	2.5	1996	2428.9	42.1
1987	973.3	16.9	1997	3161.4	54.9
1988	613.9	10.6	1998	3265.3	56.7
1989	1845.4	32.1	1999	3976.9	69.1
1990	2258.0	39.2	2000	3423.3	59.3
1991	1441.6	25.0	2001	3853.5	67.0

Source: IAEA Power Reactor Information System

The third nuclear station (ANGRA 3), a 1,309 MW(e) PWR reactor and similar to ANGRA 2, was acquired to Siemens/KWU together with ANGRA 2. ANGRA 3 has about 70 per cent of the design work completed and 70 per cent of the imported major equipment already manufactured and stored on site. The civil works and electro-mechanical assemblies' activities were postponed in 1991. ELETRONUCLEAR and several independent consulting firms developed technical and economical feasibility studies for ANGRA 3, which were submitted to government authorities. An authorization to re-start the construction works is under consideration at the CNPE (National Council of Energy Policy).

3.4. Organisational Chart

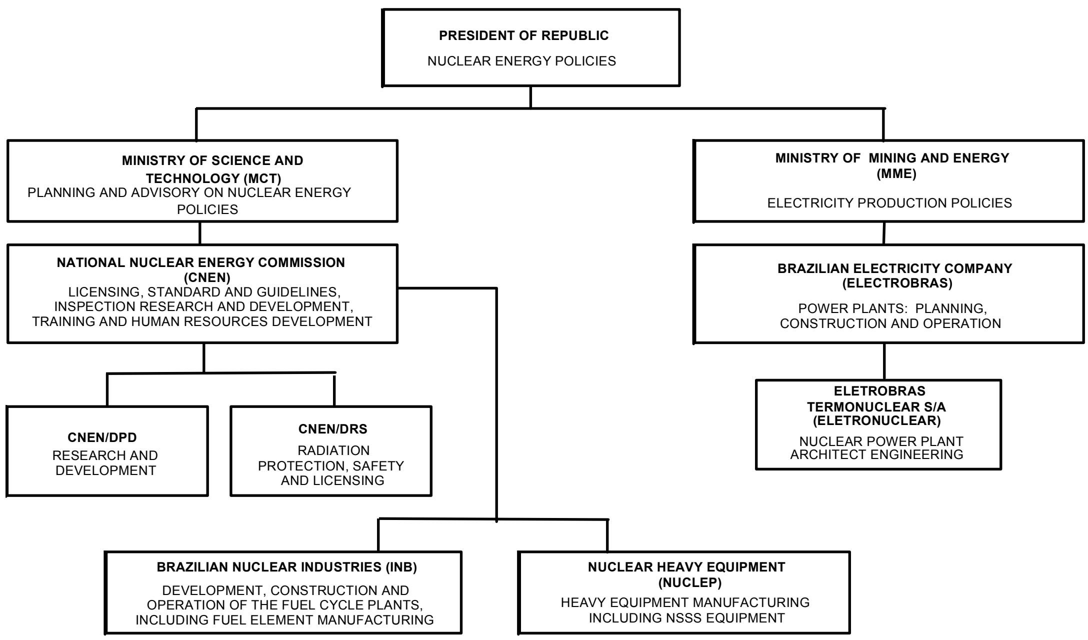

FIG. 1. Organization Structure for Nuclear Energy Development in Brazil

The organizational structure of Brazil's nuclear sector and the relationships among different organizations are shown in Figure 1. The National Nuclear Energy Commission (CNEN), is the regulatory body, which reports to the Ministry of Science and Technology (MCT). The Brazilian Electricity Company (ELETROBRÁS), responsible for planning and co-ordinating all activities of the electrical sector at national level, is under the Ministry of Mining and Energy. The remaining organizations are discussed in the following sections.

4. NUCLEAR POWER INDUSTRY

4.1. Supply of Nuclear Power Plants

Two companies related to nuclear power plant engineering and component supply are active at the nuclear sector: NUCLEP (Nuclear Heavy Equipment) as a subsidiary of CNEN and ELETRONUCLEAR - ELETROBRÁS Termonuclear S/A.

NUCLEP was established to design and fabricate heavy nuclear power plant components, especially those used in the reactor primary circuit. NUCLEP specializes in fabrication of large components made from alloy steels, nickel alloys and titanium alloys. It maintains modern quality control laboratories, outfitted with precision instruments, qualified and certified according to international standards, for mechanical, chemical and metallurgical testing.

