SECOND NATIONAL

REPORT OF

BRAZIL

FOR THE

NUCLEAR SAFETY

CONVENTION

September 2001

FOREWORD

On 20 September 1994 the Convention on Nuclear Safety was open for signature at the headquarters of the International Atomic Energy Agency in Vienna. Brazil signed the Convention in September 1994, and deposited the instrument of ratification with the Depositary on 4 March 1997.

The Convention objective is to achieve and maintain a high level of nuclear safety throughout the world. One of the obligations of the Parties to the Convention is the preparation of a periodical National Report describing the national nuclear programme, the nuclear installations involved according to the Convention definition, and the measures taken to fulfill the objective of the Convention.

The first National Report was prepared by a group composed of representatives of the various Brazilian organizations with responsibilities related to nuclear safety, and presented to the Parties of the Convention in September 1998. The first National Report contained a description of the Brazilian policy and programme related to the safety of nuclear installations, and an article by article description of the measures Brazil is taking to implement the Convention obligations. During the review process established by the Convention, the Report was evaluated by the other Parties, which formulated 62 questions and 2 comments. These questions were answered in a Supplement to the first National Report, which was presented in the review meeting in April 1999, in Vienna.

According to the obligations of the Convention, this Second National Report of Brazil was prepared to update the information provided in the previous Report with information related to the period 1998/2001. The Report contains also additional information as recommended by the Report of the Review Meeting of April 1999.

The authors decided to prepare the Second National Report of Brazil as a self-standing document, with some repetition of the information provided in the first National Report so that the reviewers do not have to consult frequently the previous document. To the extent possible, new information has been identified in the text. The most relevant new information refers to the coming into operation of the second Brazilian nuclear power plant, Angra 2. Restructuring of the Brazilian organizations is also reported. New laws and regulations are presented, including a new law on tax and fees for licensing, which was approved in 1999.

SUMÁRIO

Em 20 de setembro de 1994 a Convenção sobre Segurança Nuclear foi aberta para assinaturas na sede da Agência Internacional de Energia Atômica em Viena. O Brasil assinou a convenção em setembro de 1994 e ratificou-a através do decreto legislativo n. 4 de 22 de janeiro de 1997, depositando o instrumento de ratificação no Depositário em 4 de março de 1997.

O objetivo da Convenção é alcançar e manter o alto nível de segurança nuclear em todo o mundo. Uma das obrigações das Partes da Convenção é a preparação a cada 3 anos de um Relatório Nacional descrevendo o programa nuclear nacional, as centrais nucleares existentes, e as medidas tomadas a fim de cumprir os objetivos da Convenção.

O primeiro relatório nacional do Brasil foi preparado por um grupo composto por representantes das várias organizações brasileiras com responsabilidades relacionadas com a segurança nuclear, e apresentado às Partes da Convenção em Setembro de 1998. O Relatório continha uma apresentação da política nuclear brasileira e o programa relacionado com a segurança das centrais nucleares e uma descrição das medidas tomadas pelo Brasil para implementar as obrigações de cada artigo da Convenção. Durante o processo de Revisão pelas Partes estabelecido pela Convenção, o relatório nacional do Brasil foi analisado pelos demais países que formularam 62 perguntas e 2 comentários. Estas perguntas foram respondidas num suplemento ao primeiro Relatório Nacional que foi apresentado na reunião de revisão que se realizou em Abril de 1999, em Viena.

De acordo com as obrigações da Convenção, este Segundo Relatório Nacional do Brasil foi preparado para atualizar a informação contida no relatório anterior com dados relativos ao período 1998/2001. O capítulo 1 contém uma descrição da política nuclear brasileira e do programa de centrais nucleares. Os capítulos 2 a 5 apresentam, de acordo com cada artigo da Convenção, uma análise das organizações, estruturas e atividades brasileiras relacionadas com as obrigações da Convenção. O capítulo 2 descreve as centrais nucleares existentes. O capítulo 3 dá detalhes sobre a legislação e normas, incluindo uma descrição dos processos regulatórios e dos órgãos reguladores. O capítulo 4 cobre as considerações gerais de segurança descritas nos artigos 10 a 16 de Convenção. O capítulo 5 refere-se à segurança das centrais nucleares durante a localização, construção e operação. O capítulo 6 descreve outras atividades já planejadas para aprimorar ainda mais a segurança. O capítulo 7 contém informações adicionais em tópicos específicos, conforme recomendado pelo relatório da reunião de revisão de Abril de 1999. O capítulo 8 faz considerações finais sobre o grau de cumprimento das obrigações da Convenção sobre Segurança Nuclear pelo Brasil.

Os autores decidiram preparar o Segundo Relatório Nacional do Brasil como um documento completo, com alguma repetição das informações contidas no primeiro Relatório Nacional de maneira que os revisores não tivessem que consultar freqüentemente o relatório anterior. Na medida do possível, as novas informações são indicadas no texto. A nova informação mais relevante diz respeito à entrada em operação da segunda usina nuclear, Angra 2. A reestruturação das organizações nucleares brasileiras está também descrita no presente Relatório. Novas leis, normas e decretos, incluindo a nova lei das taxas para licenciamento nuclear, aprovada em 1999 também estão descritas.

As considerações finais apresentadas no capítulo 8, levam à conclusão de que o Brasil alcançou e vem mantendo um alto nível de segurança em suas centrais nucleares, implementando e mantendo defesas efetivas contra o potencial perigo radiológico a fim de proteger os indivíduos, a sociedade e o meio ambiente de possíveis efeitos da radiação ionizante, evitando acidentes nucleares com conseqüências radiológicas e mantendo-se preparado para agir efetivamente em uma situação de emergência.

Consequentemente, o Brasil alcançou os objetivos da Convenção sobre Segurança Nuclear.

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SECOND NATIONAL REPORT
OF
BRAZIL

Chapter 1. INTRODUCTION

1.1. The Brazilian nuclear policy

The Brazilian Federal Constitution of 1988 states in articles 21 and 177 that the Union has the exclusive competence for managing and handling all nuclear energy activities, including the operation of nuclear power plants[1]. The Union holds also the monopoly for the survey, mining, milling, exploitation and exploration of nuclear minerals, as well as the activities related to industrialization and commerce of nuclear minerals and materials. All these activities shall be solely carried out for peaceful uses and always under the approval of the National Congress.

The national policy for the nuclear sector is implemented through the Plan for Science and Technology 2000/2005 (Plano Plurianual de Ciência e Tecnologia - PPA 2000/2005), which establishes quantitative targets that define the Government strategy. Among these targets is the National Nuclear Power Policy aiming at guiding research, development, production and utilization of all forms of nuclear energy considered of strategic interest for the Country in all aspects, including scientific, technological, industrial, commercial, energy production, civil defense, safety of the public and the environment.

Another important target is to increase the participation of nuclear energy in the national electricity production. This involves the continuous development of technology, and the design, construction and operation of nuclear industrial facilities related to the nuclear fuel cycle. This includes also the technological and industrial capability to design, construct and operate nuclear power plants, to provide electrical energy to the Brazilian grid in a safe, ecologically sound and economic way. Moreover, this also requires the development of necessary human resources for the establishment and continuity of the activities in all these fields.

The Comissão Nacional de Energia Nuclear (Brazilian National Commission for Nuclear Energy - 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 with alterations determined by Laws 6189/74 and 7781/89. Thereafter, CNEN became the Regulatory Body in charge of regulating, licensing and controlling nuclear energy, and the nuclear electric generation was transferred to the electricity sector.

1.2. The Brazilian nuclear programme

[1] In this Report the terms Nuclear Installation and Nuclear Power Plant are used as synonyms, in accordance with the definition adopted in the Nuclear Safety Convention (Art. 2 - i).

Currently, Brazil has two nuclear power plants in operation (Angra 1, 657 MWe gross/626 MW net, 2-loop PWR and Angra 2, 1345 MWe gross /1275MWe net, 4-loop PWR), and one under construction (Angra 3, 1312 MWe gross/1229 MW net, 4-loop PWR). Angra 3 has had the construction temporarily interrupted since 1991 and its restarting is presently being considered by the Federal Government, due to the present critical situation of energy supply in the Country. 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.

The construction of nuclear power plants in Brazil required great efforts in qualifying domestic engineering, manufacturing and construction firms, to comply with the strict nuclear technology transfer. The result of these efforts, based on active technology transfer, has led to an increasing national participation.

Brazil has established a nuclear power utility/ engineering company Eletrobras Termonuclear S. A. (ELETRONUCLEAR), a heavy components manufacturer, Nuclebras Equipamentos Pesados (Nuclebras Heavy Equipment - NUCLEP), a nuclear fuel manufacturing plant (Fábrica de Combustível Nuclear - FCN) and a yellow-cake production plant belonging to Industrias Nucleares do Brasil (Nuclear Industries of Brazil - INB). Brazil has also 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 approximate 310,000 t U_3O_8 in situ, recoverable at low costs.

In accordance to the 10-years Expansion Plan 2000/2009 of Eletrobras – the Brazilian electric energy holding, Angra 3 is due to enter commercial operation by 2006. The plant is included as well in the pluriannual planning of the Brazilian Federal Government

1.3. Structure of the National Report

This Second National Report was prepared to fulfill the Brazilian obligations related to the Convention on Nuclear Safety[1]. Chapters 2 to 5 present an article by article analysis of the Brazilian structures, actions and activities related to the Convention's obligations (Chapter 2 of the Convention), and follow the revised Guidelines for the preparation of National Reports[2]. 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 addresses questions raised during the first review meeting[3] and for which additional information was requested from the Parties to the Convention. Chapter 8 presents final remarks related to the degree of compliance with the Convention obligations.

The Second National Report of Brazil has been prepared as a self-standing document, with some repetition of the information provided in the first National Report [4] so that the reviewers do not have to consult frequently the previous document. To the extent possible, new information has been identified in the text.

Since Brazil has only two nuclear installations in operation and one under construction, more plant specific information is provided in the report than is recommended in the Guidelines[2]. This was purposely done for the benefit of the reader not familiar with the current Brazilian situation.

The report also contains two annexes where more detailed information is provided with respect to the nuclear installations and the Brazilian nuclear legislation and regulations.

Chapter 2. NUCLEAR INSTALLATIONS

2.1. Article 6. Existing nuclear installations

As mentioned in item 1.2, Brazil has two nuclear power plants in operation (Angra1, 657 MWe gross/626 MW net, 2-loop PWR and Angra 2, 1345 MWe gross/1275 MWe net, 4-loop PWR) and one under construction (Angra 3, 1309 MWe gross/1229 MW net, PWR, similar to Angra 2, with construction temporarily interrupted). 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[5], available through the Internet as well as in the ELETRONUCLEAR home page http://www.eletronuclear.gov.br.

Angra 1 and Angra 2 are very important to ensure 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 plants also play 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.

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 contracted directly, respectively the Chicago Bridge & Iron Company and Construtora Norberto Odebrecht S.A, a Brazilian contractor which eventually also became contractor of the civil works of Angra 2. To assist in the implementation of the overall quality assurance programme, FURNAS contracted an independent consultant, Ebasco Services Co. To assist in the implementation of the nuclear fuel quality assurance programme, NUS Corporation was contracted as an independent consultant.

CNEN granted the construction permit for the plant in 1974. The operating licence was issued in September 1981, at which time 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 required equipment modifications, the plant finally entered into commercial operation on 1st January 1985.

In 1998, plant ownership has 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 grid connection of the plant, from FURNAS, NUCLEN (now both at ELETRONUCLEAR) and other engineering companies, acquired considerable experience in dealing with the plant's technical matters.

The improvement in engineering support together with the implementation of specific improvement programmes in maintenance, chemistry and better planning of reload down times are reflected in the plant performance of the last 3 years (1998 to 2000) shown below, as measured by the WANO Plant Availability indicator.

Table 1 - Angra 1 Plant Availability

Year	Plant Availability
1998	79.70%
1999	96.10%
2000	80.81%

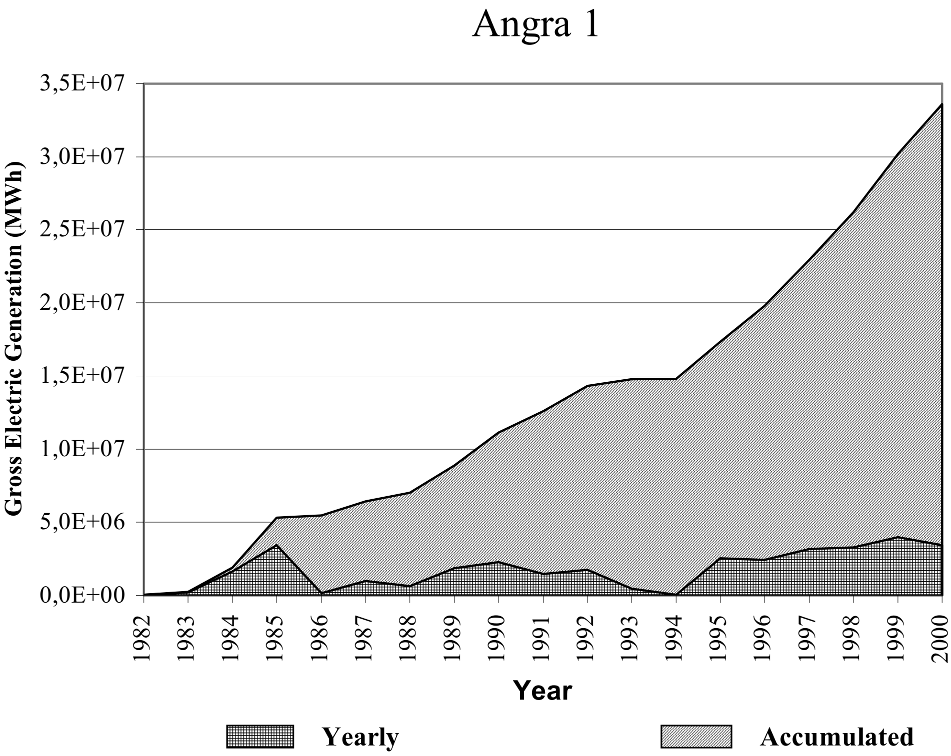


Fig.1 - Angra 1 – Energy Generation

2.1.1.1. Safety improvements at Angra 1.

Angra 1 safety status 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 after the occurrence of safety significant events in similar plants, such as the fire at Browns Ferry NPP and the accident at Three Mile Island.

During operation, Angra 1 has been reviewed and upgraded based on its own operational experience, on new CNEN requirements, and on 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 new items or design modifications related to the lessons learned from the Three Mile Island accident such as a safety parameters display system, post accident monitoring instrumentation, venting on the top of the reactor vessel, on-line monitoring of H_2/O_2 in the containment, improvements with respect to station blackout, procedure and improvements for ultimate actions like feed and bleed, middle loop operation level monitoring system. Modifications related to 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 in the spent fuel pool. On the analysis side, a preliminary Probabilistic Safety Analysis (PSA) was conducted using generic plant data. A new detailed PSA study has been completed in 1999 and revised in 2000, which takes into account actual plant data, human reliability analysis, and additional events such as internal flooding.

Within the period 1998/2000 the main safety improvements performed in the plant were: replacement of three containment electric penetrations, replacement of the wide range level transmitters of the containment sump, Diesel generators upgrade, installation of a new waste compactation system , redundant cooling water system installation in spent fuel pit, reactor core thermocouples replacement and environmental qualification of the system, modernization of meteorological monitoring system, replacement of obsolete instrumentation (current), replacement of instrumentation according to requirements of US NRC Regulatory Guide 1.97, implementation of a radioactive waste recipient qualification programme and replacement of feedwater heaters for secondary system improvement.

2.1.2. Angra 2

In June 1975, a Cooperation Agreement for the peaceful uses of nuclear energy was signed between Brazil and the Federal Republic of Germany. Under that agreement Brazil accomplished the procurement of two nuclear power plants, Angra 2 and 3, from the German company, KWU - Kraftwerk Union A.G., now SIEMENS/KWU nuclear power plant supplier branch.

Considering that one of the objectives of the Agreement was a high degree of domestic participation, Brazilian engineering company Nuclebras Engenharia S.A. - Nuclen (now ELETRONUCLEAR, after merging with the nuclear part of FURNAS, in 1997) was founded in 1975 to act as architect engineer for the Angra 2 and 3 project, with KWU as the overall plant designer, and, on the process, to acquire the required technology to design and build further nuclear power plants.

Furthermore, great efforts were done to qualify Brazilian engineering firms and local industry to comply with the strict standards of nuclear technology. Indeed, this allowed a growing participation of national companies (engineering firms, equipment industries, erections firms, testing laboratories, etc.) in this major undertaking, always under the conditions that the same level of safety be achieved as in similar plants of the technology supplier country.

Angra 2 civil engineering contractor was Construtora Norberto Odebrecht and the civil works started in 1976. However, from 1983 on, the project suffered a gradual slowdown due to financial resources reduction. In 1991, Angra 2 works were resumed and in 1994, the financial resources necessary for its completion were defined. In 1995, a bid was called for the electromechanical erection and the winner companies formed the consortium UNAMON, which started its activities at the site in January 1996 (see Figure 2).

