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

Environment and Renewable Natural Resources (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis - IBAMA), with the participation of state and local environmental agencies as provided by the National Environmental Policy Act.

These principles were established by the Federal Constitution of 1988, at a time when Angra 1 was already in operation, and Angra 2 was already under construction. Therefore, licensing procedures for these power plants followed procedures slightly different from the ones described below.

3.1.1. Nuclear licensing process

CNEN was created in 1956 (Decree 40.110 of 1956.10.10) to be responsible for all nuclear activities in Brazil. Later CNEN was re-organized and its responsibilities were established by the Law 4118/62 as amended by Laws 6189/74 and 7781/89. Thereafter, CNEN became the Regulatory Body in charge of regulating, licensing and controlling nuclear energy.

CNEN's responsibilities relating to this Convention include, among others, the following activities:

- the preparation and issuance of nuclear safety, radiation protection, radioactive waste management and physical protection regulations;
- accounting and control of nuclear materials (safeguards);
- licensing and authorization for siting, construction, operation and decommissioning of nuclear facilities;
- regulatory inspection of nuclear reactors;
- acting as a national authority for the implementation of international agreements and treaties concerning nuclear safety activities;
- participating in the national preparedness for, and response to nuclear emergencies.

Under this framework, CNEN has enacted radiation protection regulations and regulations for the licensing process of nuclear power plants, safety during operation, quality assurance, licensing of operational personnel and their medical certification for active duty, reporting requirements for the operational nuclear power plants, plant maintenance, among other things (See Annex 2. Item 2.3 for a complete list of CNEN regulations).

The licensing regulation CNEN NE 1.04[4] establishes that no nuclear installation shall operate without a licence. It also establishes the necessary review and assessment process, including the specification of the documentation to be presented to CNEN at each phase of the licensing process. It finally establishes a system of regulatory inspections and the corresponding enforcement mechanisms to ensure that the licensing conditions are being fulfilled. The enforcement mechanisms include the authority of the CNEN to modify, suspend or revoke the licence.

The licensing process is divided into several steps:

- Site Approval;
- Construction Licence;
- Nuclear Material Utilization Authorization;
- Authorization for Initial Operation;

- Authorization for Permanent Authorization;
- Authorization for Decommissioning

For the first step, site selection criteria are established in Resolution CNEN 09/69[5], considering factors such as the design and the site itself, which may contribute to violation of established dose limits at the proposed exclusion area for a limiting postulated accident. Additionally, by adopting the principle of "proven technology", CNEN's regulation NE 1.04 requires, for the site approval, the adoption of a "reference plant" for the nuclear installation being licensed.

For the construction licence, CNEN performs a detailed review and assessment of the information received from the licensee in a Preliminary Safety Analysis Report (PSAR). The construction is followed closely by a system of regulatory inspections.

For the authorization of initial operation, CNEN reviews the construction status, the commissioning programme including results of pre-operational tests, and updates its review and assessment of plant design based on the information submitted in the Final Safety Analysis Report (FSAR). At this time CNEN also licenses the reactor operators in accordance with regulation NE 1.01 [6]. Startup and power ascension tests are closely followed by CNEN inspectors, and hold points at different power levels are established.

Authorization for permanent operation, which is limited to a maximum of 40 years, is awarded only given after a complete review of commissioning test results has been completed, and the deficiencies identified during construction and initial operation have been solved. The authorization establishes limits and conditions for operations and lists the programmes which should be kept active during operation, such as the radiological protection programme, the physical protection programme, the quality assurance programme for operation, the fire protection programme, the environmental monitoring programme, the qualification and training programme, the preventive maintenance programme, the retraining programme, etc. Reporting requirements are also established through CNEN regulation NE 1.14[7]. These reports, together with a system of regulatory inspections performed by resident inspectors and headquarters personnel are the basis for monitoring the safety of plant operation.

Other governmental organizations are involved in the licensing process, through appropriate consultations. The most important ones are the Institute for Environmental and Renewable Natural Resources (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis - IBAMA), which is in charge of environmental licensing and the Secretariat for Strategic Affairs (Secretaria de Assuntos Estratégicos - SAE) which is involved in emergency planning aspects.

3.1.2. Environmental licensing

IBAMA was created through Law n. 7.735 of 22 February 1989 under the Ministry for Environment, Hydro Resources and the Legal Amazonia (Ministério do Meio Ambiente, Recursos Hídricos e da Amazonia Legal - MMA) with the responsibility to execute and enforce the National Environmental Policy (PNMA) established by the Law N°. 6938/81.

The PNMA established the National System for the Environment (SISNAMA), which is composed by the National Council for the Environment (Conselho Nacional para o Meio Ambiente - CONAMA) and executive organizations at the federal, state and municipal levels. The central executive body for SISNAMA is IBAMA, which is, therefore, responsible for the environmental licensing process of any installation with potential significant environmental impact. This involves the development of an Environmental Impact Study (EIA) and the preparation of an Environmental Impact Report (RIMA), which is made available to the public and discussed in a public hearing, according to the national legislation (see Annex 2, item 2.4 for list of CONAMA regulations).

Actually, the environmental licensing of Angra 1 took place before the creation of IBAMA, at the

time that the State Foundation for Environment Engineering (Fundação Estadual de Engenharia do Meio Ambiente - FEEMA) was the state organization in charge of environmental matters.

Since 1989, after the establishment of the legal competence of IBAMA for environmental licensing of nuclear installations, with the participation of CNEN and state and local environmental agencies, the Institute became involved with the licensing of Angra 2. Although Angra 2 was already under construction, IBAMA has required from FURNAS, now ELETRONUCLEAR, the preparation of an Environmental Impact Study (EIA) and a Report on Environmental Impact (RIMA) for the operation environmental licence.