ELETRONUCLEAR is responsible for design, procurement & follow up of Brazilian and foreign equipment, management of construction, erection and commissioning of nuclear power plants and is the sole owner and operator of nuclear power plants in the country.

4.2. Operation of Nuclear Power Plants

ELETRONUCLEAR is the only utility responsible for construction and operation of Brazilian nuclear power plants ANGRA 1 and 2. The ANGRA site has a PWR/ANGRA 2 type simulator in operation since 1985. The simulator has provided operator-training services for utilities from countries such as Spain, Switzerland, Germany and Argentina, which operate nuclear power plants supplied by KWU.

4.3. Fuel Cycle and Waste Management Service Supply

Indústrias Nucleares do Brasil S.A. - INB, a state company which has succeed NUCLEBRÁS, has as its main goal the implementation of industrial units related to the nuclear fuel cycle for nuclear power plants. Nowadays, there are in Brazil industrial units for: uranium concentrated (yellowcake) production, powder and pellets production, and assembling fuel elements. The mineral exploration program carried out in the last decades resulted in the discovery of new deposits that projected Brazil to be the sixth geological resources in the world, responsible for 11% of that total. It should be taken into account that only 25% of the Brazilian territory has been prospected, which enable us to predict very good perspectives of increasing those resources, due to favorable geological conditions

Since 1992, a uranium mine located in Poços de Caldas (Figure 2) has been operated with a nominal production capacity of 400 t U_3O_8, but in 1997 the mine was shutdown because the high-grade ore became exhausted, and now the mine is under decommissioning. Up to now Lagoa Real area - Caetité Unit is the main uranium district discovered in Brazil. It was discovered in 1977 and its known resources were estimated to a total of 85,500 t U of below U$80/kgU. Today, there are 34 occurrences detected. In this group, twelve of them were considered uranium ore deposit, according to the exploration systematic used. Due to the high potential demonstrated, both in respect with its volume and contents, Cachoeira Ore Deposit has been selected to be the first exploited. The RAR of Cachoeira Ore Deposit calculated using geostatistic methods, achieved 20,500 t of U. Included in this resources, 4,600 t U can be extracted by open pit mine, down to nearly one hundred meters depth, during 16 years. The main factor of the project is its low investment cost, about US$23 million, in order to produce, in the beginning, 340 t of U only for internal needs. This plant is in operation since the year 2000.