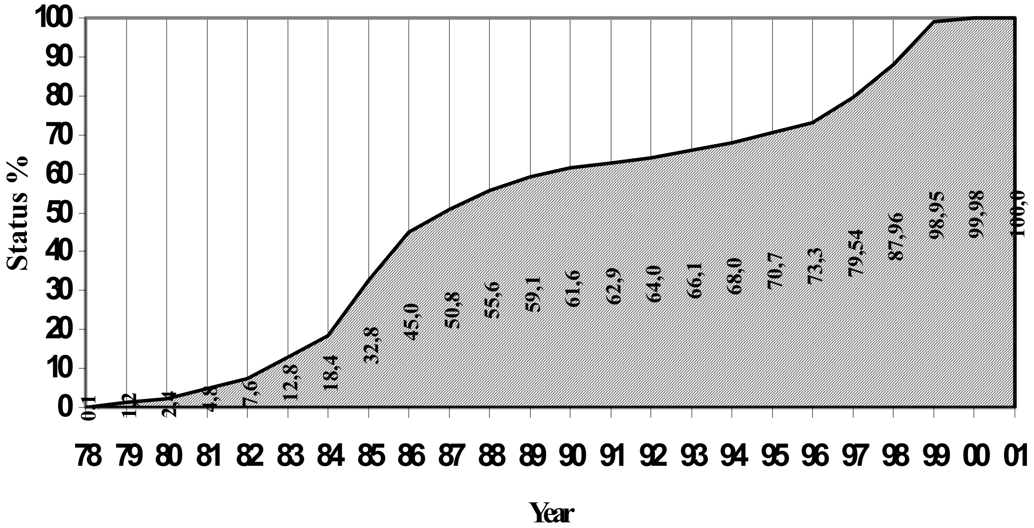


Fig. 2 – Angra 2 Construction Progress

Hot trial operation was started in September, 1999. In March 2000, after receiving from CNEN the Authorization for Initial Operation (AOI) initial core load started, followed by initial criticality on 17 July 2000, and first connection to the grid on 21 July 2000. The power tests phase was completed in November, 2000. The Angra 2 NPP has been operating at full power since mid November 2000. In March 2001, the Authorization for Initial Operation (AOI) was extended for one year, to allow CNEN's evaluation of the complete commissioning programme and the closure of some open questions still remaining from the FSAR review and assessment activity.

The commissioning phase was a very successful one. No major equipment problems occurred in spite of the very long storage time (~20 years), indicating the high quality of the component conservation programme.

For illustration, some milestones of the commissioning phase are presented below.

Table 2 – Angra 2 Commissioning Milestones

	Foreseen	*Actual*	
	Beginning	Beginning	End
Pressure test Primary System	10.04.99	15.05.99	19.05.99
1st Hot Trial	10.07.99	19.09.99	16.11.99
Core loading	15.03.00	30.03.00	02.04.00
2nd Hot Trial	29.03.00	13.04.00	29.05.00
1st Criticality	15.06.00	14.07.00	14.07.00
Synchronisation to grid (at 30% power)	25.06.00	21.07.00	21.07.00
80%power tests phase	18.08.00	21.08.00	19.09.00
100% power tests phase	09.09.00	28.09.00	23.11.00
Trial Operation	21.10.00	24.11.00	21.12.00

Angra 2 operational record for the first 7 month of 2001, as measured by the WANO Availability indicator, is 94.1%.

2.1.2.1 Safety status of Angra 2

The Angra 2 NPP belongs to the 1300 MWe Siemens-KWU PWR family, with 4 x 50% redundant safety systems, with consequent physical separation of trains. The plant has also a high degree of automation of the control, limitation and protection systems, complying with the 30 minutes non-intervention rule and a very reliable emergency power supply system, consisting of 2 independent sets of 4 Diesel generators each. A separate, fully protected building is provided to host the Emergency Control Room and the required water and energy (batteries and 2nd set of Diesel Generators) supplies to shut down and maintain the cooling of the plant, in case of major natural or man-made hazards.

Angra 2 status is the one of a modern NPP, as a result of a consistent programme of upgrading that has been carried on along the construction years, with implementation of all safety related modifications added to the German reference plant Grafenrheinfeld, as well as most improvements built in the newest German KONVOI plant series. Comprehensive testing carried out along the commissioning phase has allowed to adjust and confirm the design basis of the safety related equipment as well as of the operational equipment.

The fact that most of the people from the former NUCLEN who helped design and build the plant has remained with ELETRONUCLEAR, is a guarantee of adequate engineering support for the Angra 2 operation.

2.1.3 Angra 3

To date (July 2001),the Angra 3 construction programme remains interrupted. Most of its components, of imported scope, are already in Brazil and the site is ready for concrete pouring. The required engineering is essentially all available since for economy and standardization reasons Angra 3 is to be as similar as possible to Angra 2. Several positive independent evaluations of the economics of concluding Angra 3 were done by Brazilian and international consultants and the subject is presently being discussed at Government level.

For supporting the decision of Angra 3 construction restarting, the performance of economical feasibility studies to evaluate project competitiveness in comparison with other alternatives of electricity production in the country became mandatory. The feasibility studies were performed in 1998 and the results checked and confirmed by independent evaluation performed by Electricité de France (EDF) and IBERDROLA, demonstrating the economic atractiveness of the Project.

Following the original concept, Angra 3 is planned to be a twin plant of Angra 2. This concept has been submitted to and approved by the Brazilian licensing authority – CNEN, proposing “Angra 2 as-built” as the reference plant for Angra 3. In this context, the only major technical modification planned for Angra 3 is the replacement of the conventional instrumentation and control by modern digital technique. The concept is being worked out together with FRAMATOME ANP (successor of Siemens-KWU) for a final decision to be reached by the end 2001.

Since Angra 3 will be constructed directly on rock material, and not using a pile foundation as Angra 2, seismic acceleration spectra has been analized and, with some assumptions already discussed with CNEN, no relevant changes in the piping support design are expected.

As preparation for restarting plant construction, the “as-built” condition of Angra 2 is being implemented on the design documents using CAD technique, to be applied as the reference design documents for Angra 3 construction.

Concerning supplies, more than 65% in value of the imported equipment is already stored in the warehouses, including not only the primary circuit heavy components and the turbine-generator set but also special pumps, valves and piping material. Excellence of the preservation plan for long term storage has been demonstrated during Angra 2 completion, whereby no relevant equipment malfunction due to long term storage had adverse impact on plant commissioning or initial operation. The preservation measures including the 24 months inspection programme continue to be applied for the Angra 3 components stored at the site.

Table 3 – Angra 3 Current Status

ESTIMATED PROGRESS	
ITEM	**PROGRESS**
DESIGN	Approx. 70 - 75%
IMPORTED SUPPLY	Approx. 65 - 75%
NATIONAL SUPPLY	Approx. 5%
CIVIL CONSTRUCTION	Approx. 5%
ELECTROMECHANICAL ERECTION	0%
COMMISSIONING	0%
TOTAL ENTERPRISE	**30%**

For the national scope of supplies, more than 50% in value is concentrated in supply contracts already signed with Brazilian companies, including condensers, heat exchangers and tanks. The general guidelines for renegotiating the contracts are established and the re-negotiation will be started immediately after plant construction decision. Contract for civil construction had already been signed in the past and the scope and commercial conditions are now being reevaluated for re-negotiation with the contractor.

Preparation of the Preliminary Safety Analysis Report (PSAR) for the Nuclear Licensing process is under way. As agreed with CNEN, the Angra 3 PSAR will be prepared based on the approved Final Safety Analysis Report of Angra 2, with the necessary adaptations.

As a critical path for restarting construction, the Environmental Impact Study will be prepared along 2001 in the frame of the Environmental Licensing Process.

Plant construction is planned for a 66 months duration, from starting of reactor annulus slab concrete work up to end of power tests and start of commercial operation. Effective restart of Angra 3 project depends on final decision of the Brazilian Government authorities, expected for the second half of 2001.

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 Federal Union, the 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 nuclear activities related to electricity generation, including regulating, licensing and controlling nuclear safety (Articles 21 and 22). In this regard, the Comissão Nacional de Energia Nuclear (Brazilian National Commission for Nuclear Energy - 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) require 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 Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (Brazilian Institute for the Environment and Renewable Natural Resources – IBAMA), with the participation of state and local environmental agencies as stated in the National Environmental Policy Act. These principles were established by the Federal Constitution of 1988, at the time that Angra 1 had already been in operation, and Angra 2 had already been under construction. Therefore, licensing procedures for these power plants followed slightly different procedures, as described below.

A recent restructuring of the Federal Government has abolished the Secretary for Strategic Affairs (SAE) and placed CNEN under the Ministry of Science and Technology (MCT).

The relation amongst regulatory organizations and operators is shown in Figure 3.

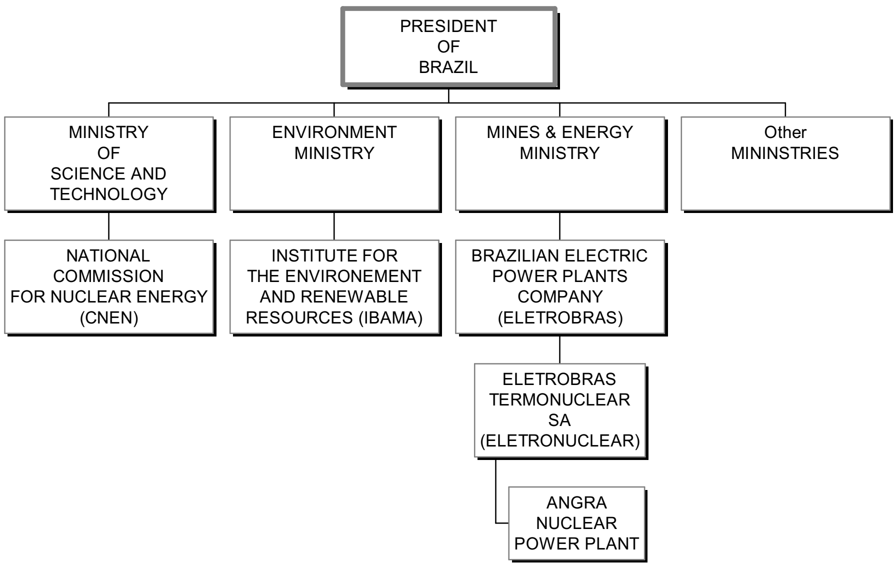


Fig. 3 – Brazilian Organizations Involved in Nuclear Power Plant Safety

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 Law 4118/62 with alterations determined by Laws 6189/74 and 7781/89. Thereafter, CNEN became the Regulatory Body in charge of regulating, licensing and controlling nuclear energy. Since 2000, CNEN is now reporting to the Ministério de Ciência e Tecnologia (Ministry of Science and Technology - MCT).

CNEN responsibilities related to this Convention include, among others:

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

Under this framework, CNEN has issued 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, and others (see Annex 2. Item 2.3 for a complete list of CNEN regulations).

The licensing regulation CNEN NE 1.04[6] 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 CNEN to modify, suspend or revoke the licence.

The licensing process is divided in several steps:

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

Federal Law 9.756 has been approved in 1998 establishing taxes and fees for each individual licensing step, as well as for the routine work of supervision of the installation by CNEN.

For the first step, site selection criteria are established in Resolution CNEN 09/69[7], taking into account design and site factors that 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 regulation NE 1.04 requires for site approval the adoption of a “reference plant” for the nuclear installation to be 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 for 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 CNEN-NE-1.01[8]. Startup and power ascension tests are closely followed by CNEN inspectors, and hold points at different power levels are established.

Authorization for permanent operation, limited to a maximum of 40 years, is given after a complete review of commissioning test results and the solution of any deficiencies identified during construction and initial operation. The authorization establishes limits and conditions for operation 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 regulation CNEN-NE-1.14[9]. These reports, together with a system of regulatory inspections performed by resident inspectors and headquarters personnel, are the basis for monitoring safety during plant operation.

Other governmental bodies are involved in the licensing process, through appropriate consultations. The most important ones are the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (Institute for Environmental and Renewable Natural Resources - IBAMA), which is in charge of environmental licensing and the Coordination of Technical and Scientific Programmes of the Ministry for Science and Technology (MCT) with respect to emergency planning aspects.

3.1.2. Environmental licensing

IBAMA was created through Law n. 7.735 of 22 February 1989 under the Ministério do Meio Ambiente (Ministry for Environment - MMA) with the responsibility to implement and enforce the National Environmental Policy (PNMA) established by Law N^{o}. 6938/81. The objective of the PNMA is to preserve, improve and recover the environmental quality, ensuring the conditions for social and economic development and for the protection of human dignity.

The PNMA established the National System for the Environment (SISNAMA), which is composed by the Conselho Nacional para o Meio Ambiente (National Council for the Environment - 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 potentially significant environmental impact.

The environmental licensing process includes the following steps:

- Pre-installation Licence, given at the preliminary planning stage, approving the siting and general concept of the installation, evaluating its environmental feasibility and establishing the basic requirements and conditions for the next implementation phases.

- Installation Licence, authorizing the construction of the installation in accordance with the approved specifications, programmes and projects including measures which are considered essential to protect the environment.
- Operating Licence, authorizing the operation of the installation after the verification of the effective fulfillment of the previous licence conditions, and the effective implementation of measures to protect the environment during operation.

One of the requirements for the issuance of a Pre-installation Licence is the development of an Environmental Impact Study (EIA) and the preparation of an Environmental Impact Report (RIMA). The RIMA is prepared to explain the project and evaluate other alternative sites and technologies and to describe the proposed activities, in order to allow for public participation and discussion with the local community in an effective way.

Public participation in the environmental licensing process is ensured by legislation through the conduct of public hearings (CONAMA Resolution 09/87). One of the requirements is transparency in the process, through the publication in the official newspapers and local press of any licence application and the decision to grant it or not by the relevant environmental agencies.

3.1.2.1 Environmental Licensing of Angra 1, 2 and 3.

The construction of Angra 1 and Angra 2 took place before the creation of IBAMA. The operation of Angra 1 started in 1981, before the current environmental regulation was established.

At that time, the Fundação Estadual de Engenharia do Meio Ambiente (State Foundation for Environment Engineering - FEEMA), the Rio de Janeiro state agency in charge of environmental matters, issued an Installation License.

Since 1989, with the definition of the legal competence of IBAMA for environmental licensing of nuclear installations, with the participation of CNEN and state and local environmental agencies, IBAMA has been involved in the licensing process of Angra 1 and Angra 2.

The updating of environmental licence of Angra 1, in accordance with the current IBAMA requirements, is being done through an “adaptive licensing” to adjust the enterprise to the environmental regulations. This process defines the necessary environmental studies to be carried out and submitted to IBAMA in order to justify the issuance of an Operating Licence.

Although Angra 2 was already under construction, CONAMA determined that IBAMA should require from FURNAS, now ELETRONUCLEAR, the preparation of an Environmental Impact Study (EIA) and a Report on Environmental Impact (RIMA).

These documents were submitted to IBAMA and formed the basis for IBAMA evaluation of the environmental impact. They also served as a basis to define environmental plans and programmes detailed in a Basic Environmental Project (PBA) , to be carried out by the licensee.

. The RIMA served also as a basis for the 2 public hearings about Angra 2 impact, which took place in the surroundings of the plant in the period of 1999-2000. Based on these evaluations and taken into consideration the discussion during the hearings, IBAMA has issued a special Licence for Initial Operation. Currently IBAMA is analysing the complementary documentation and evaluating the results of the environmental monitoring programmes to issue the Operating Licence for Angra 2.

With respect to Angra 3, IBAMA has proposed in 1999 the Terms of Reference for the preparation of the development of the EIA/RIMA which should be prepared under the responsibility of ELETRONUCLEAR.

Since CNEN has the technical competence for the evaluation of radiological impact in the environment, IBAMA and CNEN have established a formal agreement to specify the respective scope of action and 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 7 October 1980. The subsequent Decree 2210 of 22 April 1997 defined the Secretaria de Assuntos Estratégicos (Secretariat for Strategic Affairs - SAE), directly linked to the Presidency of the Republic, as the Central Organization of SIPRON responsible for the general supervision of the preparedness and response to nuclear emergencies in the Country.

More recently, a Governmental restructuring has designated the Ministry of Science and Technology (MCT) as the Central Organization for SIPRON, which now stays under the Special Advisor for the Coordination of Technical and Scientific

Programmes of MCT (see Figure 4).

