nuclear technology transfers. The result of these efforts, part of on active process of transfer of technology, has led to an increasing domestic participation in the production.

Brazil has established a nuclear power utility/ engineering company Eletrobras Termonuclear S. A. (ELETRONUCLEAR), a heavy components manufacturer, Nuclebras Heavy Equipment (Nuclebras Equipamentos Pesados - NUCLEP), a nuclear fuel manufacturing plant (Fuel Element Factory - FEC), and a yellow-cake production plant belonging to Nuclear Industries of Brazil (Industrias Nucleares do Brasil - INB). Brazil also has the basic technology for Uranium conversion and enrichment, as well as private engineering companies and research and development (R&D) institutes and universities devoted to nuclear power development. Over 15,000 individuals are involved in these activities. Brazil ranks sixth in world Uranium ore reserves which amounts to approximately 310,000 t U_3O_8 in situ, recoverable at low costs.

According to the long-term plan for the electric power sector, three different scenarios are being considered for the year 2015. The first one, predominantly based on hydro resources does not foresee the construction of any new nuclear power plant. In the second, which has a strong thermal component, four additional nuclear power plants would be connected to the grid in the years 2009, 2011, 2013 and 2015. The third scenario, considered to be the 'recommended' one, foresees the inauguration of two additional nuclear units, one in 2011 and the other in 2013.

1.3. Structure of the National Report

This National Report was prepared to fulfill the Brazilian obligations under the Convention on Nuclear Safety[1]. Chapters 2 to 5 follow the Guidelines for the preparation of National Reports [2] and present an article by article analysis of the Brazilian framework, actions and activities related to the Convention's obligations (Chapter 2 of the Convention). In Chapter 2 some details are given about the existing nuclear installations. Chapter 3 provides details about the legislation and regulations, including the regulatory framework and the regulatory body. Chapter 4 covers general safety considerations as described in articles 10 to 16 of the Convention. Chapter 5 addresses to the safety of the installations during siting, design, construction and operation. Chapter 6 describes planned activities to further enhance nuclear safety. Chapter 7 presents final remarks regarding the degree of compliance with the Convention's obligations.

Since Brazil has only one nuclear installation in operation and two under construction, more plant specific information is provided in the report than is recommended in the

Guidelines [2]. This was intentionally done for the benefit of the reader not familiar with the current Brazilian situation.

The report also contains a series of annexes where more detailed information is provided with respect to the nuclear installations, the Brazilian nuclear legislation and regulations and relevant technical reports. Organizational charts of relevant organizations are presented as attachments.

Chapter 2. NUCLEAR INSTALLATIONS

2.1. Article 6. Existing nuclear installations

As mentioned in item 1.2, Brazil has a nuclear power plant in operation (Angra1, 657 MWe gross/626 MW net, PWR) and two under construction (Angra 2, 1309 MWe gross/1229 MW net, PWR and Angra 3, similar to Angra 2, whose construction has been temporarily halted). Angra 1, 2 and 3 are located at a common site, near the city of Angra dos Reis, some 130 km from Rio de Janeiro. More details about these units can be found in Annex 1 or in the PRIS [3], available through the Internet.

2.1.1. Angra 1

Site preparation for Angra 1, the first Brazilian nuclear unit, started in 1970 under the responsibility of FURNAS Centrais Eletricas SA. The actual construction of the plant began, however, only in 1972, shortly after the contract with the main supplier of equipment, Westinghouse Electric Co. (USA), was signed. The Westinghouse contract included supply and erection of the equipment, as well as engineering and design of the plant on a turnkey basis. Westinghouse sub-contracted Gibbs and Hill (USA) in association with the Brazilian engineering company PROMON Engenharia S.A. for engineering and design. For the erection work, Westinghouse brought in a Brazilian contractor, Empresa Brasileira de Engenharia S.A. (EBE). For the supply of the containment steel structure and the civil works not included in the Westinghouse contract, FURNAS hired directly, respectively, the Chicago Bridge & Iron Company and Construtora Norberto Odebrecht S.A, a Brazilian contractor who eventually also became contractor of the civil works for Angra 2. To assist in the implementation of the overall quality assurance programme, FURNAS hired an independent consultant, Ebasco Services Co. To assist in the implementation of the nuclear fuel quality assurance programme, NUS Corporation was contracted as independent consultant.

CNEN granted the construction permit for the plant in 1974. The operating licence was issued in September 1981, when the first fuel core was also loaded. First criticality was reached in March 1982, and the plant was connected to the grid in April 1982.