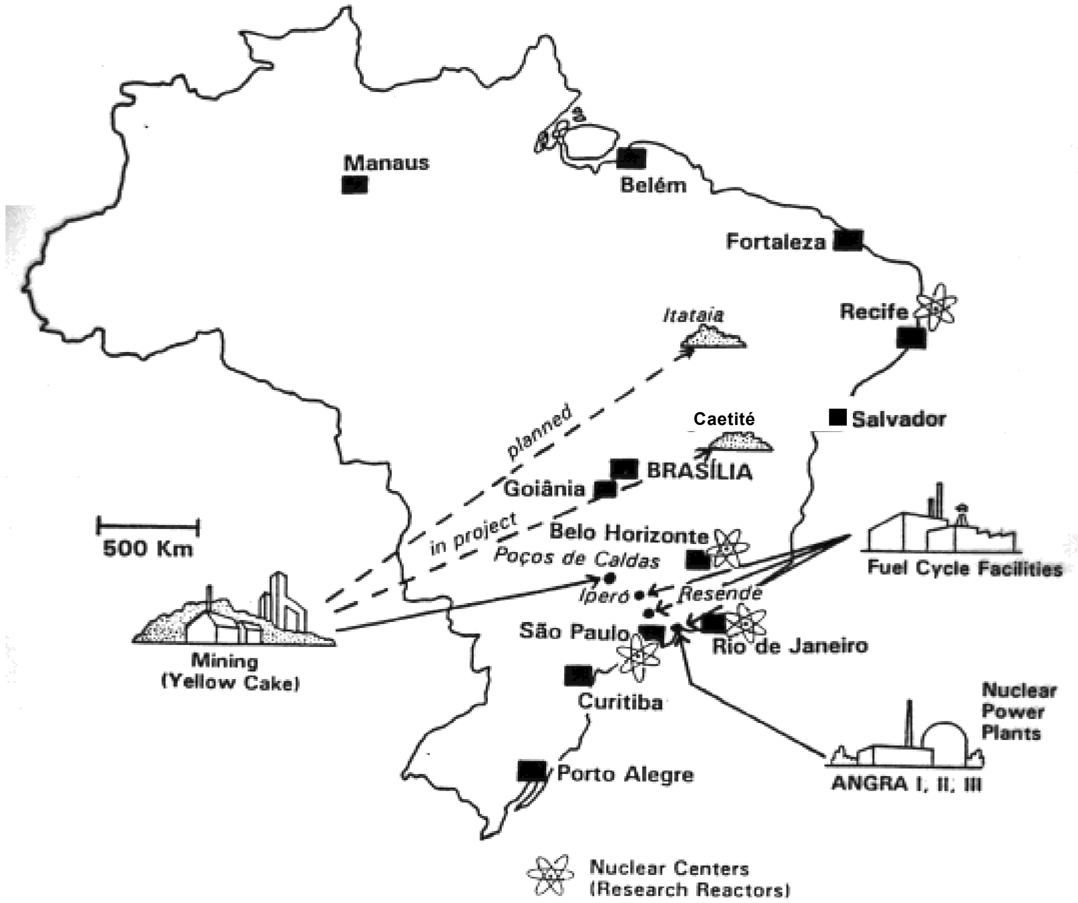

FIG. 2. Brazilian Nuclear Installations

The uranium resources in Itataia area (Figure 2) are associated with phosphoric rocks. So the uranium extraction depends on the phosphoric acid production, raw material for the fertilizer production. With the gradual increase of the agricultural boundaries in the Northeast states, the possibility of implementing the project with an investment of about US$100 million, together with the private sector is foreseen. That amount could decrease substantially if the equipment of the CIPC plant (Poços de Caldas site) could be used.

The Fuel Fabrication Plant (FEC) is located at Resende, State of Rio de Janeiro, with two units, and has a production capacity of 280 tons of uranium per year. At present, FEC was refurbished and produces at the unit I the fuel rods and fuel elements for Brazilian nuclear reactors. The Unit II, responsible for pellets fabrication, is operating since June 1999 with a capacity of 120 tons of UO2 pellets /year. The UO_2 powder production line, using the AUC process, and pellets fabrication are in operation since September 1999, with an overall capacity production of 140 tons uranium per year, at Unit II. The Fuel Fabrication Plant also produces other fuel element components, such as top and bottom nozzles, spacer grids, and end plugs.

INB has also a demonstration plant for solvent extraction of individual rare earth oxides in the North of the Rio de Janeiro State, producing samarium oxide 99,9%, gadolinium and europium carbonates, itrium carbonate, dysprosium and other heavy elements, lanthanium carbonate 90% and didymium carbonate. A second phase was concluded, with the production of neodymium and praseodymium carbonates at 96%. Now INB is planning the itrium, terbium, holmium and erbium oxides production and the scale-up for an industrial plant production. An association with the private sector for the implementation of the industrial plant is very important, as it would be responsible for the required investments.

As part of its nuclear propulsion programme, the Brazilian Navy installed in Iperó (60 km from São Paulo) a demonstration enrichment centrifuge pilot plant. Recently the Brazilian Government decided to start the industrial implementation of the ultracentrifuge process developed by the Brazilian Navy Research Institute (CTMSP). This process is intended to be operating in eight years, to attend the Angra 1 needs and partially the needs of Angra 2 and 3. A future increase of this capacity will depend on technical evaluation and resource availability.

The major sources of radioactive waste producers in Brazil are the two nuclear power plants and the Monazite processing industry. The waste generated by the uranium mining and milling industrial complex, although significant in volume, is kept at the site, in a dam specially built for this purpose. The waste management policy takes into account both the accumulated and projected waste generated by the above mentioned facilities and the existing 3,500 cubic meters of Caesium-137 waste produced as a result of the decontamination work performed in Goiânia, following the 1987 accident that involved a 1,375 Curie teletherapy source.

The National Nuclear Energy Commission, CNEN, is responsible for regulation and final disposition of radioactive waste. Political and psychosocial aspects related to the subject of radioactive waste disposal, specially the "not-in-my-back-yard syndrome", contribute to the difficulties faced by the Brazilian Government when decisions concerning radioactive waste management are to be taken.