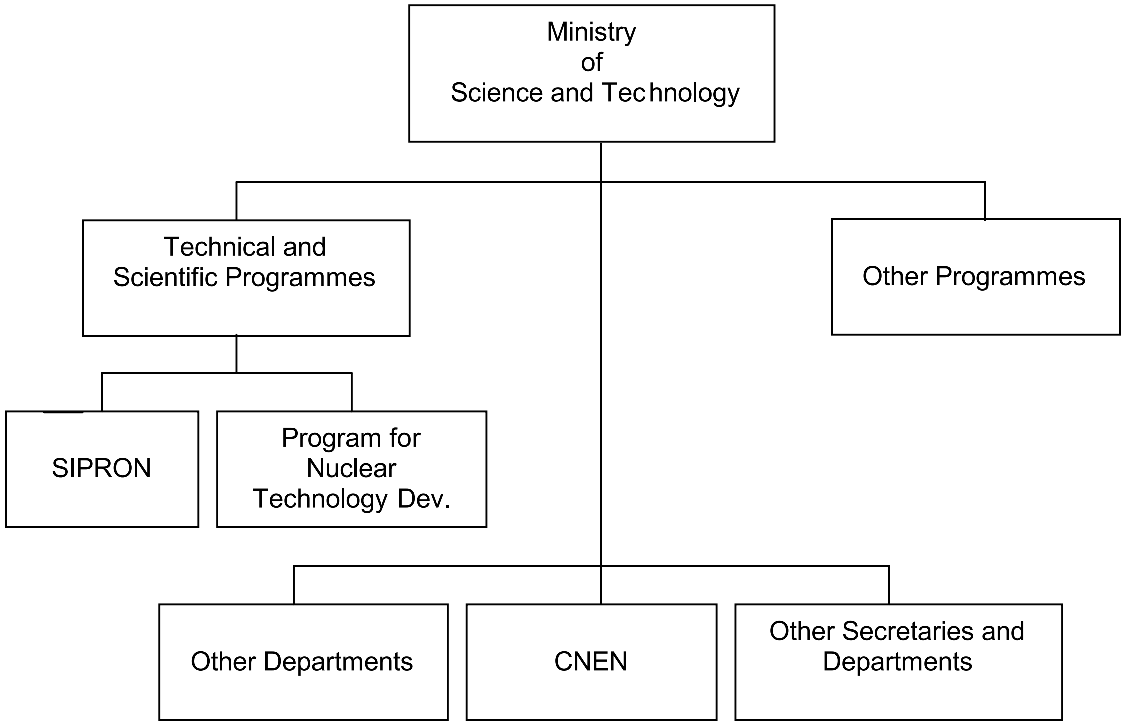


Figure 4 – SIPRON position within the MCT Structure

The Decree 2210 also establishes a system structure composed of the organization and agencies involved and the Commission for Protection of the Nuclear Programme (COPRON) as the coordination mechanism.

SIPRON guidelines, issued by COPRON (see Annex 2, item 2.5), require that ELETRONUCLEAR and the State Civil Defense prepare, keep up to date and exercise a plan for nuclear emergency situations. As a matter of fact, the guidelines require that CNEN and other organizations and agencies involved have their emergency plans, as well (see also 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. Other governmental bodies are also involved in the licensing process, such as the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA).

3.2.1. CNEN

CNEN authority is a direct consequence of Law 4118/62 and its alterations determined by Laws 6189/74 and 7781/89, which created 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".

Effective separation between the functions of the regulatory body (CNEN) and the organization concerned with the promotion and utilization of nuclear energy for electricity generation (ELETRONUCLEAR) is provided by the structure of the Brazilian Government in this area. While CNEN is linked to the Ministry of Science and Technology (MCT), ELETRONUCLEAR is fully owned by ELETROBRAS, a national holding company for the electric system, which is under the Ministry of Mines and Energy (MME) (see Figure 3).

The structure of CNEN is presented in Figure 5. 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 in support of some licensing activities. Review and assessment is performed mainly by the Reactor Coordination (CODRE) of the General Coordination for Licensing and Control (GCLC). CODRE is also in charge of regulatory inspection of nuclear power plants, which includes 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 the coordination of the Norms Service (SENOR).

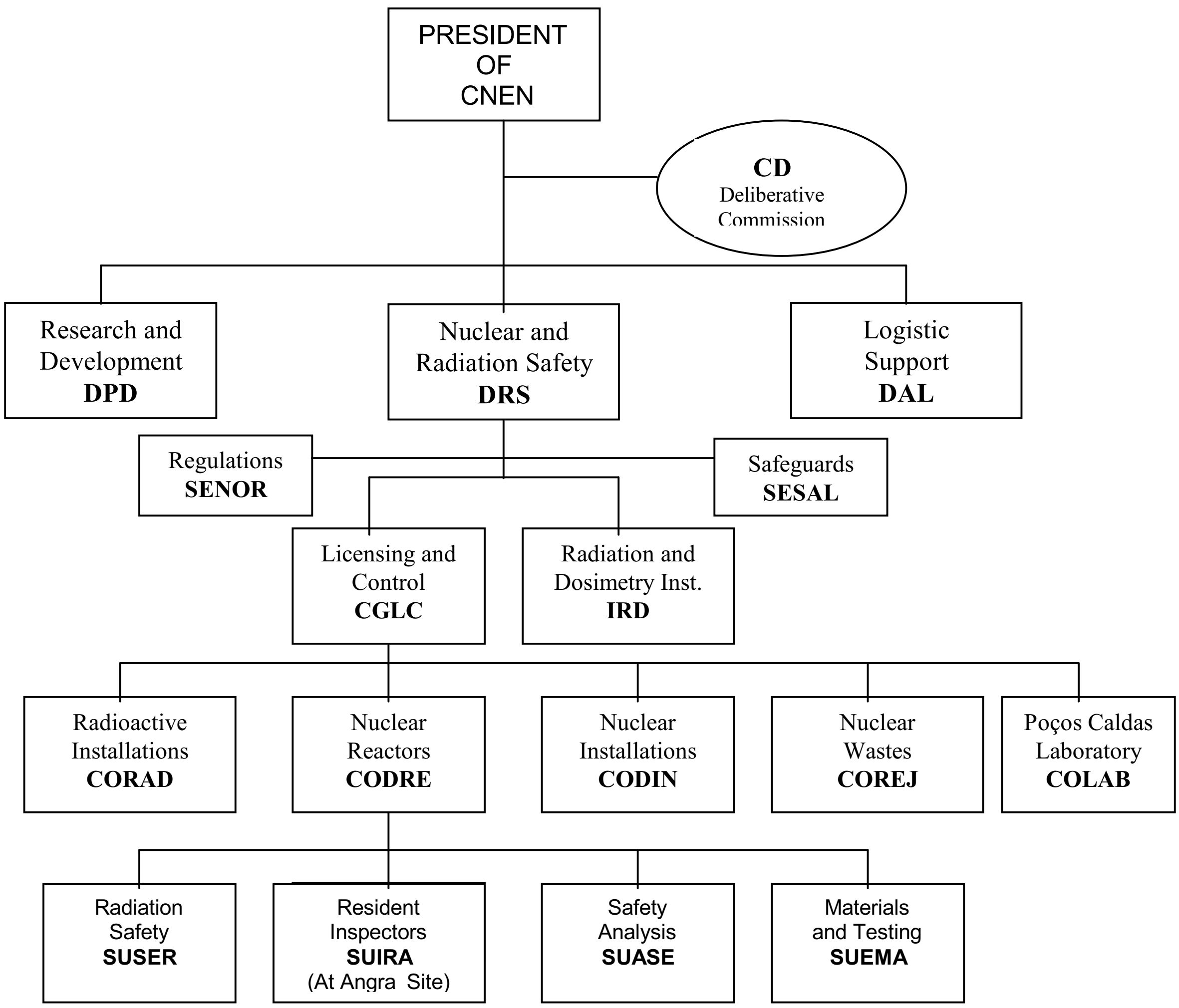


Fig. 5 – CNEN Structure

Adequate human resources are provided to CNEN. A total staff of 2756 people, 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. GCLC itself comprises 183 people, 149 of which are technical.

CODRE, the unit directly involved with nuclear power plants licensing and control, has a staff of 52, of which 47 are technical, with 9 possessing a doctoral and 24 a master degree in nuclear science or engineering. Presently, 7 persons are involved in a doctorate programme and 4 persons are involved in a master programme.

The main activities are review and assessment of the submitted documentation, and inspection of licensee's activities. Inspection activities are conducted on a permanent basis by a group of resident inspectors at the power plant site. For specific inspections and audit activities, support from specialists from headquarters is used. During 1998-2000, CNEN conducted 17 inspections in Angra 1 and 47 in Angra 2. Complementary to field activities, operation follow up is performed also based on licensee reports, as required by regulation CNEN-NE.1.14.

CODRE technical staff receives nuclear general training and specific training according to the field of work, including both academic training and courses attendance, technical visits, participation in congresses and national and international seminars.

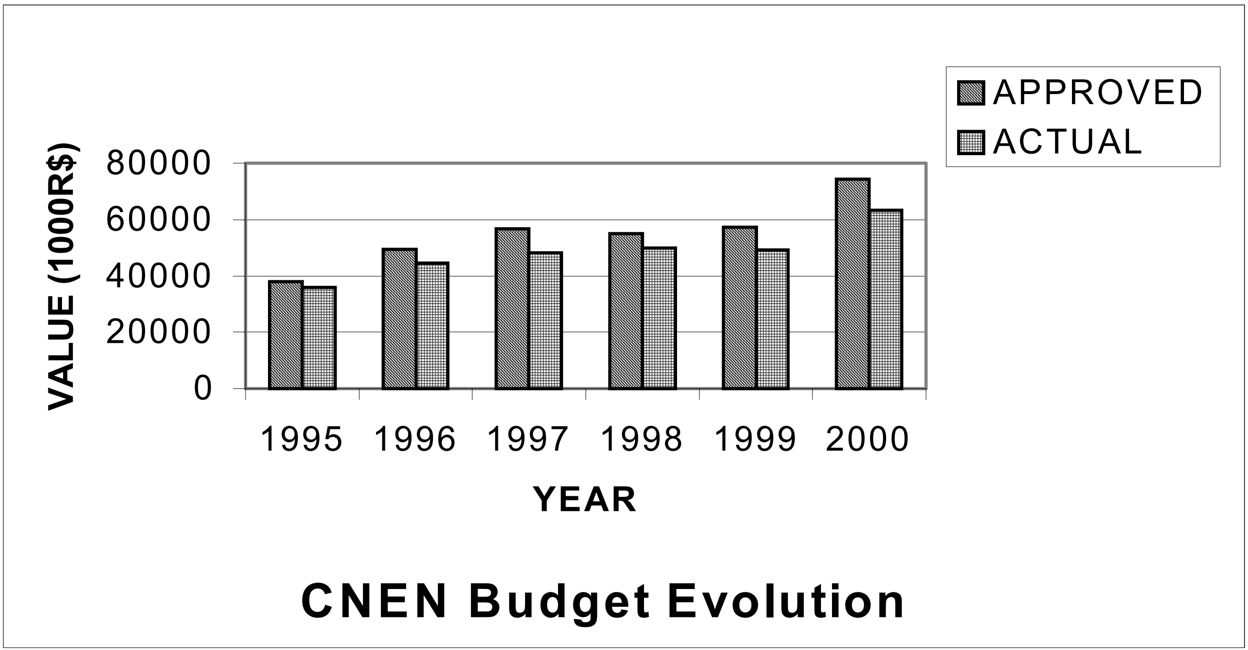
From the training courses conducted during the year 2000, the "Regional Basic Professional Course on Nuclear Safety", sponsored by IAEA and with participants from other Latin American countries, held on the Instituto Militar de Engenharia, in Rio de Janeiro, during the period of November 06 to December 15 must be highlighted.

CODRE personnel also attended, during the year of 2000, the following courses:

- Advances in Monitoring, Assessment and Enhancement of Operational Safety of Nuclear Power Plants
- High Studies on Politics and Strategy
- Evaluation of Environmental Radiological Impact
- Basic Radiation Protection
- Use of Computer Codes for Accident Analysis.

Also during the year of 2000, the following technical visits were conducted by CODRE personnel:

- National Oceanic Atmospheric Administration – NOAA (USA);
- Kernforschungszentrum Karlsruhe (Germany);
- HSK, Nagra and Zwilag (Switzerland);
- Nuclear Regulatory Comission – NRC (USA);



- Gesellschaft für Reaktor Sicherheit – GRS (Germany);
- Pisa University (Italy).

In the period of 1999 - 2000, 13 technical assistance missions have been received from the IAEA and the Gesellschaft für Reaktor Sicherheit – GRS.

Financial resources for CNEN are provided directly from the Government budget. Since 1998, taxes and fees are being charged to the licensees, but this income is deducted from the Government funds allocated to CNEN.

Figure 6 shows the evolution of CNEN budget in recent years, demonstrating a slight increase. The distribution of this budget among the several areas of actuation is shown in Figure 7. However, one should notice that salaries expenses, one of the main components of the licensing activities, are not included, since they are paid directly by the central Government.

Fig. 6 - Evolution of CNEN budget in recent years (salaries not included).

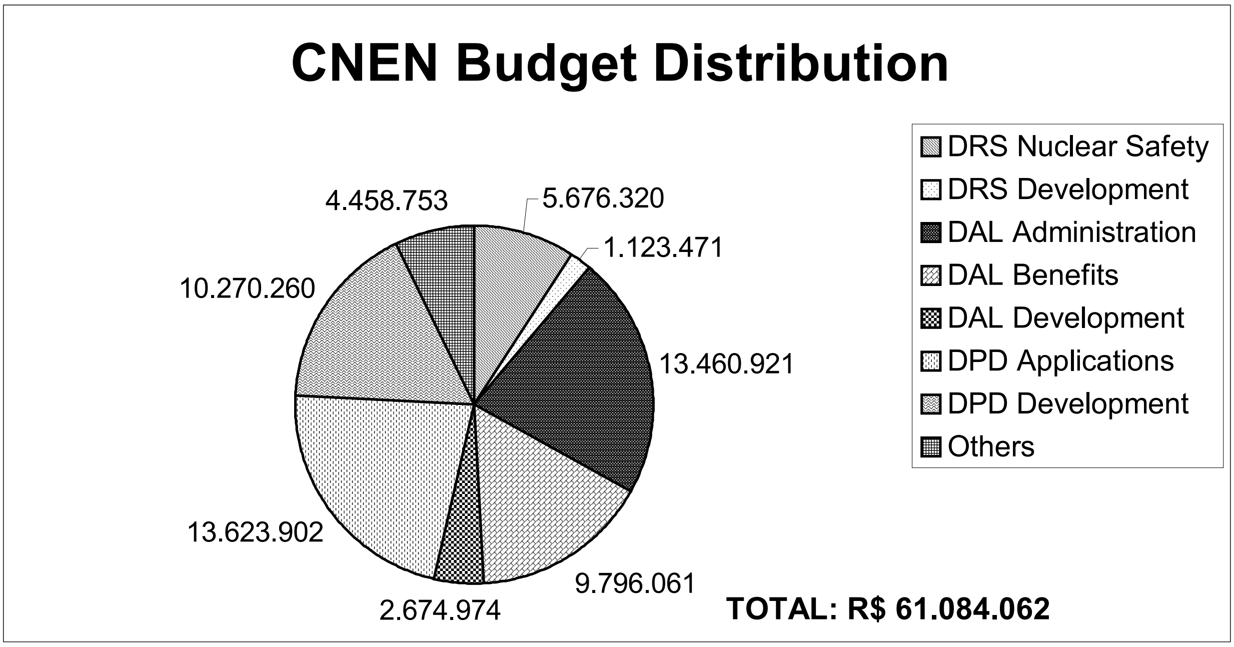


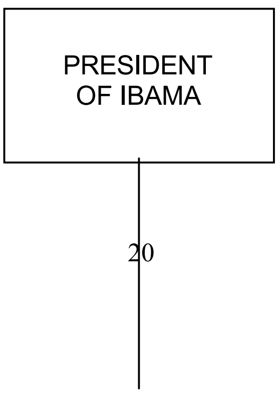
Fig.7 - CNEN Budget Distribution in 2001

Salaries of CNEN staff are subject to the Federal Government policies and administration. Presently there are two important concerns related to technical staff and salaries: i) most of the personnel is at the end of the scale; ii) the salaries are lower than those of equivalent utility personnel.

3.2.2 IBAMA

The licensing structure of IBAMA is presented in Figure 8. The environmental licencing for nuclear installations is conducted by the Directorate for Licensing and Environmental Quality, more specifically by its General Coordination for Environmental Licensing. This Coordination has a multidisciplinary technical staff of 35 professionals (3 PhD, 17 MSc and 15 Specialists), 11 of which are dedicated to the licensing of nuclear power plants (1 PhD, 5 MSc, 5 Specialists). There is an effort to adequate this human resources to an increased demand of evaluation in the nuclear area.

For the licensing process of Angra 2, IBAMA works in close cooperation with CNEN in relation with the radiological impact aspects. Both also cooperate with the Rio de Janeiro State Foundation for Environmental Engineering (FEEMA) and the Angra dos Reis Municipal Secretary for Environment.