Since CNEN has the technical competence for the evaluation of radiation impact on the environment, IBAMA and CNEN have established a formal agreement to specify their respective areas of activity so as to optimize both licensing processes (see also 5.1).

3.1.3. Emergency preparedness legislation

With respect to emergency preparedness additional requirements have been established by the creation of the System for Protection of the Brazilian Nuclear Programme (SIPRON) through Law 1809 of October 7 1980. The subsequent decree 2210 of April 22 1997 has defined the Secretariat for Strategic Affairs (Secretaria de Assuntos Estratégicos - SAE), directly linked to the Presidency, as the central organization of SIPRON that is responsible for preparedness and the response to nuclear emergencies in Brazil (see diagram in Attachment 1E). This decree also establishes the system's structure: its organization, the agencies involved and the Commission for Protection of the Nuclear Programme (COPRON) as the coordinating mechanism.

SIPRON guidelines, set forth by COPRON (see Annex 2, item 2.5), require that ELETRONUCLEAR prepare, keep up- to- date and exercise a plan for nuclear emergency situations. As a matter of fact, the guidelines require CNEN and other organizations and agencies involved to have their own emergency plans, as well (see item 4.7).

3.2. Article 8. Regulatory body

As mentioned in item 3.1, the Brazilian National Commission for Nuclear Energy (CNEN) has been designated as the regulatory body entrusted with the implementation of the legislative framework related to safety of nuclear installations. However, other governmental bodies are also involved in the licensing process, such as the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA).

CNEN authority is a direct consequence of Law 4118/62 as amended by Laws 6189/74 and 7781/89, which creates CNEN. These laws established that CNEN has the authority "to issue regulations, licences and authorizations related to nuclear installations", "to inspect licensed installations" and "to enforce the Laws and its own regulations".

Financial resources for CNEN are provided directly by the Government budget. Currently, the licensee is not charged fees or taxes. A bill of law establishing licence fees and taxes is under discussion in the National Congress.

The structure of CNEN is provided in Attachment 1B. The main organizational unit involved with the licensing of nuclear power plants is the Directorate for Radiation Protection and Nuclear Safety (DRS), although technical resources can be drawn from any other units. Review and assessment is performed mainly by the Reactor Coordination (CODRE) of the Superintendence for Licensing and Control (SLC). CODRE is also in charge of regulatory inspection of nuclear power plants, including a group of resident inspectors at the Angra site. In the areas of radiation protection and environmental monitoring technical support is obtained from the Institute for Radiation Protection and Dosimetry (IRD). The necessary regulations and standards are developed by working groups under coordination of the Norms Service (SENOR).

Adequate human resources are provided to CNEN. A total staff of 2756 employees, of which 85% are technical staff, is available at CNEN and its research institutes. Forty-eight percent

(48%) of the staff are university graduates, 17% having a master degree and 7% having a doctoral degree. SLC itself comprises 183 individuals, 149 of which are technical personnel. CODRE, the unit directly involved with nuclear power plants, has a staff of 42, of which 40 are technical, of which 20 possessing a doctoral or master degree in nuclear science or engineering.

Effective separation between the functions of the regulatory body (CNEN) and the organization responsible for the promotion and utilization of nuclear energy for electricity generation (ELETRONUCLEAR) is provided by the organizational structure of the Brazilian Government itself. While CNEN is subsidiary body of SAE, which is directly linked to the Presidency of the Republic, ELETRONUCLEAR is a part of ELETROBRAS, a national holding company for the electric system, which is subordinated to the Ministry of Mines and Energy (Minstério de Minas e Energia - MME) (see Attachment 1A).

The licensing structure of IBAMA (see Attachment 1D) comprises its Department of Project Evaluation, with a graduated technical staff of 18 professionals and 7 technicians. For the licensing of Angra 2, they work in close cooperation with CNEN staff concerning the radiological impact aspects. They also cooperate with the Rio de Janeiro State Foundation for Environmental Engineering (FEEMA) and the Angra dos Reis Municipal Secretary for Environment.

3.3. Article 9. Responsibility of the licence holder

The Brazilian regulation ascribes to the operating organization the prime responsibility for the safety of a nuclear installation.

ELETRONUCLEAR, as the owner and operator of the Angra plant, has issued a company policy statement regarding its commitment to safe operation, which reads as follows:

> **"Safety is a priority that precedes production and economics. Safety shall never be jeopardized for any reason"**
>
> It further states that:
>
> **"Responsibility for safety is shared equally by the entire corporate structure - Directors, Advisors, Superintendents, Managers and Divisions Heads. Careless acts or actions by employees do not diminish the responsibilities of their supervisors".**

The text of this company policy statement, reproduced in its original Portuguese version in Attachment 2, is fully based on the IAEA INSAG-4 publication on Safety Culture.

The implementation of this policy is based on a programme that adopts the concept of Safety Culture, defines safety objectives and establishes requirements, appropriate management structure (Attachment 1C), resources and self-assessment.

CNEN, through the licensing process, and especially through its regulatory inspection programme, ensures that the regulatory requirements for safe operation are being fulfilled by the licensee. The licensee reports periodically to CNEN in accordance with regulation CNEN-NE-1.14 [7]. In addition, CNEN maintains a group of resident inspectors on the site, who can monitor licensee performance on a daily basis. Finally, a number of regulatory inspections by headquarters staff take place every year, focusing on specific topics or operational events.

Chapter 4. GENERAL SAFETY CONSIDERATIONS

4.1. Article 10. Priority to safety

ELETRONUCLEAR is the product of a merger between the nuclear area of the electric energy utility FURNAS and the nuclear engineering company NUCLEN, both of which had operated for more than 20 years in their fields. Both companies traditionally had policies aiming at giving