CNEN has the responsibility for the regulation and final disposal of radioactive waste. There are no plans for the management of high level wastes. The spent fuel from Angra 1 is currently stored in ponds on site. Wastes from CNEN, industrial and medical installations and wastes from the accident at Goiania are stored in a special repository at Abadia, Goias.

The waste generated by the uranium mining and milling industrial complex, located at the Poços de Caldas plateau in the Brazilian state of Minas Gerais, is kept in a 29.2 hectares dam system, specially built for this purpose with an actual volume of one million cubic metres. It is estimated that 4.8 Tbq (130 Ci) of U^{238} and 15 Tbq (405 Ci) of Ra^{226} have been deposited at this site. The chemical processing of monazite sands to extract rare earth elements, is a significant source of thorium, a nuclear material with no planned short-term application, and a complex compound of Ra^{228} with barium sulphate, called "mesothorium", with no foreseeable use. There is, presently, about 300 metric tons of "mesothorium" with an estimated Ra^{228} activity of 1.85 Tbq (50 Ci) in a provisional storage facility waiting for final disposal. The material containing thorium hydroxide, separated from the rare earth elements during monazite processing, although not formally classified as waste, is also stored. It amounts, approximately, to 17,000 metric tons. Since the Brazilian authorities have not ruled out the reprocessing option, spent fuel is not classified as high-level radioactive waste.

Because the Brazilian reprocessing programme has not been clearly defined, the ANGRA 1 spent fuel is temporally stored on-site, in the reactor basin. As of December 2000, 180,9 metric tons of spent fuel (506 fuel elements) are stored in racks at the on-site reactor basin of ANGRA 1 nuclear power plant. A new compact storage rack was installed in ANGRA 1, in 2002, with a planned capacity of 1,252 fuel assemblies, increasing the storage capacity of the on-site reactor basin. Another 0.06 metric tons of spent fuel from one of the research reactors are under storage conditions at IPEN, in São Paulo. Presently, there are no firm plans concerning the management of high-level nuclear waste.

4.4. Research and Development Activities

The National Nuclear Energy Commission (CNEN), created in 1956, has a twofold mission: to regulate, license and inspect the peaceful use of nuclear energy and to promote, orient and co-ordinate research and development in all areas related to nuclear energy. CNEN comprises three directorates whose responsibilities are:

i) Directorate of Administration and Infrastructure (DAL): human resources, administration and information management, financial reporting and control;

ii) Directorate of Research and Development (DPD): fuel cycle and materials, reactor technology, radiation utilization, radioisotopes application and production, instrumentation and control, safety, nuclear physics and chemistry, etc.;

iii) Directorate of Radiation Protection and Safety (DRS): Radiation protection, safety, control and licensing of nuclear power plants and other nuclear installations.

During the last decades, four large research nuclear centres were established for carrying out R&D in nuclear sciences and engineering. Research reactors, accelerators and various R&D laboratories, including pilot plant facilities, were progressively set up in these centres. These four research centres are:

IPEN (São Paulo) **-** Institute for Energy and Nuclear Research

- Research Reactors: 2 (one 5 MW/pool type and one zero power reactor/tank type)
- Cyclotron
- Radioisotopes Production (^{99m}Tc; ^{131}I; ^{121}I; etc.)
- Research on fuel cycle and materials; reactor technology; safety; fundamentals; radiation and radioisotope applications; etc.

IEN (Rio de Janeiro) - Institute for Nuclear Engineering

- Research Reactor: 1 (100 kW, ARGONAUTA)
- Cyclotron
- Research on fast reactor; instrumentation and control; fundamentals.

CDTN (Belo Horizonte) - Centre for Nuclear Technology Development

- Research Reactor: 1 (250 kW, TRIGA)
- Research on mining; reactor technology; materials, safety; chemistry; environment technology.

IRD (Rio de Janeiro) - Institute for Radiation Protection and Dosimetry

- Research on radiation protection and safety; environmental technology.

Within CNEN organizational chart IPEN, IEN and CDTN institutes report to the Directorate of Research and Development white IRD institute reports to the Directorate of Radiation Protection and Safety.