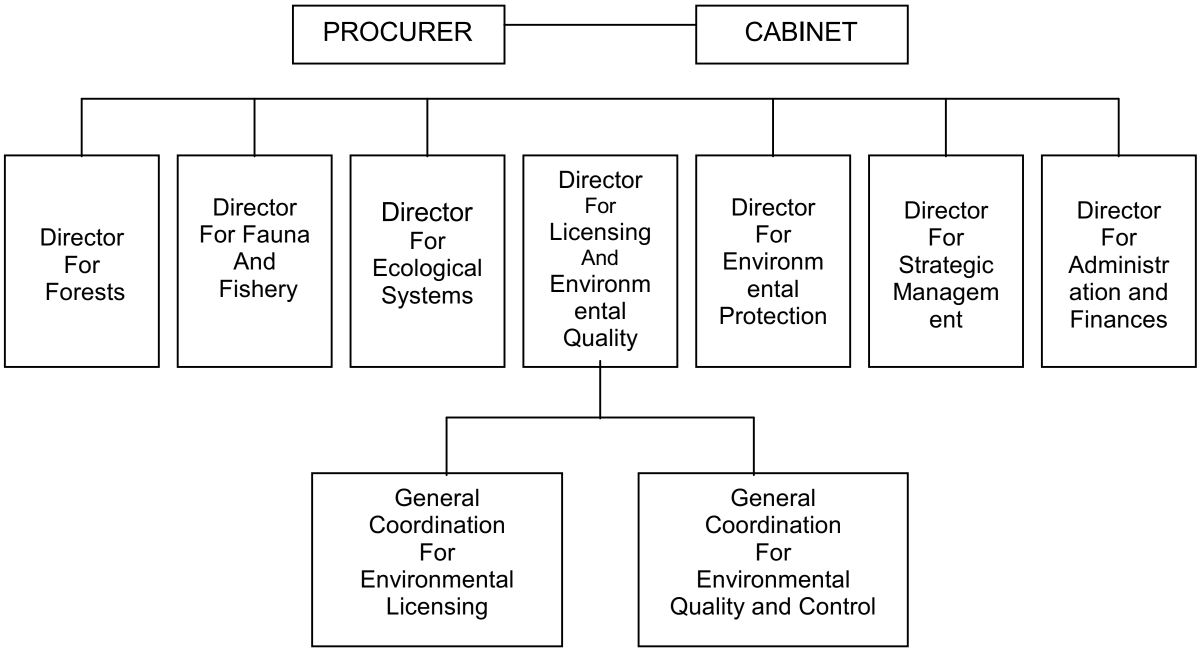


Fig. 8 – IBAMA Structure

3.3. Article 9. Responsibility of the licence holder

The Brazilian legislation defines the operating organization as the prime responsible for the safety of a nuclear installation.

Therefore, to obtain and maintain the corresponding licences, the operating organization, ELETRONUCLEAR, must fulfill all the prerequisites established in the legislation which are translated in regulations presented in Annex 2.

More specifically, the regulation CNEN-NE-1.26 [10] defines the operating organization as the prime responsible for the safety of a nuclear installation by stating: "**The operating organization is responsible for the implementation of this regulation.**"

ELETRONUCLEAR, as the owner and operator of the Angra 1 and Angra 2 plants, has issued a company policy stating its commitment to safe operation, which states:

> **"Safety is the priority and precedes production and economics. Safety shall never be jeopardized by any other reason."**

It states further that:

> **"Responsibility for safety is equally shared by all corporate structure – Directors, Advisors, Superintendents, Managers and Divisions Heads. Careless acts or actions by employees do not relieve the responsibilities of their supervisors".**

This company policy statement 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, 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 [9]. 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

4.1.1 At CNEN

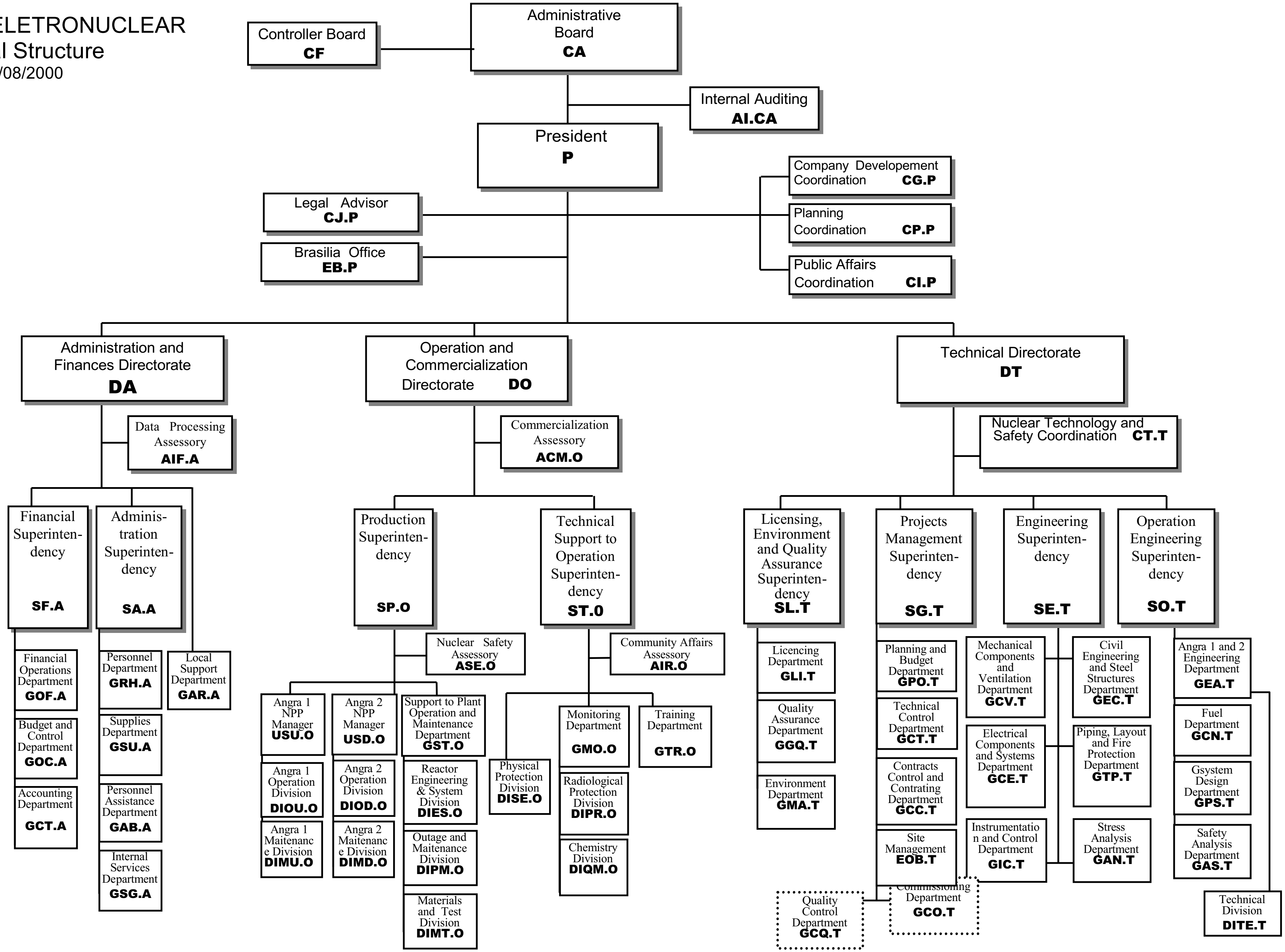
CNEN has issued a safety policy[11] and quality assurance statements[12] in December 1996, which is based on the concept of Safety Culture. In November 2000, a working group was constituted to coordinate the implementation of this policy in the General Coordination for Licensing and Control. To date, the following activities have been performed or are under way: planning meeting with coordinators and supervisors; preliminary proposal of goals and activities, identification of existing procedures and instructions, preparation of a proposal with diagnosis, priority actions and implementation strategy for the next 3 to 4 years.

CNEN has established in its regulatory standards requirements to the applicants or licence holders based on safety principles, defense-in-depth and ALARA concepts, quality assurance control and human resources management. According to regulation CNEN-NE-1.26 [10] the licensee shall establish an organizational structure with qualified staff and managers to deal with technical and administrative matters using principles of a Safety Culture.

4.1.2. At ELETRONUCLEAR

ELETRONUCLEAR is a company resulting from the merger of the nuclear portion of the electric utility FURNAS and the nuclear engineering company NUCLEN, both with more than 20 years of experience in their field of activities. Both companies had policies aiming at giving priority to nuclear safety. The current organization structure of ELETRONUCLEAR is presented in Figure 9.

Fig.9- ELETRONUCLEAR
General Structure
Rev.: 01/08/2000



At the time of the merger, one of the first acts of the new company ELETRONUCLEAR was the approval by the Board of Directors of a document establishing formally the company priority to safety. As mentioned in section 3.3, the safety policy statement establishes that “Safety is the priority and precedes production and economics. Safety shall never be jeopardized by any other reason.”

To ensure that this policy is being implemented, ELETRONUCLEAR has established a Committee for Nuclear Operation Analysis (CAON), with the responsibility to review activities related to nuclear safety. By its own initiative ELETRONUCLEAR has been engaged since beginning of 1999, in a programme of “self assessment” of the safety culture of the company, with the support of the IAEA**,** following the guidelines of the IAEA documents, Safety Series No. 75, INSAG-4, “Safety Culture”, Safety Report Series No. 11, “Developing Safety Culture in Nuclear Activities”. The goal of this activity is to determine the existing level of safety culture of the new company, identify any weaknesses and develop and implement a plan for improvement.

Following the line of the merged companies, from the beginning a strong Quality Assurance unit (SL.T) was established at ELETRONUCLEAR, with the level of Superintendency, which monitors all design, construction and operation activities and coordinates /supervises the plants nuclear and environmental licensing (see Eletronuclear Organization Chart, Fig. 9)

4.2. Article 11. Financial and human resources

4.2.1. Financial resources

As a governmental enterprise, ELETRONUCLEAR has its financial situation subjected to the holding company ELETROBRAS, which controls all federal electric utilities in Brazil. Its basic source of revenue comes from the selling of electricity, originally the energy from Angra1(626 Mw of net capacity) and beginning in September of 2000, of Angra 1 plus Angra 2 (1901 Mw of net installed capacity) through a long term energy supply contract ending in 2014, at a guaranteed minimum tariff, which today is of 57.91R$/Mwhr (~24 US$/Mwhr). This long-term contract was the mechanism utilized to protect nuclear generation from the unforeseeable situations that might occur with the ongoing liberalization of the Brazilian electricity market.

Adequate funds for operation and maintenance of Angra 1 and Angra 2 plants are made available through the annual budget, which includes the plants upgrading programme. For the sake of illustration the ELETRONUCLEAR budget for the year 2000 was of about 305 million US dollars, split as follows:

Primary Costs	In million US$
Personnel (salaries + benefits)	75
Other costs (subcontractors, insurance, office rent, equipment, consumables, etc.)	55
TOTAL	**135**
Investment	In million US$

Angra 1 (O&M, fuel and upgradings)	40
Angra 2 (completion of construction, Commissioning, trial operation)	126
Angra 3 (engineering)	2
Infrastructure	2
TOTAL	**170**

Feasibility studies for restart of Angra 3 project estimated total investments for plant completion about US$ 1.7 billion, US$ 1.1 billion for supplies and services in the Brazilian scope and US$ 0.6 billion for the import scope. The import scope is connected with the Supply and Service Contracts, transferred from SIEMENS A.G. to FRAMATOME A.N.P. Financing possibilities for the Brazilian scope are under evaluation in connection with the definition of the contractual arrangement with main suppliers to support the project.

In spite of the current privatization of the electric sector, now under way in Brazil, ELETRONUCLEAR will remain part of ELETROBRAS due to the constitutional provisions mentioned in item 1.1.

The provision of funds for decommissioning activities is to be obtained from ratepayers, and is included in the tariff structure, during the same period of depreciation of the plant (5%/year). For Angra 1, presently a reference decommissioning cost of 111 million dollars is estimated, corresponding to about 10% of the construction cost.

4.2.2. Human resources

Adequate human resources are available for ELETRONUCLEAR from its own personnel or from contractors. Currently ELETRONUCLEAR has a total of 1902 persons on its permanent staff and a few long-term contractors which supply additional personnel. At present there are 457 subcontracted persons working for ELETRONUCLEAR. Of the 1902 ELETRONUCLEAR employees 697 (37%) have a university degree, 937 (49%) are technicians and the remainder 264 are administrative personnel. Of the 1902 employees two hundred and fifty (250) are new employees hired in 2001 by ELETRONUCLEAR to fill in different positions in the organization, to compensate for the personnel to be retired in the coming next two years.

A project was organized in 2001 called “Determination of the Technological Know-how of ELETRONUCLEAR”, which aims at identifying, in a formalized way, the know-how which exists in the company. Once this is done, the gaps will be identified and actions to fill these gaps will be proposed. In particular, loss of knowledge due to personnel attrition has to be considered. This is a pilot project with the broader aim of introducing Knowledge Management as a systematic activity in the company, in order to preserve the essential knowledge necessary for the safe and efficient construction and operation of its nuclear installations.

Activities related to qualification, training and retraining of plant personnel are performed by the Training and Simulator Department of ELETRONUCLEAR, which reports to the Operational Support Superintendent. Three facilities are available for training at the residential village close to the plant: a general training center, a training simulator for Angra 2, and a maintenance training center.

Angra 1 has no plant simulator. The installation of a full scope simulator for Angra 1 is scheduled to be completed in 2004. The specification for that simulator is ready and the international bidding is foreseen for the second semester of 2001.

Meanwhile, operators for Angra 1 are trained in simulators of similar plants in the USA (Ginna Simulator), Spain (Tecnatom Simulator) and, more recently in Slovenia (Krsko Simulator). Simulator training load is of at least 60 hours per year for each individual. The composition of control room teams is specified in plant administrative procedures. The minimum control room team comprises a Shift Supervisor (who must hold a current Senior Reactor Operator - SRO licence), a Shift Foreman (also a SRO), a Reactor Operator (who must hold a Reactor Operator – RO licence) and a Balance of Plant Operator (also a RO). Although not required by CNEN, all Angra 1 Shift Supervisors are graduated engineers with five years of academic education.

The requirements for organization and qualification of the entire Angra 1 staff are established in Chapter 13 of the FSAR. Implementation and updating of these requirements are subject of CNEN audits of the licensee training and retraining programme and examination of new operators to comply with the regulations NE1.01 [8] and NE-1.06 [13].

In particular, the Plant Manager, the Deputy Plant Manager, the head of Operation Department, the head of Technical Support and the head of the Safety Team are currently licensed SROs or have previously held a SRO licence. The Radiation Protection Supervisor holds a special licence issued by CNEN, according to regulation CNEN-NE-3.03[14].

A full scope simulator for Angra 2 is available for training. Since the beginning of 1985 practical training of Brazilian specialists is being conducted. Instructors from ELETRONUCLEAR have also ministered classroom and practical training for operators, managers and licensing specialists from Germany, Spain, Argentina and Switzerland. The first group of control room operators was licensed in the beginning of 2000. Qualification training of additional Angra 2 operators is currently being performed.

Specialized training is also provided to the different groups of plant personnel. Maintenance technicians follow a qualification programme corresponding to their field of activity. Chemistry and radiological protection technicians follow extensive on-the-job training on a yearly basis aimed at a continuous updating of basic concepts learned during their initial technical training. The fire brigade and security personnel are trained according to the requirements established by related CNEN regulations.

Technical visits and reviews of ELETRONUCLEAR training programme and training center by experts from the International Atomic Energy Agency (IAEA), the Institute for Nuclear Power Operation (INPO) and the World Association of Nuclear

Operators (WANO) have provided valuable contribution to the identification and implementation of good practices for enhancing the quality of the training activities.

CNEN monitors the adequacy of the human resources of the licensee through the evaluation of its performance, especially through the analysis of the human factor influence on operational events. The training and retraining programme is also evaluated by CNEN within the licensing procedure and through regulatory inspections.

In the specific case of reactor operators, CNEN has established regulations related to their authorization[6] and their medical qualification[9]. CNEN conducts written and practical examinations for Reactor Operators and Senior Reactor Operators before issuing each individual authorization.

During the year 2000, for Angra 1 power plant, 27 Senior Reactor Operators (SRO) and 6 Reactor Operators (OR) licenses have been renewed and 3 SRO and 1 RO new licenses have been granted. For Angra 2, in the same period, 10 new SRO and 12 RO licenses have been issued.

Radiation Protection Supervisors certification is done in accordance with regulation CNEN – NN 3.03 “Certification of the Radiation Protection Supervisor Qualification”[14]. With the beginning of Angra 2 commissioning tests, Radiation Protection Supervisors had to be trained for their qualification also in this unit. In 1999, 4 Radiation Protection Supervisors were qualified from Angra 1 to Angra 2 and a new one was approved for actions in the two plants. In August 2000, ELETRONUCLEAR submitted the nomination of 4 technicians as candidates to the CNEN licence. These candidates are presently being submitted to the training programme provided by ELETRONUCLEAR in order to fulfill the requirements for the CNEN qualification examination.

4.2.2.1. Technical capability of ELETRONUCLEAR in the design and construction areas

The Brazilian-German Agreement of 1975 provides for the transfer of the technology necessary to the activities of design, equipment manufacture, construction and operation of NPPs to Brazilian companies involved in the nuclear programme. For Angra 2, the German counterpart assumed technical responsibility for the jointly built plant.

For this purpose, several contracts were signed, of which the foremost is the Technical Information Contract, with NUCLEN (now ELETRONUCLEAR) which provides for the necessary technology transfer. In the scope of this Contract, the following was accomplished (in round numbers):

- On-the-job training of Brazilian personnel in Germany: 250 engineers (550 man-years);
- German assignees in Brazil: 150 engineers, along 20 years;
- Documents transferred: 70.000.