After a long commissioning period due to a steam generator generic design problem, which entailed modifying some of the equipment, the plant finally began to operate commercially on January 1st, 1985. After a good operating record in 1985, some forced outages and operational problems related to the secondary side were experienced during the period 1986- 1987, culminating in a forced outage due to the electric generator stator's burnout, which entailed its complete reconstruction. After this main repair, which took about 16 months, the plant resumed operation late in 1988 and operated with high availability until 1993, when a significant fuel failure occurred. After repair performed by the fuel supplier that took about one year, the plant operated during the period January- December 1995 with high availability (some 90%), and remained synchronized in the grid during 337 days. Since the last fuel reload, the plant has been operating with high availability. Angra 1 is very important for ensuring a reliable power supply to the state of Rio de Janeiro which imports some 70% of its electricity needs from long distance hydro power plants. The plant also plays a fundamental role in supplying reactive power to the system near the main load consumption centers, thus becoming a valuable factor in the reliable operation of the interconnected system.

Plant ownership has recently been transferred to the newly created company ELETRONUCLEAR, which has absorbed all the operating personnel of FURNAS, and part of its engineering staff, and the personnel of the design company Nuclebras Engenharia (NUCLEN).

The personnel in charge of all modifications and improvements carried out since the first connection of the plant to the grid, from FURNAS, NUCLEN (now both at ELETRONUCLEAR) and other engineering companies, acquired considerable experience in dealing with different technical problems.

2.1.1.1. Safety improvements at Angra 1.

The safety status of Angra 1 had been under constant review by FURNAS, and continues to be reviewed by ELETRONUCLEAR. Plant safety upgradings have been carried out during the life of the installation. Major upgrading programmes, still during the construction phase, were carried out following significant events in similar plants, such as the fire at Browns Ferry NPP and the accident at Three Mile Island. In addition, a comprehensive review of the accident analysis was carried out following changes in the designer models due to new requirements established in the Appendix K of the US regulation 10CFR50, in 1976.

During operation, Angra 1 has been reviewed and upgraded according to its own operational experience, to new CNEN requirements, and to the review of international experience in similar plants. Major upgrades refer to the installation of new Titanium condenser tubes, the addition of two new Diesel generators, and items related to the lessons learned from the Three Mile Island accident such as a safety parameters display system, venting on the top of the reactor vessel, on-line monitoring of H_2/O_2 in the containment, and post- accident sampling capability. Modifications related to the evolution of nuclear technology include the replacement of battery banks, installation of anticipated transient without scram (ATWS) mitigation system, cold overpressurization protection, new portal monitors in the controlled area, and new compact storage racks at the spent fuel pool (a detailed list of modification carried out at the Angra 1 plant is presented in Annex 3). On the analysis side, a preliminary Probabilistic Safety Analysis (PSA) was conducted using generic plant data. A new study is being conducted to take into account actual plant data, human reliability analysis, and additional events such as fire and flooding.

2.1.2. Angra 2 and 3

Angra 2 and 3, 1309 MWe gross/1229 MW net PWRs, using SIEMENS/KWU technology are under construction with a high degree of technology transfer, according to the framework established by the Brazilian-German Agreement on Peaceful Uses of Nuclear Energy signed in 1975. Their commercial operations, according to present ten-year expansion programme of the power sector, are to take place in 1999 and 2005, respectively. These two units, whose commercial operation was scheduled to begin in the mid-eighties, suffered various delays due to economic and financial difficulties faced by Brazil from 1983 onwards.

Considering that one of the objectives of the Brazilian-German Agreement was a high degree of domestic participation, the construction of Angra 2 and 3 required great efforts in qualifying Brazilian engineering firms and local industry so as to comply with the strict standards of nuclear technology. Indeed, this allowed for a growing participation of national companies (engineering firms, equipment industries, erection firms, testing laboratories and so on) in this major undertaking, always under the conditions that the same level of safety be attained as in similar plants found in of the technology supplier country.

As of December 31, 1997, the construction of Angra 2 is 88 % complete. The base foundation of Angra 3 has not been started yet, but all its main components are already in Brazil and the site is ready for the pouring of concrete. Engineering is practically complete, since Angra 3 is to be identical to Angra 2.

Chapter 3. LEGISLATION AND REGULATION

3.1. Article 7. Legislative and regulatory framework

Brazil has established and maintained the necessary legislative and regulatory framework to ensure the safety of its nuclear installations. The Federal Constitution of 1988 specifies the distribution of responsibilities among the Union, the federal states and the municipalities with respect to the protection of the public health and the environment, including the control of radioactive products and installations (Articles 23, 24 and 202). As mentioned in item 1.1, the Union is solely responsible for the nuclear activities related to electricity generation, including regulating, licensing and controlling nuclear safety (Articles 21 and 22). In this regard, the Brazilian National Commission for Nuclear Energy (Comissão Nacional de Energia Nuclear - CNEN) is the national regulatory body, in accordance with the National Nuclear Energy Policy Act.

Furthermore, the constitutional principles regarding protection of the environment (Article 225) establish that any installation which may cause significant environmental impact shall be subject to environmental impact studies that shall be made public. More specifically, for nuclear power plants, the Federal Constitution provides that the siting of the installation shall be approved by law (Article 225, Paragraph 6). Therefore, licensing of nuclear power plants are subject to both a nuclear licence by CNEN and an environmental licence by the Brazilian Institute for the