4.5. International Co-operation in the Field of Nuclear Power Development and Implementation

The agreement signed with the Federal Republic of Germany in 1975 included clauses for technology and know-how transfer in all areas of the nuclear technology, including enrichment process, called “jet-nozzle”, then in a development stage. The agreement included training of Brazilian personnel in German industries, laboratories and universities.

Under the sponsorship of International Atomic Energy Agency, Brazil has been participating in many technical assistance programs, advisory groups and symposium meetings. Brazil has technical co-operation agreements with other countries, like the United States of America, France, Argentina and China in exchange of information on nuclear safety and radiological protection, computer codes development and assessment, training, radioactive waste management and radioactive materials transportation.

5. REGULATORY FRAMEWORK

5.1. Safety Authority and the Licensing Process

The governmental organization responsible for the licensing of nuclear power plants (NPPs) and other nuclear installations in Brazil is the National Nuclear Energy Commission (CNEN). In August 1962, with the enactment of law No. 4,118, a National Policy on Nuclear Energy was established with the Government monopoly of nuclear materials and minerals.

The process involves the issuance of five licenses or authorizations as listed below:

In the early 1970's, due to the needs of the Brazilian Nuclear Power Programme, three experimental standards were issued by CNEN on Site Selection, Licensing Process and Radiological Protection, the Resolução CNEN 09/72, CNEN 06/72 and CNEN 06/73. An extensive set of rules and standards, as listed under section 5.2, regulate the nuclear activities in Brazil. CNEN licenses nuclear installations. The process involves the issuance of five licenses or authorizations as listed below:

- Site Approval;
- Construction Permit;
- Nuclear Material Utilization Authorization;
- Initial Operation Authorization; and,
- Permanent Operation Authorization.

Standard CNEN-NE-1.04 establishes the requirements for the licensing process. The Initial Operation Authorization is issued with some temporary conditions and the Permanent Operation Authorization (POA) is limited to 40 years. A Periodic Safety Reassessment is conducted every ten years of operation, when the conditions of authorization can be modified or extended. In January 1999 a law establishing fees and taxes for license and operating authorization was approved by the National Congress and signed by the President of Brazil (Law 9,765/99). It establishes a fee of US$ 2,700,000.00 for an operating license and an annual fee of US$ 450,000.00 per operating unit. These fees will be directed to a special account to be used by CNEN in its activities, but not for salaries of the staff, which is provided by governmental funds.

In 1981, the Environmental Policy Law was promulgated and, from 1983 to 1989, CNEN was also responsible for conducting the environmental licensing of nuclear installations. In 1989, the Brazilian Institute of Environment (IBAMA) was created and designated to conduct the environmental licensing of all installations, including nuclear facilities.

During the operational phase of nuclear facilities periodic safety reports are required. Regulatory safety assessment is conducted by CNEN through the review of the licensee's reports as well as through periodic inspections. On-site resident inspectors are assigned for permanent supervision of operational safety.

5.2. Main National Laws and Regulations

The National Congress approves the main legislation. CNEN's regulations and standards are based on IAEA standards, commonly used by many nations. The main laws and standards used in Brazil are:

- Law No. 4,118: National Policy on Nuclear Energy, 1962.
- Law No. 6,189: CNEN's Set-up as Regulatory and Licensing Federal Authority, 1974.
- Law Nº 9, 765; Licensing, control and fiscalization tax for nuclear and radioactive materials and the utilities, 1999.

CNEN's main standards are:

- CNEN-NE.1.04: Licensing of Nuclear Installations, 1984.
- CNEN-NE.1.16: Quality Assurance for Nuclear Power Plants, 1984.
- CNEN-NE.1.01: Licensing of Nuclear Reactors Operators, 1979.

- CNEN-NN.1.12: Qualification of Independent Technical Supervisory Organisation, 1981.
- CNEN-NE.1.14: Operating Reports of Nuclear Power Plants, 1983.
- CNEN-NN.1.15: Independent Technical Supervisory in Quality Assurance Activities for Nuclear Power Plant, 1983.
- CNEN.NE.2.01: Physical Protection of Operational Units of Nuclear Installations, 1981.
- CNEN-NE.2.02: Nuclear Material Control and Safeguards, 1982.
- CNEN-NE.2.03: Fire Protection in Nuclear Power Plants, 1988.
- CNEN-NE.3.01: Basic Limits, for Radiological Protection, 1988.
- CNEN-NE.5.02: Transport Storage and Handling of Nuclear Fuels, 1989.