In addition, 22 technology transfer contracts were signed with foreign traditional firms by different private Brazilian component suppliers. This assured a solid and continuous local technological basis for the design, construction and operation of Angra 2 and for support of Angra 1 operation.

After completion of the Angra 2 plant, SIEMENS supply and service contracts, now transferred to FRAMATOME ANP, are still in force. As foreseen in the service contract, FRAMATOME continues to provide services for post-completion activities and to support operation and maintenance areas in the first Angra 2 operation cycle. Post-completion activities include mainly updating of design documentation and data-banks, design modifications following commissioning experience and elaboration of technical reports to meet additional licensing requirements. The Supply Contract in this phase has been applied mainly for re-supply of spare and wear parts used during commissioning and supply of equipment and material for the design modifications planned for the first operation cycle.

4.3. Article 12. Human factors

Angra 1 was designed at a time when human factors were not formally and systematically taken as a prime issue in nuclear safety. Following the accident at Three Mile Island, and still before commencement of operations, a critical review of plant design with respect to man-machine interface was undertaken. This resulted in numerous modifications in the control room, including the installation of the Angra 1 Integrated Computer System (SICA) which encompasses a safety parameter display system for monitoring critical safety functions. At the same time, plant emergency operating procedures were greatly improved in their format, which now incorporate double columns, the left one with the expected action and the right one with actions to be taken in case of inadequate response.

Later on, human factors were considered in a much broader sense and several management initiatives were undertaken in this area, such as a programme for team-work training and a Human Performance Enhancement System (HPES). Training related to Safety Culture aspects was also undertaken using IAEA guidelines.

CNEN also established in the Regulation NE-1.26 [10] requirements for the periodic safety review which considers human factor as an important area of review. For Angra 1, at the opportunity (December, 2004) CNEN will review and assess the situation in areas of I&C and man-machine interface.

For the Angra 2 plant, CNEN has required during the licensing process that an additional chapter 18 to be included in the FSAR, addressing the Human Factor Engineering (HFE). The content and format of this new chapter was based on the guidance framework of chapter 18 of the Standard Review Plan (NUREG 800 - 1996 Revision), which defined the nine areas of human factor review (NUREG 711) by an HFE management group. The licensee has made a comprehensive review of the operational experience of German plants, Angra-1 and other plants (specially theTMI-2 accident). It has been also established the HFE Committee as part of the organizational structure, with the main responsibility to review the internal and external operational experience according to the nine areas of human factors and to approve any proposed man-machine interface modifications during the plant operational lifetime. HFE analyses of accident sequences and associated operator actuation times are being performed for the existing Angra 2 main control room panel. The purpose of these analyses is to identify man-machine interface problems and to propose improvements in the control room. As example of the improvements of the man-machine interface that have been introduced in the original design, it may be mentioned the computer system to monitor the Critical Safety Functions(CSF). A functional requirement analysis is described in chapter 18 of the FSAR concerning the definition of plant safety functions carried out by the automated actions of the reactor limitation and protection systems, and the definition of Critical Safety Functions (CSF).

ELETRONUCLEAR elaborated Chapter 18, Human Factors Engineering (HFE), according to the philosophy recommended by NUREG-711. Consequently the HFE Programme now being implemented has the purpose of assuring that, from the beginning of Angra 2 commercial operation on, the plant operational events will be evaluated following procedures which take due account of human factor aspects.

Still in the premises of the behavioural science, as already mentioned in item 4.1, ELETRONUCLEAR was engaged along 1999 and 2000, in a pioneering experience of self-evaluation of its safety culture. The overall result was satisfactory, but the assessment showed considerable margin for improvement. Presently, an action plan was developed with the purpose of improving the company safety culture relative to the weak points resulting from the self-assessment phase. After an action plan application period of about 2 years a repetition of the self-evaluation step is planned, for evaluation of the implemented measures and for eventual correction of direction. The work of the above programme in safety culture has been continuously supported by technical assistance from the IAEA.

4.4. Article 13. Quality assurance

The requirement for a quality assurance programme in any nuclear installation project in Brazil is established in the licensing regulation[6]. Specific requirements for the programmes are established in a specific regulation, Quality Assurance for Nuclear Power Plants, CNEN-NE-1.16[15] which is based in the IAEA code of practice 50-C-QA Rev.1 - Quality Assurance for Nuclear Power Plants, but with the introduction of the concept of an Independent Technical Supervisory Organization (Organização de Supervisão Técnica Independente - OSTI)[16].

Former FURNAS and now ELETRONUCLEAR have established their quality assurance programmes according to these requirements. The corresponding procedures have been developed and are in use. The programme provides for the control of the activities influencing the quality of items and services important to safety. These activities include design, design modifications, procurement, fabrication, handling, shipping, storage, erection, installation, inspection, testing, operation, maintenance, repair and training. The quality assurance programmes are described in Chapter 17 of the FSAR.

The Licensing, Environment Management and Quality Assurance

Superintendence (SL.T), reporting to the Technical Directorate, is responsible for the establishment and supervision of ELETRONUCLEAR Quality System. The Committee for Nuclear Operation Analysis (CAON) is a collective body under the coordination of the Production Superintendent (SP.O) whose purpose is to examine, follow-up and analyze issues concerning Angra 1 and 2 operational safety and to make recommendations to improve safety. Plant Operation Review Committees (CROUs) are collective bodies under the respective unit manager (USU.O for Angra 1 and USD.O for Angra2) with the responsibility to review and analyze, on a closer basis, questions related to operating nuclear power plants units.

The ELETRONUCLEAR Quality Assurance Department (GGQ.T) is responsible for performing internal and external audits in order to verify compliance with all aspects of the quality assurance programme. All audits are performed in accordance with written procedures. In case of internal audits, persons involved with the activities being audited have no involvement in the selection of the audit team. Audit reports are distributed to, and formally reviewed by organizations responsible for the area being audited and also by the CAON. In the three year period 1998-2000, 94 external audits and 65 internal audits have been conducted.

Audits and inspections by CNEN verify that quality assurance requirements are being implemented and that the quality assurance has been effective as a management tool to ensure safety. During the same period of 1998-2000, CNEN conducted 17 audits or regulatory inspections in Angra 1 and 47 in Angra 2. The high number of audits/inspections in Angra 2 reflects the increased supervision during the commissioning activities during that period.

4.5. Article 14. Assessment and verification of safety

A comprehensive safety assessment is a requirement established by the licensing regulation in Brazil[6].

For the Angra 1 and Angra 2 plants, both a Preliminary Safety Analysis Report (PSAR) and a Final safety Analysis Report (FSAR) were prepared. The FSARs followed the requirements of US NRC Regulatory Guide 1.70 - Standard Format and Contents for Safety Analysis Report of LWRs. These reports were reviewed and assessed by CNEN, and extensive use was made of the US NRC - Standard Review Plan (NUREG - 800).

For the Angra 2 NPP, the licensing process was started in accordance to the German licensing procedure. Such process foresaw a series of partial approvals, by each, a large amount of the actual design and licensing data being supplied for analysis to the Brazilian licensing authorities. No comprehensive licensing document such as a PSAR was adopted in this procedure . This approach turned out not to be practical; CNEN had already licensed Angra 1, along the line of USNRC procedures. It judged that to use two different approaches for licensing would be too time and resources consuming. Accordingly, it requested to have a FSAR following USNRC Guide 1.70, to be able to use the Standard Review Plan methodology as done for the first plant. Preparation of an FSAR for Angra 2 was a major task, which involved extensive adaptation and revision work internally and extensive exchange of information with CNEN. Along the licensing period CNEN has submitted approximately 800 requests for information, which were already answered by ELETRONUCLEAR. Through such a review, optimization of safety calculations, clarification of limit conditions of operation, and other relevant matters have been addressed. As far as applicable, the FSAR has been revised to incorporate the modifications derived from these improvements. On the basis of this revision ELETRONUCLEAR was granted the Authorization for Initial Operation.

In parallel with the paper version, the FSAR has also been issued, in a user-friendly format, as a "hypertext" CD-ROM, envisaging better handling and consultation .

The safety assessment, with the purpose of demonstration of the adequacy and safety of the plant design bases, included both deterministic and probabilistic approaches to safety analysis. The deterministic approach followed the traditional western methodology of using qualified, internationally accepted, conservative computer codes and assumptions for the analysis of a large set of postulated events, established in national/international guides and regulations, ranging from minor transients to a large loss of coolant accident (LOCA).

An exception to the above referred conservative approach is the Angra 2 large break LOCA Analysis. With basis on the extensive Large Break LOCA research and development in recent years and evolution of the regulatory requirements, ELETRONUCLEAR has submitted to the Brazilian regulatory body a LB-LOCA analysis performed with the latest analysis tools and methodology, that is, use of a “best estimate code” of the RELAP5 MOD2 family, coupled with uncertainty evaluation. This analysis is being evaluated by CNEN through an independent calculation performed with the support of a contract with the University of Pisa.

Although a full Probabilistic Safety Assessment (PSA) was not a formal licensing requirement at the time, a preliminary level 1 study was performed in 1983 for Angra 1 using generic plant data. This study indicated a strong contribution of the reliability of the Emergency Diesel-Generator system to the total risk, which supported the decision to install two additional Diesel-Generator sets at Angra 1. Additionally, the surveillance interval of seven check valves of the High Pressure Safety Injection (HPSI) system was reduced, to increase system reliability, and therefore reduce this system contribution to the total risk.

A new study, was concluded in 1998 (revision 0) and revised in 2000 (revision 1), consisting of a detailed level 1 PSA, for the Angra 1 plant, in accordance with the methodology described in NUREG/CR-2300, “PRA Procedures Guide”. The event tree/fault tree logic (i.e. accident sequence) quantification was performed by fault tree linking using the SAPHIRE 6.67 code. The model represents accident and transient initiating events starting from power operation and continuing for a 24 hours mission time. Component reliability analysis was performed using a generic industry data base updated with plant-specific data using Bayesian procedures for most of the modeled systems. Dependent (i.e. common cause) failure analysis was performed using Multiple Greek Letter method. Human reliability analysis was performed using the ASEP and HCR models for the cognitive portion of human errors and THERP methodology for the executive portion of human errors.

Several important findings, leading to upgrading of plant hardware and operational procedures, arose from this second PSA study, of which some highlights are described below :

1) The configuration at Angra 1 has a single instrument air line going into containment. An important weakness identified in the PSA was the failure to open the containment solenoid-activated-air-operated isolation valve (previously closed due to a S-signal) . Based on the PSA results a handwheel was installed in this containment isolation valve to allow the operator to open this valve locally, if it fails to open from the control room, in order to reestablish instrument air to the containment to increase the reliability of the Reactor Coolant System depressurization and cooldown functions.

2) Also identified as a weakness was the potential for a Reactor Coolant Pump (RCP) seal LOCA due to a loss of RCP seal cooling under loss of Service Water System, Component Cooling System or loss of off-site power. To minimize the potential for RCP seal LOCA the following actions were taken: a) the line-ups of the Service Water System and Component Cooling Water System were modified; b) a recommendation was issued to perform the electrical alignment of the small flow positive displacement charging pump (used for seal injection flow) based on the train of Service Water and Component Cooling Water which are in service during the event; c) a spare electrical motor was bought for the Service Water System pumps to improve the availability of the system;.

The implementation of hardware and/or procedural measures, originated from the results of the above referred PSA study, led to a considerable reduction of the calculated Angra 1 Core Damage Frequency (CDF), down to the range of 10E-5 per reactor.year.

As a further application, the Angra 1 level 1 PSA is being used to support the development of the Maintenance Rule in agreement with the NUMARC 93-01 Revision 2. Also a plant configuration control based on the risk rate (CDF) and the weekly cumulative risk (CDP) is being used for on-line maintenance planning.

ELETRONUCLEAR is planning to start a Angra 1 level 2 PSA this year. Fire analysis and shutdown risk analysis will be planned for the near future, after the level 2 PSA is finished.

In the case of Angra 2 the probabilistic insight comes from a major level 3 German PSA study performed for the 1300 MWe German PWR family, having as reference the Biblis B NPP- the German Risk Study (DRS), Phases A and B. A preliminary evaluation of the Angra 2 core melt frequency as well as gathering of information for Accident Management countermeasures development has been done, taking the DRS study as a basis, and adapting its models for the main design differences between Biblis B and Angra 2.

ELETRONUCLEAR plans to conduct a specific level 1 PSA also for Angra 2, to be initiated in the near future and concluded at most within four years.

4.6. Article 15. Radiation protection

Radiation protection requirements and dose limits are established in Brazil in the regulation for radiation protection[17]. These require that doses to the public and the workers be kept below established limits and as low as reasonably achievable (ALARA).

Implementation of this regulation is performed by developing the basic plant design in accordance with the ALARA principle and through the establishment of a Health Physics Programme at each installation. Plant design is assessed at the time of the licensing review and by evaluating the dose records during normal operation.

The Health Physics Programme of Angra 1 and Angra 2, included in the Final Safety Analysis Reports, sets forth the philosophy and basic policy for radiation protection during operation. The highest level policy is to maintain personnel radiation exposure below the limits established by CNEN and to keep exposures to as low as reasonably achievable (ALARA), taking into account technical and economical considerations.

The annual dose limits to workers are 50 mSv for effective dose equivalent and 500 mSv for dose equivalent for individual organs and tissues, except in the case of the eye lens whose limit is 150 mSv. For women of reproductive capacity the doses are limited to 10 mSv in any quarter of year and, if they should become pregnant, the limit is reduced to 1mSv for the entire gestation period. These limits are in accordance with CNEN regulations, with applicable labor legislation which has endorsed CNEN limits, and with the international Convention n. 115 of the International Labor Organization (ILO) to which Brazil is a Party.

The actual personnel radiation doses at Angra Nuclear Power Plants are much lower than the established limits. The dose distribution for workers at the Angra site demonstrates an adequate radiological protection programme, with almost all averaged annual accumulated individual doses below 5 mSv and no one with radiation dose above the annual administrative dose limit (20 mSv). The annual collective dose for the last 3 years has usually been lower than 1,30 Man.Sv and 0,20 Man.Sv, respectively during a year with and without outage. Actual dose distribution for the year 2000 is presented in Figure 10. The collective dose variation along the years is shown in Figure 11.

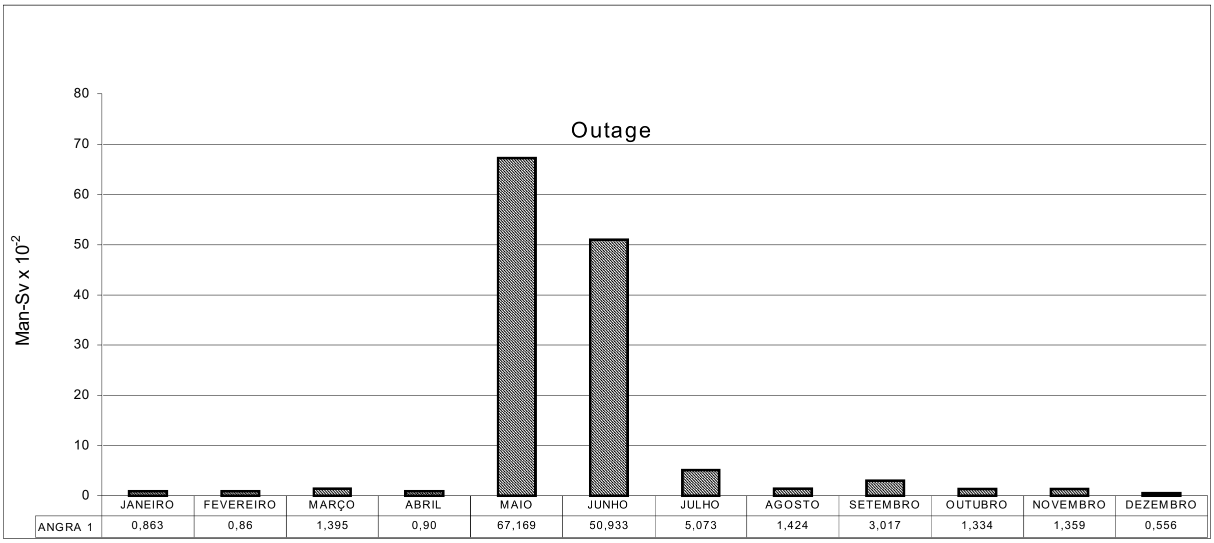
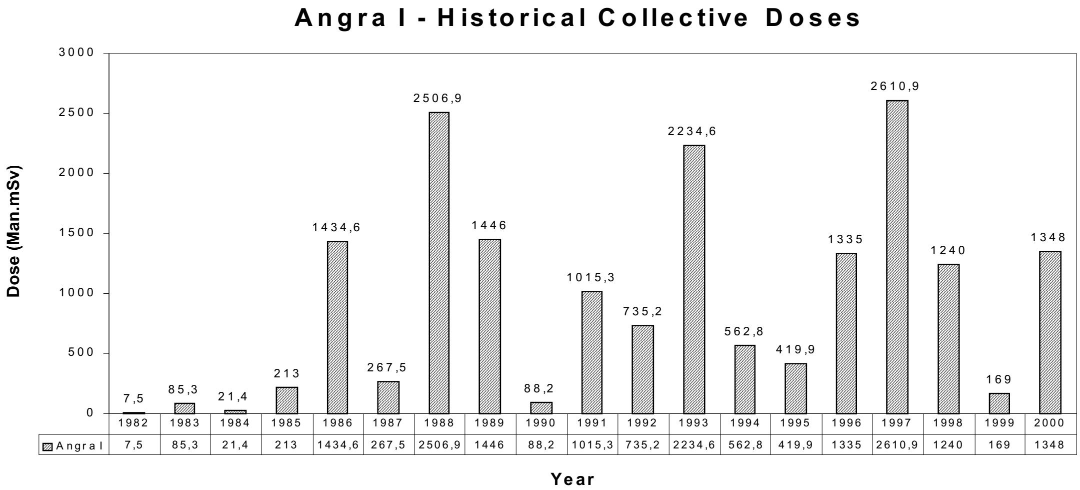


Fig. 10 – Occupational dose distribution at Angra 1 during 2000.