5.3. International, Multilateral and Bilateral Agreements

AGREEMENTS WITH THE IAEA

• IAEA Statute	Signature:	26 October 1956
• Amendments to the Article VI and XIV of the IAEA Statute	Not signed	
• Agreement on privileges and immunities	Entry into force:	13 June 1966
• Quadripartite safeguards agreement INFCIRC/435	Entry into force:	4 March 1994
• Additional protocol	Not signed	
• Safeguards agreement Brazil/Germany INFCIRC/237	Suspension signed:	16 October 1998
• Safeguards agreement Brazil/USA INFCIRC/110	Entry into force:	31 October 1968
• Amendment to the safeguards agreement Brazil/USA	Signature:	27 July 1972
• Supplementary agreement on provision of technical assistance by the IAEA	Entry into force:	27 February 1991
• ARCAL	Entry into force:	September 1984
• New ARCAL Agreement	Signed:	4 August 1999

MAIN INTERNATIONAL TREATIES

• NPT	Entry into force:	18 September 1998

• Tlatelolco Treaty Amendment of the Treaty	Ratified Ratified:	29 January 1968 30 May 1994
• Convention on the physical protection of nuclear material	Entry into force:	8 February 1987
• Convention on early notification of a nuclear accident	Entry into force:	4 January 1991
• Convention on assistance in the case of a nuclear accident or radiological emergency	Entry into force:	4 January 1991
• Vienna convention on civil liability for nuclear damage	Entry into force:	26 June 1993
• Paris convention on civil liability for nuclear damage	Not applicable	
• Joint Protocol	Non-Party	
• Protocol to amend the Vienna convention on civil liability for nuclear damage	Not signed	
• Convention on supplementary compensation for nuclear damage	Not signed	
• Convention nuclear safety	Entry into force:	2 June 1997
• Joint convention on the safety of spent fuel management and on the safety of radioactive waste management.	Signature:	31 October 1997

OTHER RELEVANT INTERNATIONAL TREATIES

• ZANGGER Committee	Non-member	
• Improved procedures for designation of safeguards inspectors	Not accepted	
• Nuclear suppliers group	Member	
• Nuclear export guidelines	Not adopted	
• Acceptance of NUSS Codes	No replay	
• Treaty for prohibition of experiences with nuclear weapons in the atmosphere, cosmic space and under water	Signature:	5 August 1963
• Partial test ban treaty	Entry into force:	15 December 1964

• ILO Convention	Signature:	7 April 1964
• Technical assistance agreement between UN, its specialised agencies and the IAEA	Signature:	29 December 1964
• Treaty on the prohibition of the installation of nuclear weapons and other lethal weapons in the seabed, deep ocean floor and sub-seabed.	Signature:	3 September 1971
• Convention on civil liability in the field of maritime carriage of nuclear material	Signature:	17 December 1971
• Convention on prevention of marine pollution by dumping of wastes and other materials	Signature:	29 December 1972
• Convention on the control of movement of dangerous wastes and their deposits	Signature:	16 June 1992

MULTILATERAL AGREEMENTS

• Antarctica Treaty	Signature:	1 December 1959
• Treaty for prohibition of nuclear weapons in Latin America	Signature:	9 May 1967

BILATERAL AGREEMENTS:

• Co-operation agreement concerning peaceful uses of nuclear energy	Paraguay	18 August 1961
• Co-operation agreement concerning peaceful uses of nuclear energy	Bolivia	11 January 1966
• Co-operation agreement in the field of peaceful uses of nuclear energy	Ecuador	11 June 1970
• Agreement concerning nuclear ships in Brazilian waters	Germany	7 June 1972
• Co-operation agreement concerning peaceful uses of nuclear energy	Germany	27 June 1975
• Co-operation agreement concerning peaceful uses of nuclear energy between CNEN and the Nuclear Research Centre in Karlsruhe	Germany	8 March 1978
• Special agreement between CNEN and the Research Centre in Jülich	Germany	8 March 1978