Fig. 11 - Collective Doses at Angra 1

Release of radioactive material to the environment is controlled by



administrative procedures and kept below CNEN established limits, in accordance with administrative procedures. Additionally, the amount of radioactive waste and the radioactive effluents discharged to the environment also follow the ALARA principle.

Those limits are in accordance with the limits fixed in the Offsite Dose Control Manual (ODCM), approved by CNEN. In this manual, the dose for the hypothetical critical individual is calculated.

According to the CNEN regulation[5], an Effluents Releasing and Wastes

Report is issued every semester, documenting the liquid, gaseous and aerosol effluents – batch number, present radionuclides and concentration, waste quantity and type sent to the repository and the meteorological data in the period. Also, the effective equivalent dose for the critical individual is presented. In the period of 1998-2000, this dose reached the average 7 x 10^{-4} mSv, which is much lower than the 1 mSv value established in regulation CNEN-NE-3.01[17].

IBAMA also monitors the impact of the plants on the environment through a system of inspection in which the State Foundation for Environment Engineering (FEEMA) and the Prefecture of Angra dos Reis also participate.

A plant ALARA Commission composed of different groups (Operation, Maintenance, Chemistry, System Engineering and Radiation Protection) is in charge of implementing and monitoring the ALARA Programme that describes procedures, methodologies, processes, tools and steps to be used in planning the work. The ALARA Programme is continuously being revised and represents the best effort to minimize occupational doses.

A Radiological Environmental Monitoring Programme, based on CNEN requirements, is conducted by ELETRONUCLEAR to evaluate possible impacts caused by plant operation. This programme defines the frequency, places, types of samples and types of analyses for the survey of exposure rates. The evaluation of exposure rates is also made by direct measurement using thermoluminescent dosimeters distributed in special sectors around the Angra site, and at points located in the nearest villages and cities. The results of the monitoring programme are compared with the pre-operational measurements taken, in order to evaluate any possible environmental impact. Annual reports are presented to CNEN. To date no major impact has been detected.

Typical results of the monitoring programme is presented in Figure 12, for two areas: Impact area (27measuring points within 5 km radius from the plant) and Control area (15 measuring points beyond 5 km). The lines give the annual average values, and the bars the maximum and minimum values. The average values for the impact and Control areas are statistically equivalent, indicating the absence of radiological impact from the power plants.

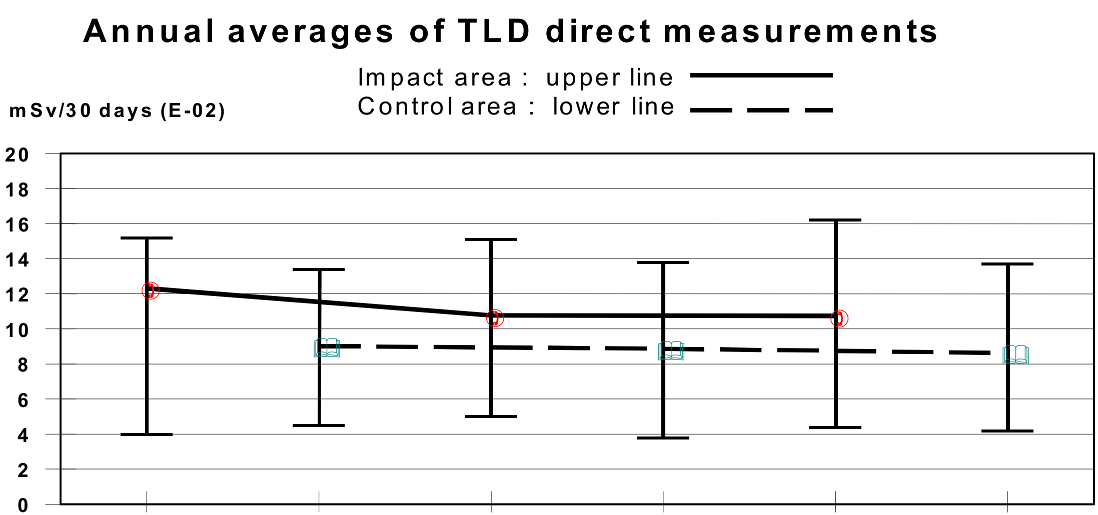


Fig. 12 – Environmental Monitoring Programme Results for 2000

4.7. Article 16. Emergency preparedness

The planning basis for on- and off-site emergency preparedness in case of an accident with radiological consequences in the Angra Nuclear Power Station is based on the Emergency Planning Zone concept.

The Emergency Planning Zone (EPZ) encompasses the area within a circle with radius of 15 km centered at the nuclear power plants. This EPZ is further subdivided in 5 smaller zones with borders at approximately 1.5 , 3, 5, 10 and 15 km from the power plants.

4.7.1. On Site Emergency Preparedness

The On-site Emergency Plan covers the area of property of ELETRONUCLEAR, and comprises the first zone (up to ~1,5 km from the power Plants). For these area, the planning as well as all actions and protection countermeasures for control and mitigation of the consequences of a nuclear accident are of ELETRONUCLEAR responsibility.

Specific Emergency Groups (Power Plants- Units 1 and 2, Support Services, Head Office and Medical) under the coordination of the Site Superintendent or his deputy are responsible for the implementation of the actions of the On-site Emergency Plan. Emergency Centers for coordination of the Emergency Plan activities, equipped with redundant communication systems and emergency equipment and supplies are established in different locations inside this area.

A meteorological data acquisition and processing system composed of 4 meteorological towers, provides continuous data on wind temperature, speed and direction as well as air temperature gradient to a computerized system in the Technical Support Center / Control Room of Units 1 and 2, through which the follow up and calculation of the spreading of the radioactive cloud is made.

The On-site Emergency Plan involves several levels of activation, from single alert status, through area emergency up to general emergency.

The initial notification for activation of the On-site Emergency Plan is done by the shift supervisor from the Control Room, which notifies the Plant Manager, as Emergency Group coordinator, which alerts the coordinators of the other Emergency Groups, the Site Superintendent and the Authorities (resident inspector and Headquarters). The Plant personnel and the members of the public inside this emergency zone are warned by means of the internal communication system, sirens and loudspeakers.

Twenty-four-hour / 7-day-a-week on-call personnel, under the responsibility of the Site Superintendent, ensures the prompt actuation of the Emergency Groups.

Plant personnel emergency training and exercises are performed yearly. Information to the public on how to behave in a situation of nuclear emergency is provided by ETN through periodic campaigns, distribution of printed information, the local press and permanent information available in the Site Information Center.

4.7.2. Off Site Emergency Preparedness

Brazil has established an extensive structure for emergency preparedness under the so-called System for Protection of the Brazilian Nuclear Programme (SIPRON). This includes organizations at the federal, state and municipal level involved with licensing and control activities as well as those involved with public safety and civil defense. Operators of nuclear installations and facilities and supporting organizations are also part of SIPRON.

SIPRON was established by Law n. 1809 of 7 October 1980. The Decree n. 2210 of 22 April 1997 has defined the Secretary for Strategic Affairs (SAE), directly linked to the Presidency of the Republic, as the Central Organization of SIPRON. More recently, a Governmental restructuring has designated the Ministry of Science and Technology (MCT) as the Central Organization for SIPRON, which now stays under the responsibility of a Special Advisor to the Minister as a part of the Coordination of Technical and Scientific Programmes of MCT (see Figure 4).

The decree also establishes a Coordination Commission (COPRON) composed of representatives of the agencies involved. Besides ELETRONUCLEAR, as the operator, and CNEN, as the nuclear regulatory body, other agencies are involved as support organizations of SIPRON, such as the municipal civil defense, the state civil defense, the Angra Municipality, the IBAMA, the National Road Department (DNER), the National Army, Navy and Air Force, and the Ministries of Health, Foreign Relations, Justice, Finance, Planning and Budget, Transportation and Communications (see Figure 13).

Within SIPRON, the Central Organization issued a General Norm for Emergency Response Planning (SIPRON- NG-02)[18] and has prepared specific guidelines for Angra site emergency planning (Diretriz Angra 1 and Diretriz Angra 2)[19], consolidating all requirements of related national laws and regulations and stating the responsibilities of each of the involved organizations. Additional norms related to emergency centers, communications, intelligence and information to the public were also issued by the Central Organization.

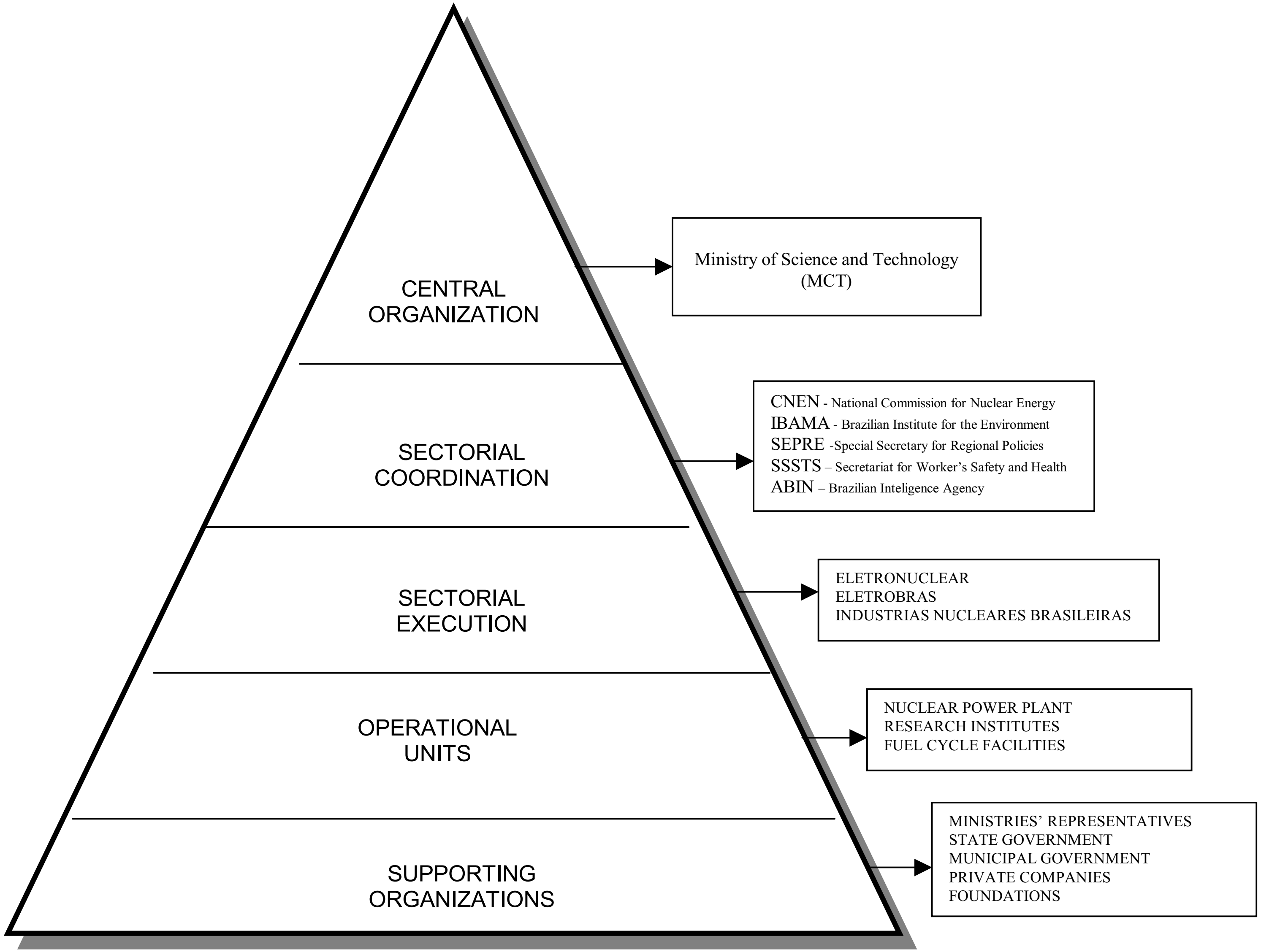
The approach to emergency preparedness is based in a “municipalization” of the response action to an emergency situation, utilizing mainly the resources available at the Municipality. The State and Federal Governments complement the local resources as necessary. In this way, SIPRON works at the operational level with the Municipal Government, and the State Government, and at the political level, through the Federal Government which provides the necessary material and financial resources.

At the plant level, a comprehensive Emergency Plan has been established and is periodically tested. The plan involves several levels of activation, from single alert status, through area emergency, to a general emergency. Dedicated facilities at the plant site have been designated and the equipment for emergencies has been greatly upgraded.

At the off-site level, a National Center for Management of Nuclear Emergency Situation (CNAGEN) has been created in Brasilia in the MCT. A State Center for Management of Nuclear Emergency Situations (CESTGEN) has been established in Rio de Janeiro. A Center for Coordination and Control of Nuclear Emergency Situation (CCCEN) and a Center for Information in Nuclear Emergency (CIEN) have been established in the city of Angra dos Reis. This centers' activities during an emergency have been established in the revised Rio de Janeiro State Plan for External Emergency, approved by the state governor by Decree 26586 of 21 June 2000.

Corresponding plans for CNEN, its support Institute for Radiation Protection and Dosimetry (IRD) and other involved agencies have been prepared, and detailed procedures have been developed and are periodically revised.

Fig. 13 SIPRON STRUCTURE



In 1996, after a review of the existing plans and comparing with information obtained during the observation of an emergency exercise in the United States by a SIPRON working group, substantial changes were introduced in the emergency response approach. After these modifications were introduced, in 1997, the Central Organization of SIPRON coordinated two partial exercises and a full scale emergency exercise. The general emergency exercise established 20 objectives to be demonstrated and evaluated to verify and validate the adopted systematic approach. The exercise was observed by international experts from the IAEA and Argentina, who prepared a report [20] that concludes that the exercise achieved most of its objectives.

Since then, the Central Organization established that a full scale exercise should be performed biannually. On the other hand, one partial exercise should be performed between two full scale exercises. Therefore, a full scale exercise was performed in 1999, and partial exercises were conducted in 1998 and 2000. Another full scale exercise is schedule for November, 2001, under the coordination of MCT, including the activation of several shelters and the simulated evacuation of part of the population in the Emergency Planning Zone (EPZ).

During the partial exercise on August 31, 2000, a new expanded siren system initiated its operation. This system is composed by 8 siren towers (the double of the old system) and has the capability to transmit both sound and voice messages. The system was tested during the exercise and demonstrate its adequacy to cover the whole Emergency Planning Zones of 3 and 5 km radius (EPZ-3 and –5).

Regarding information to the public, SIPRON norm NG-05[21] establishes the requirements for public information campaigns about emergency plans. The first public information campaign was conducted by FURNAS in 1982 before the first criticality of Angra 1. Several other campaigns have been conducted on a regular basis. The last campaign in 2000 combined information on both on-site and off-site emergency plans, including the population living in the 15-km area around the plant. This campaign included the distribution of informative material on a house-to-house basis, to local newspaper, radio, TV broadcast, buses and bus stations, schools, community association, churches, and administrative offices. These campaigns are conducted by a joint working group composed by personnel from the federal, state and municipal civil defense, state fire brigade, ELETRONUCLEAR volunteers, and CNEN and ELETRONUCLEAR technical and public information personnel. Preceding every siren test or a general emergency exercise, specific flyers are distributed in relevant areas and handed along main routes to passing drivers and buses, and vehicles fitted with loudspeakers circulate through villages making announcements to ensure that all residents have been properly informed.

A training course on emergency preparedness and response was created in 2000 by the State Civil Defence of Rio de Janeiro in co-operation with CNEN and ELETRONUCLEAR. The course was primarily designed to civil defence personnel at the local and state levels.

It should be noted that, due to the particular geographical location of the Angra plants, no radiological impact is expected in any neighboring countries, even in the improbable event of a major release. Notwithstanding that fact, Brazil has signed both the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in Case of a Nuclear Accident or Radiological Emergency, and a bilateral agreement with Argentina for notification and assistance in case of a nuclear accident.