• Assistance in establishing the conditions of the application of uranium hexafluoride	France	6 January 1981
• Agreement for the co-operation on the peaceful uses of nuclear energy	Colombia	12 March 1981
• Co-operation agreement concerning peaceful uses of nuclear energy	Peru	26 June 1981
• Co-operation agreement in the field of peaceful uses of nuclear energy	Italy	29 July 1981
• Memorandum of understanding	Great Britain	2 December 1981
• Co-operation agreement in the field of peaceful uses of nuclear energy	Spain	12 May 1983
• Co-operation agreement concerning peaceful uses of nuclear energy	Venezuela	30 November 1983
• Technical co-operation agreement	USA	6 February 1984
• Memorandum of understanding on co-operation in the field of peaceful uses of nuclear energy	China	29 May 1984
• Co-operation agreement concerning peaceful uses of nuclear energy	China	11 October 1984
• Agreement concerning early notification and mutual assistance in case of nuclear accident or radiological emergency	Argentina	18 July 1986
• Agreement concerning peaceful uses of nuclear energy	Argentina	18 July 1991
• Application of safeguards	Argentina	13 December 1991
• Agreement on the privileges and immunities	ABACC	27 March 1992
• Co-operation agreement in the field of peaceful uses of nuclear energy	Russian Federation	15 September 1994

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[1] IAEA Energy and Economic Data Base, (EEDB).
[2] IAEA Power Reactor Information System (PRIS).
[3] PLAN 2015: Energy Supply and Demand Study - System Expansion Strategy, ELETROBRÁS.
[4] PLAN 2015: Electric Energy Sector and Brazilian Economy: Perspectives, ELETROBRÁS.
[5] Brazilian Energy Balance (BEN), Mining and Energy Ministry, DNGE/SEN/MME.
[6] Brazilian institute for geography and statistics, www.ibge.gov.br.

Appendix

DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

NATIONAL ATOMIC ENERGY AUTHORITY

National Nuclear Energy Commission Rua General Severiano 90, BOTAFOGO 222290-900 - Rio de Janeiro-RJ, Brazil	Tel: (5521) 2756597 Fax: (5521) 5462316 http://www.cnen.gov.br/

NUCLEAR ENERGY COMMISSION INSTITUTES

Centro de Desenvolvimento de Tecnologia Nuclear (CDTN) Prof. Mário Werneck, S/N^{o}, Cidade Universitária 30161-970 - Belo Horizonte-MB, Brazil	Tel.: (5531) 499 3261 Fax: (5531) 499 3444 http://www.uranco.cdtn.br/
Instituto de Engenharia Nuclear, IEN Cidade Universitaria Ilha do Fundão 21945-970 - Rio de Janeiro-RJ, Brazil	Tel.: (5521) 280 6830 Fax: (5521) 590 2692 http://www.ien.gov.br/
Instituto de Pesquisas Enérgeticas e Nucleares (IPEN) Travessa "R", 400 Cidade Univesitaria 05508-900 - São Paulo – SP, Brazil	Tel.: (5511) 816 9000 Fax: (5511) 212 3546 http://www.ipen.gov.br/
Instituto de Radioproteção e Dosimetria, IRD Av. Salvador Allende, S/N^{o}, Barra da Tijuca 22780-160 - Rio de Janeiro – RJ, Brazil	Tel.: (5521) 442 1927 Fax: (5521) 442 1950 http://www.ird.gov.br/

OTHER NUCLEAR ORGANIZATIONS

Indústrias Nucleares Brasileiras (INB) R. Mena Barreto, 161 22271-100 - Rio de Janeiro-RJ, Brazil	Tel.: (5521) 552 1845 Fax: (5521) 286 8261 http://www.inb.gov.br/
Eletrobras Termonuclear S/A (ELETRONUCLEAR) Rua da Candelária 65 20091-020 - Rio de Janeiro – RJ, Brazil	Tel.: (5521) 588 7000 Fax: (5521) 588 7200 http://www.eletronuclear.gov.br/
Nuclebrás Equipamentos Pesados S/A (NUCLEP) Av. Gal, Euclides de Oliveira Figueiredo, 200, Itaguaí 23825-410 - Rio de Janeiro-RJ, Brazil	Tel.: (5521) 688 2056 Fax: (5521) 688 3011 http://www.nuclep.gov.br/
Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC)	http://www.abacc.org/
Nuclear Energy Association of Brazil (ABEN)	http://www.alternex.com.br/~aben/
Agriculture Nuclear Energy Center (CENA)	http://www.cena.usp.br/
Nuclear Fuel Generation National Synchrotron Light Laboratory (LNLS)	http://www.lnls.br/