Chapter 5 - SAFETY OF INSTALLATIONS

5.1. Article 17. Siting

The Brazilian siting regulation CNEN 09/69[7] requires a site approval before the issuance of a construction authorization. The Angra site has already been approved in principle for the 3 units, but many aspects are being reviewed and updated to comply with current regulations for authorization of Angra 3. Site parameters are further evaluated during the PSAR preparation and review and are taken into consideration in the plant design.

For the Angra 1 plant, which started construction in 1972, the environmental impact was not formally evaluated before site approval, since no related regulations existed at the time. The environmental impact was assessed at the time of the installation licence by FEEMA, as described in section 3.1.2.1.

Since the promulgation of Law 6938 of 31 August 1981, which establishes the National Policy on Environment (PNMA), "the construction, installation, expansion and operation of facilities or activities which cause or may cause pollution or are capable of causing environmental degradation" requires an environmental licence. This involves the conduct of an Environmental Impact Study (EIA) and the preparation of an Environmental Impact Report (RIMA) before site approval. Considering that the site of Angra nuclear power plant has been already in use for a nuclear unit, the environmental licensing of Angra 2 included the preparation of an EIA/RIMA only for the operation licence. These documents were reviewed by IBAMA in cooperation with CNEN and from their evaluation a Basic Environmental Project (PBA) was established and is being implemented by ELETRONUCLEAR.

The RIMA also constituted the main document discussed during the public hearings which took place during the environmental licensing process. These hearings are established in accordance with Resolution CONAMA n. 9/87 with the objective to explain to interested parties the contents of the RIMA. The population directly affected has an opportunity to get acquainted with the RIMA and to raise questions about its contents.

Two of these hearings were conducted during the environmental licensing of Angra 2, on two different locations. Several questions were raised by participants, and responded by IBAMA and ELETRONUCLEAR. The main topics were:

- The conditions of roads in the vicinity of the plant and its possible impact in case of an evacuation;
- The treatment and storage of radioactive wastes;
- The conduct of emergency exercises on weekend and rainy days;
- The conditions of regional hospital facilities, and their possible impact in case of an emergency.

These and other topics are being considered in the environmental licensing process as discussed in item 3.1.2.

With respect to Angra 1, site parameters continue to be evaluated during plant operation, especially those related to the demographic distribution in relation with the emergency preparedness. An updating of the detailed population census in the vicinity (5-km radius) of the power plant was conducted in 1996.

5.2. Article 18. Design and construction

The design of the Brazilian nuclear power plants are based on established nuclear technology in countries with more advanced programmes. The licensing regulation CNEN-NE-1.04[6] formally requires the adoption of a “reference plant” which shall have a similar power rating, shall be under construction in the country of the main contractor, and shall go into operation with sufficient time to allow the use of the experience of pre-operational tests and initial operation.

Therefore, Angra 1 was designed and constructed with American technology, which incorporates the concept of defense in depth, including the use of multiple barriers against the release of radioactive material. Extensive use was made of American codes and guides such as ASME 3, ASME 11, IEEE standards, ANSI standards and US NRC Regulatory Guides. Operating experiences from American plants, especially the fire at Browns Ferry and the accident at Three Mile Island, were incorporated through modification in the design, during the construction phase. Design review and assessment were performed through preparation by FURNAS and its contractors of a PSAR and a FSAR, which were evaluated by CNEN during the licensing process.

Construction adopted a quality assurance programme, which encompassed all activities related to safety conducted by FURNAS and its contractors and subcontractors. CNEN monitored the implementation of the quality assurance programme through the regulatory inspection programme and with the establishment of a resident inspector group during the construction phase.

In a similar manner, Angra 2 has been designed and constructed with German technology, within the framework of the comprehensive technology transfer agreement between Germany and Brazil. The plant is referenced to the Grafenrheinfeld nuclear power plant, currently in operation in Germany. The problem of the long construction delay has been addressed through a continuous updating of the design, incorporating feedback from operational experience from German and other nuclear power plants, and new licensing requirements in Brazil and Germany. The problem of long storage time of early manufactured components was dealt with by an appropriate and careful storage process, which involved adequate package, storage, monitored environmental conditions and a periodical inspection programme. The electromechanical erection was performed by the Brazilian consortium UNAMON, which started its activities at the site in January 1996, with a strong technical support from ELETRONUCLEAR, Siemens and foreign specialised companies. A specific Quality Assurance Programme was established for the erection phase, including the main erector activities. Erection activities supervision and inspection were carried both by the main erector as well as by

ELETRONUCLEAR. The electromechanical component pre-operational tests were performed in this phase, by the commissioning staff under the plant designer responsibility, as soon as allowed by the erection process.

5.3. Article 19. Operation

5.3.1. Item i. Initial authorization

The operation of a nuclear power plant in Brazil is subjected to two formal approval steps by CNEN within the regulatory process: authorization for initial operation (AOI) and authorization for permanent operation (AOP).

The authorization for initial operation is issued after the completion of the review and assessment of the Final Safety Analysis Report (FSAR), and taking into consideration the results of regulatory inspections carried out during the construction and pre-operational test period. Additionally, it requires the operator to have already an authorization for utilization of nuclear materials, and a physical protection programme in accordance with CNEN regulations, to have an emergency plan in accordance with SIPRON regulations and to have financial guarantees with respect to the civil liability legislation. In parallel, the corresponding environmental licence has to be obtained from IBAMA, in accordance with the national environmental legislation.

The Angra 2 Core Loading and Initial Operation Authorisation (AOI) were issued in March, 2000. A comprehensive programme of individual system tests and integrated tests was carried out from September, 1999 to December, 2000, comprising the 1st and 2nd Hot Trial and the Power tests commissioning phases. During this phases the systems' and plant operational and safety parameters have been adjusted and/or confirmed.

The adequacy of the equipment conservation measures referred in item 5.2 above was confirmed by the low amount of problems resulting from inoperable or malfunctioning equipment during commissioning, trial and further power operation.

The Authorization for Permanent Operation, in addition to the AOI requirements, is based on the review of start up test results. Safety requirements during operation are established by regulation CNEN-NE-1.26[10].

Operation is monitored by CNEN through an established system of periodical reports[9], notification of safety related events and through the regulatory inspection during operation. A group of CNEN resident inspectors is present at the site.

In the period 1998-2000, CNEN have conducted 17 inspections in Angra 1 power plant, including the following areas: Radiochemistry of the Primary Circuit, Radiation Protection, Physical Protection, Implementation of the Local Emergency Plan, Meteorology, Unusual Events Investigation, Maintenance Quality Assurance, Implementation of the Action Plan for Improvement of the Performance Indicators, Event Analysis, Monitoring of the Radioactive Effluents Release, Commissioning of the Solid Waste Treatment System, Managing of the Plant Aging and the Fuel

Elements Integrity.

Referring to the Improvement Plan, mentioned in the Angra 1 Authorization for Permanent Operation – AOP, the following activities were followed up by CNEN: in service inspections of components welding; tests and inspections on supports and dampers; withdrawing of reactor vessel test samples; applicability of the pressurized thermal shock and thermal stratification phenomena; tests on the steam generators tubes by using eddy current; operational results obtained from the fuel elements of the KWU/SIEMENS project; fire hazard protection of the Diesel generators; and qualification programme for electrical equipment.

During the period 1998-2000, CNEN conducted 57 audits and inspections activities in Angra 2, concentrated in the following areas: fulfillment of the commissioning tests acceptance criteria; systematic for quality control; systematic for commissioning tests results evaluation; fuel elements handling and loading; assembly of the electric and instrumentation and control cables; status of the pipes, equipment and chemical laboratory; physical protection; installation and structure of the radiation protection service; residual heat removal; safety cooling systems; electric power supply systems; ventilation system; radiation monitoring system; waste treatment systems; emergency feed water system, reactor cooling system; main steam system; containment vessel; reactor control and protection system; radiological protection supervisors and reactor operators training; following up of the secondary pressure test; quality requirements for the fabrication/assembly of the pipe lines; and fuel elements transport and reception.

CNEN conducted inspections on the implementation of Angra 2 commissioning programme by using test samples collected from some specific areas, and audits on the tests documentation.

On September 16th, 1999, the Authorization for Nuclear Material Utilization was granted, allowing ELETRONUCLEAR to receive and store the fuel elements for the first core load. The transport of the fuel elements to the site started on October 4th,1999, under close supervision of CNEN.

At the end of 1999, the substitution of the site meteorology system was concluded, following CNEN recommendations.

5.3.2. Item ii. Limits and conditions for operation

Limits and conditions for operation are proposed by the applicant in the FSAR, reviewed and approved by CNEN during the licensing process, and referenced in the licence document. No changes in these limits and conditions shall be made by the licensee without previous approval by CNEN.

For Angra 1 the original Technical Specifications of the plant designer (Westinghouse) were later adapted to the Standard Format established in NUREG 1431.

For Angra 2, the German licensing framework did not foresee Technical Specifications in the strict USNRC sense. The equivalent documentation, called "safety specifications" in the German procedure, is part of the Operating Manual, and is much more concise than the American ones. For the sake of uniformity, CNEN required that Technical Specifications following the Standard Format of NUREG 1431 be prepared also for Angra 2. This was again a huge adaptation job with extensive revision work. Presently, a final version of the Angra 2 Technical Specifications is ready and incorporated into the FSAR.

For Angra 2, the operability criteria of the systems, as required in the Limit Conditions of Operation (LCOs), are defined in the Test Instructions. Each Test Instruction links the results of the test with the acceptance criteria of the associated LCO. A user-friendly software was developed and implemented in Angra 2 to support the Safety Function Determination Programme required in the Technical Specifications.

5.3.3. Item iii. Operation, maintenance, inspection and testing

Safety requirements during operation are established by regulation CNEN-NE-1.26[10]. Additional CNEN regulations establish more detailed requirements for maintenance[22] and in service inspection[23].

The implementation of these requirements at the plant is done through the preparation of an Operation Manual, which contains guidelines to develop, approve and control plant procedures according to the nuclear class and the Quality Assurance programme. It also contains the actual procedures for all activities to be conducted in the plant, related to operation, maintenance, inspection and testing.

An administrative procedure - Organization of Operation Manual - provides the detailed requirements to develop, approve and control all plant procedures. In the case of surveillance procedures required by Technical Specifications or other regulations (ASME Code or KTA rules), another administrative procedure gives instructions in more details for the preparation of field procedures, implementation and control. Each Unit Operation Review Committee (CROU) approves all procedures of the respective unit. The Plant Operation Review Commission (CAON), which oversees both units, analyses and approves all nuclear safety class procedures and those that are related to the Quality Assurance programme.

All employees must follow written procedures, and each Department Manager (Operation, Maintenance, Technical Support, Chemistry, Health Physics, etc.), must assure that all tasks done under his/her responsibility are accomplished using the latest revision of the approved procedure. The Quality Assurance Department monitors and controls whether the plant organization is using approved procedures during operation, maintenance, test and inspection.

The Operation Manual is divided into volumes according to specific areas of activity, such as: Administrative, Operation, Chemistry and Radio Chemistry, Reactor Performance, Nuclear Fuel, Instrumentation, Electrical and Mechanical, Health Physics, Surveillance, Training, Physical Protection, Emergency Procedures, Fire

Protection, Environmental Monitoring. Besides the Normal Operation procedures, the Operation volume contains also the Abnormal and Emergency Operation procedures for assisting in abnormal and accident occurrences. The procedures should be revised every 2 years.

In cases where contracted companies (foreign or national) perform work in the plant, a temporary procedure is necessary. For a contracted company which develops its own procedures, a plant expert or an engineer related to the work to be performed, analyses the original procedure and sends it to the Quality Assurance to check if the acceptance criteria are achieved. A cover sheet with an approval form is attached to the procedure.

For other temporary procedures, the author writes the procedure, explains the reason for its temporary nature and establishes a validation period. Temporary procedures can be used only during the validated period stamped in the procedure.

The Work Control Group is responsible for planning all the maintenance, inspection and testing tasks. Inside the work package, procedures, plant modification documents, part lists and other references applicable to the task should be included. Two more steps are necessary for actually starting a task: the discussion at the daily co-ordination meeting and the shift supervisor approval.

Work control process stamps the ”Work Permit” with a “Red Line” to identify tasks related to nuclear safety equipment. In this case, quality assurance and maintenance quality control personnel ensure that approved procedures and part lists with traceability are being used. In addition, for equipment that has a "Risk of Scram", an approved procedure must be used and this procedure has a “Red Cover Sheet” to warn workers about risks and cautions to be taken.

During outages, a written and approved outage procedure controls the overall plant safety condition for inspection, testing and refuelling operation.

A Maintenance Efficiency Programme to check and improve the efficiency of Angra1 plant maintenance was started in the middle of 2001, based on the recommendations of EPRI/NUMARC 93-01- Rev.2. The complete implementation is to be concluded by the middle of 2002. This methodology allows optimization of the plant maintenance programme by focusing maintenance work on the items important to safety and availability. On-line information on the efficiency of the actual maintenance programme will be available through an interface with the software used for maintenance work control. The extension of this programme to Angra 2 is under consideration, taking into account its specific maintenance programme

Operational safety is monitored by CNEN through the regulatory inspection programme and by the routine surveillance carried out by the resident inspector's group. Within ELETRONUCLEAR, corporate auditing is conducted by the Quality Assurance Department, and reviewed by the CAON. In addition, periodical peer review is conducted voluntarily by the operator, through the invitation of international review missions from INPO, WANO and the IAEA (see item 5.3.7, Table 4 for a list of international technical review missions conducted at Angra plant in 1998-2000).

5.3.4. Item iv. Procedures for responding to anticipated operational occurrences and accidents.

As mentioned in item 5.3.3, the Operation Manuals of Angra 1 and Angra 2 contain procedures for emergencies and abnormal conditions to respond to anticipated operational occurrences and accidents. For abnormal conditions, procedures are used to return the plant to normal conditions as soon as practical or to bring the plant to a safe state, such as hot shutdown or cold shutdown. For accidents, Emergency Operating Procedures (EOPs) were written in accordance with latest reactor manufacturer guidelines and current international practices.

Although having different formats, both the EOPs for Angra 1 and Angra 2 work on the same philosophy :

- if an event can be clearly identified, Event Oriented EOPs are used; e.g., for Angra 2, Event Oriented EOPs are provided for control of the following classes of accidents: LOCAs, steam generator tube rupture, secondary side breaks, overcooling transients, external impacts during plant operation with reduced inventory or at refueling .
- if the event can not be clearly identified, Symptom or Safety Function oriented EOPs direct the operator into monitoring and restoration of the set of fundamental safety functions (Critical Safety Functions). If these safety functions are fulfilled the plant is in a safe state. These Safety Functions are Subcriticality, Core Cooling, Coolant Inventory, Containment Integrity, and Heat Sink.

The EOP structure, taking Angra 2 as example, consists of two levels of detail. The first level includes a diagnose chart, a trends-of-plant-parameters table, an automatic actions flow diagram, a manual actions flow diagram. The second level includes an instrumentation list, detailed instructions for automatic and manual actions, explanatory remarks and diagrams and tables.

The scheme illustrating the use of Event/Symptom Oriented EOPs is shown in the Figure 14. These EOPs cover accidents in the Design Basis and Beyond Design Basis up to but not including accidents with core melt. They assume the use of all available systems, even beyond their original design purposes and operating conditions.

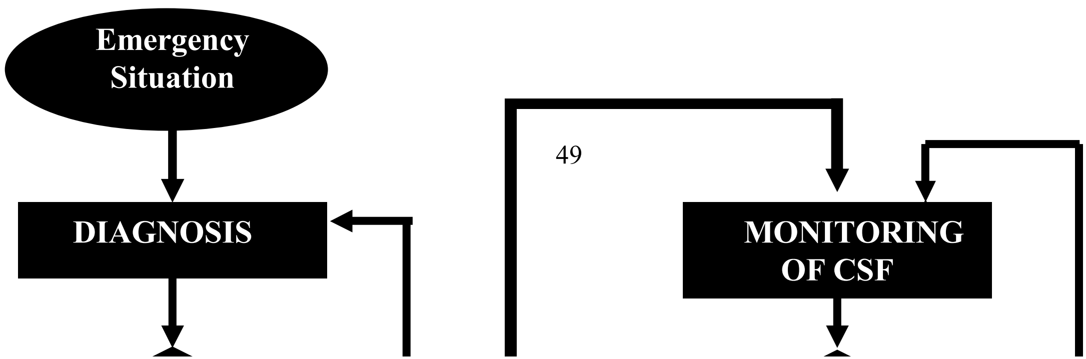


Fig. 14 - Emergency Operating Procedures use scheme

Integrated Computerized Systems, added to Angra 1 and Angra 2 after initial design, assist the operator in monitoring Critical Safety Functions (CSF) and other process variables. When a CSF (Subcriticality, Core Cooling, Coolant Inventory, Containment Integrity, and Heat Sink) is violated or there is a chance to reach the specified limits, there are approved procedures to be used to restore the CSF to normal condition. Colour codes used in the Integrated Computerized System help the operators to act in an anticipated way, to avoid reaching the protection limits. These colours (green - Normal, yellow - Alert, orange - Urgent, red - Emergency) guide the operator to what procedure should be used. In case the Integrated Computerized System is not operable, there is a procedure that must be followed by the operator to confirm that no CSF is in the process of violation or has been already violated.

5.3.5. Item v. Engineering and technical support

Engineering services and technical support are available for the operation of Angra 1 and Angra 2 within the ELETRONUCLEAR organization and supplemented by outside contractors. The technical support groups include all basic engineering disciplines: civil, electrical, mechanical, instrumentation and control, systems and components, safety analysis, stress analysis, reactor physics, and radiation protection. In this respect, the creation of ELETRONUCLEAR, combining FURNAS engineering and technical support groups with NUCLEN design capability, has significantly improved the support services available to both Angra 1 and Angra 2 (see item 4.2.2.1).

This technical staff is involved with the plant safety and operational analysis, evaluation of operational experience feedback and system and component performance, as well as with the design and implementation of the resulting plant modifications. Another source of requirements for modifications is the regulatory body, which normally updates its regulations on the basis of new technological developments, experience feedback and new international practices.

5.3.6. Item vi. Reporting of significant incidents

Reporting requirements during operations are established in regulation CNEN-NE-1.14[9]. Different types of reports are identified, such as periodical reports and reports of abnormal events. Immediate notification is required for events which involve degradation of the plant safety conditions, or exposure to radiation of site personnel or the public to levels above the established limits. Other events should be reported within 24 hours or 30 days, depending on their safety significance.

The International Nuclear Events Scale (INES) is used to classify the safety significance of the events. Only one event of INES level 1 has been reported in 1998/2000. Angra 1 reported to CNEN 21 events of INES level 0 in 1998, 19 in 1999 and 4 in 2000. In 2001 a level 1 event involving loss of coolant during reactor heat-up and pressurization has occurred and will be reported to the IAEA – IRS in the future. Angra 2 has reported 10 events of INES level 0 during the commissioning phase in 2000.

5.3.7. Item vii. Operating experience feedback

The operational experience feedback process in Brazil comprises two complementary systems: one performed by the utility, processing both in-house and external information, and one performed by CNEN.

An Operational Experience Analysis Group has been established by FURNAS and continues to work in ELETRONUCLEAR. This group investigates relevant incidents occurred in Angra and in similar nuclear installations in order to make recommendations. A programme to collect operating experience has been established using several sources of information, such as INPO and WANO. In addition, technical exchange visits conducted periodically provide a valuable source of information on other plant experiences. Table 4 presents a list of international technical missions that visited the Angra plants during the period 1998/2000.

Table 4 . INTERNATIONAL TECHNICAL MISSIONS RELATED TO ANGRA NUCLEAR POWER PLANTS DURING 1998/2000

N.	Year	Mission	Subject

N.	Year	Mission	Subject
1	1998	WANO - PC	Technical Assistance Visit in the Area of Reactor Engineering
2	1998	WANO - PC	WANO Peer Review Training Course
3	1998	WANO	Technical Visit in the Chemistry Area – Angra 2
4	1998	IAEA RLA - 04/12	Technical Meeting – Refuelling and Outage planning
5	1999	WANO	Technical Support – Engineering and Maintenance Assistance – Angra 1
6	1999	IAEA	Systematic Approach to Training (SAT)
7	1999	WANO	Human Performance and Root Cause Analysis
8	2000	IAEA RLA - 04/16	Special meeting on Cost Management
9	2000	WANO	General Peer Review – Angra 1
10	2001	IAEA	Workshop “Management of Safety and Safety Culture”

CNEN itself has its own system for operational experience feedback, analysing Angra 1 events and participating actively in international organizations to share its own operating experience, such as in the Incident Reporting System (IRS) of the IAEA. To date, Brazil has reported 11 events to IRS. The relevant IRS reports received by CNEN are transferred to the operator for evaluation, thus completing the feedback loop.

5.3.8. Item viii. Radioactive waste and spent fuel

Angra 1 nuclear power plant is equipped with systems for treatment and conditioning of liquid, gaseous and solid wastes. Concentrates from liquid wastes treatment are solidified in concrete and conditioned in 200 litre drums. Solid wastes may be conditioned in drums or in special boxes. Gaseous wastes are stored in holdup tanks and may be released from time to time. These tanks have the capacity for long term storage, which eliminates the need for scheduled discharge. For the time being, medium and low level wastes are being stored on site in a separate storage facility.

Angra 2 nuclear power plant is equipped with systems for treatment, conditioning, disposal and storage of liquid, gaseous and solid radioactive wastes. All Angra 2 waste treatment systems are highly automated to minimize human intervention and reduce operating personnel doses. Liquid wastes are collected in storage tanks for further monitoring and adequate treatment or discharge to the environment. The concentrate resulting from the liquid waste treatment is further processed in order to reduce water content before being immobilized in bitumen and conditioned in 200 litre drums. Spent resins and filter elements are also immobilized in bitumen and conditioned in 200 litre drums. Compactable and non-compactable solid wastes are conditioned in 200 litre drums. Gaseous wastes are treated in the gaseous waste treatment system, where the radioactive gases are retained in delay beds containing active charcoal to let them decay well below allowable levels, before release into the environment throughout the 150m high plant vent stack. No residues are produced in the gaseous waste treatment system, as all the system's consumables, mainly filter and delay bed fillings, are designed to last for the whole plant lifetime. The drums with waste are initially stored within the plant prior to being transported to the intermediate storage facility still at the plant site.

Generated volume of solid radioactive waste material is kept to a minimum by preventing materials from becoming radioactive, by decontaminating and reusing radioactive materials, by monitoring for radioactivity and separating non-radioactive material prior to conditioning and storage, and by other volume reduction techniques. Procedures, personnel training and quality control checks are used to ensure that radioactive materials are properly packed, labeled and transported to the storage facility.

Since the specific legislation has not been approved for construction of the final radioactive wastes repository, these wastes are being stored in a temporary storage facility located at the Angra site. The repository consists of two hangars, which are submitted to CNEN inspections.

Attending to a Brazilian Government request, an IAEA mission was received in 2000 to review the conditions of the temporary storage. The mission praised the storage condition and the effort carried out in the past to repack some of the initial waste and reduce its volume. The mission also presented some recommendations on the wastes temporary repository status. Taking into consideration the IAEA mission and CNEN recommendations, the storage facility is being expanded. In addition, the construction of a third storage facility is under study.

With respect to spent fuel of Angra 1, the spent fuel pool capacity has been expanded by the installation of compact racks to accommodate the spent fuel generated for the expected operational life of the unit.

In the case of Angra 2, the spent fuel pool, which is located inside the steel containment, has two types of racks :

a) region 1 : normal racks with capacity for 264 fuel assemblies, equivalent to one full core plus one reload of fuel of any burnup and with enrichment up to 4.3%;

b) region 2 : high-density storage racks with storage capacity for 820 spent fuel assemblies. The fuel assemblies to be stored in region 2 must have a given minimum burnup, which is a function of the original enrichment. This spent fuel storage capacity is sufficient for about 15 years of operation, which means that additional spent fuel storage space, either of the wet or dry type, will have to be provided in the medium term.

Chapter 6. PLANNED ACTIVITIES TO IMPROVE SAFETY

Safety culture requires a questioning attitude and a search for excellence. Therefore, notwithstanding the good safety record, nuclear operators and regulators in Brazil are constantly working on safety improvements.

CNEN efforts to establish an internal quality management system may represent the biggest work to be carried out in the near future to keep up-to-date with current international practices (see 4.1.1). It is recognized that this is a multi-year project which is still in its starting stages. More human and financial resources will have to be allocated to the project in the next years.

In the area of legislation, at present a bill of law is under discussion establishing administrative and monetary penalties to all nuclear facilities and services in cases of non-compliance. This is expected to strengthen the enforcement powers of CNEN.

Angra 1 Authorization for Permanent Operation has established a series of required improvements to be performed by the operator, according to a realistic schedule. These include the development of a Plant Aging Management Programme and a Maintenance Efficiency Programme. Furthermore, regulation CNEN-NE 1.26[10] has established the requirement of a periodical safety review at every 10 years of operation; the next one is due in 2004. It is expected that this will be an opportunity to review past performance and to upgrade the plant according to current safety requirements, to the extent possible.

A Level 1 Probabilistic Safety Assessment of the Angra 2 power plant is scheduled to be initiated in the near future and concluded at most within four years. As far as Angra 1 power plant is concerned, a Level 2 PSA is also planned to be initiated soon.

Following Chapter 18 of the FSAR of Angra 2, a Human Factors Engineering Programme is being implemented in the power station organization. This programme is being conducted by a multidisciplinary team, that is analysing all the relevant events of the power plant lifetime following the nine areas of Human Factors Engineering (HFE) recommended in NUREG-0711. HFE analysis of accidental sequences and associated operator actuation times are being performed for the existing Angra 2 Main Control Room panel arrangement and will be extended also for the Angra 1 Plant Control Room.

In addition of the existing full scope simulator for the Angra 2 Plant, the installation at the site of a full scope simulator for Angra 1, to be completed in 2004, will allow a more frequent and comprehensive simulator training than it is possible now, when the Angra 1 operators simulator training has to be done abroad. The specifications for that simulator is ready and the international bidding is foreseen for the second semester of 2001.

A comprehensive Safety Culture improvement programme is under way at ELETRONUCLEAR, as well as a programme of Knowledge Management, through which the present company's knowledge status and future needs are to be identified.

A study to establish ELETRONUCLEAR policy concerning radioactive wastes, including reduction of generation, reduction of volume, intermediate and final storage of low and medium level wastes is in development. Concerning intermediate storage the present storage facility is being expanded in a second block and a third intermediate storage facility is in the design process.

The replacement of Angra 1 two steam generators foreseen for 2005 will improve the plant margins and as a byproduct will provide a revised safety analysis, performed with newer methods and codes.

With respect to emergency planning, a task force has been formed to introduce a quality assurance programme for organizations involved in SIPRON, to the extent possible. In addition, formal agreements have been signed to provide the Angra Municipality and Rio de Janeiro State civil defenses with better infrastructure for public shelters, health care and other measures related to emergency preparedness. These include an agreement between ELETRONUCLEAR and the National Road Department (DNER) to improve the BR-101 federal highway passing through the Angra site, at a cost of circa 7 million US dollars to be provided by ELETRONUCLEAR. The works, already started, comprise restoration of 60 km of asphalt paving, of the road drainage and emergency lanes at the road sides, slope stabilization at the road hill side, building of crossings, underpasses and pedestrian passageways as well as elimination of three road bypasses.

In the same area of emergency preparedness, in order to provide an extra mechanism to monitor the environment, CNEN is installing an On-Line Radiation Monitoring System in the emergency planning zone (EPZ). The system is composed by thirteen Geiger Müller detectors disposed strategically around the Angra site. All data are locally collected and sent to the Institute of Radiation Protection and Dosimetry (IRD) by modem connection.

Chapter 7 – TOPICS RAISED BY THE SUMMARY REPORT OF THE FIRST REVIEW MEETING

During the final discussions of the first review meeting of the Parties of the Convention on Nuclear Safety, held in Vienna on 12 - 23 April 1999, several recommendation on improving the information provided in the National Report were made. These recommendations were recorded in the Summary Meeting Report [3] and the Parties were requested to address them in the Second National Report. This chapter addresses these topics, but instead of providing a lengthy explanation, reference is made to the items of the previous chapters were the topic was discussed.

7.1. Deregulation, Maintaining Competence, Lack of Resources

Following a worldwide tendency, Brazilian electricity market is being de-regulated and privatized. However, due to constitutional requirements, as mentioned in item 1.2, nuclear power generation is and will continue to be a State monopoly. Therefore, privatization is not expected to affect in a direct way the nuclear sector. The main impact will arise from the uncertainties relative to the competitiveness of nuclear energy compared with other sources in a deregulated market. The protection of the nuclear generation from open electricity market variations has been dealt with by the contract arrangements of ELETRONUCLEAR and with the intervention of the Operador Nacional do Sistema (National System Operator – ONS), which is the centralized organization for load dispatch (see item 4.2.1).

Maintaining competence in the nuclear area in Brazil is a key issue, like in other countries. The nuclear programmes in Brazilian universities have very few students and the average age of qualified staff is very high (estimated to be above 45 years). A large effort to replace retiring people is being done by ELETRONUCLEAR. A project launched in 2001 called “Determination of the Technological Know-how of ELETRONUCLEAR”, has the objective of establishing a permanent mechanism for identifying the existing know-how status of the company and allowing for planning to fill in the missing expertise gaps in an organized and timely manner (see item 4.2.2).

To hire new staff, CNEN carried out an admission exam at national level in 1998 and is planning another contest in 2002. These efforts also require strong efforts in the initial training of the new staff, which is being carried out in both organizations as described in items 3.2.1 and 4.2.2.

In this respect, the lack of human resources has been more limiting than the lack of financial resources.

7..2. New National Framework

As described in 3.1, a new Government structure has been adopted recently, with CNEN reporting now to the Ministry of Science and Technology (MCT). It is expected that the Fuel Assembly Fabrication facility mentioned in 1.2 soon will be removed officially from direct CNEN control, as it is being already observed “de facto."

ELETRONUCLEAR situation has not changed in recent years, but internal reorganization took place, as reported in 4.1.2, to take account of the company new work scope (less engineering, more operation) after the end of commissioning of Angra 2.

7.3. Adoption of ICRP60 and Basic Safety Standards (BSS)

In the supplement to the first National Report of Brazil, it was reported that a working group had been formed to adapt the existing Radiation Protection Regulation [17] to the new requirements of the IAEA – Basic Safety Standards (BSS) for Radiation Protection.

The work of the group has proceeded in the period, but a new regulation has not yet been issued, due to the complexity of the proposed modifications and their possible impact on the existing practices.

However, as reported in the supplement to the National Report, some of the new concepts and limits of BSS have already been implemented in practice and through other regulations such as the control of X-Ray installations by the Ministry of Health.

7.4. Status and Position of Regulatory Body

The status of the Brazilian regulatory body has not changed in the period 1998 -2000. The new position under the Ministry of Science and Technology, as reported in item 3.1 responded to a need due to the extinction of the previous Secretaria de Assuntos Estratégicos (Secretary for Strategic Affairs - SAE) under a broad Government restructuring.

7.5. Regulatory Strategies, Prescriptive versus Goal Oriented Regulations

CNEN regulation suffered very little modifications in the period. Most of CNEN regulations are prescriptive in nature, although the main regulation related to nuclear plant operation, CNEN – NE 1.26, adopted a modern risk based approach, which may be considered to be goal oriented, as discussed in item 5.3.3.

The main difficulties experienced, related to regulations, concern the adoption of safety guides and industrial standards from the supplier countries, in a nuclear programme which includes suppliers from USA and from Germany. However, as reported in 3.1.1., CNEN regulations form the main basis for the licensing process, and the adoption of foreign guides and standards was dealt with on a case by case basis, without major problems, even in the few cases were American regulatory guides were used in the licensing of the German design Angra 2 plant, as reported in 5.3.2 (Technical Specifications) and 4.3. (Human Factors).

7.6. Quality Assurance within Regulatory Body

As mentioned in item 4.1.1, CNEN has issued a Quality Assurance Policy [12], and has established a task force to develop and implement a formal Quality Management system for its nuclear safety activities. A member of this task force participated in the IAEA Peer Discussion on Regulatory Practices related to Quality Management of the Regulatory Body. Another member of the task force made a Scientific Visit to Spain to learn about the implementation of Quality Management within the Consejo de Seguridad Nacional. The task force continues its work in defining the Quality Management model for CNEN and will proceed in the medium term into the implementation phase of the system.

7.7. Independence of Regulatory Body, de jure and de facto

This topic was discussed in detail for the Brazilian situation during the first review meeting of the Convention on Nuclear Safety. Brazil reaffirms its statement that, with respect to nuclear power generation, CNEN has total independence, de jure and de facto, from ELETRONUCLEAR, as described in item 3.1.

With respect to other facilities not covered by this Convention, such as the research reactors of CNEN's institutes, and some of their pilot fuel cycle facilities, Brazil consider that the existing arrangements, through which the Safety and Radiation Protection Directorate (DRS), licenses and controls the Directorate of Research and Development (DPD) installations, provides the necessary effective separation required to ensure an independent review of design and operation.

With respect to the fuel cycle facilities of INB, CNEN has proposed a reorganization of MCT, through which INB will be formally removed from CNEN control, as it already occurs “de facto”, since INB president reports directly to MCT.

7.8. Monitoring Safety Management

CNEN has always monitored safety management of the licensee through a system of audits and inspections. Also, operational events are always analyzed from the management implications point of view.

Recent events related to a decrease in some performance indicators of Angra 1 has lead CNEN to carry out special audits which focus on management aspects, with CNEN requesting the necessary corrective actions.

7.9. International Cooperation

Brazil has established and maintained strong cooperation both bilaterally and multilaterally.

Brazil maintains a constant participation in IAEA activities, involving CNEN as well as ELETRONUCLEAR. Furthermore, CNEN is member of the Ibero American Forum of Nuclear Regulators, which includes also Argentina, Cuba, Mexico and Spain. ELETRONUCLEAR is member of INPO and WANO.

Formal bilateral agreements in the field of nuclear safety are in place also with Argentina, Germany, USA, and Korea. Informal contacts with several other nuclear electricity producing countries are made on a routine basis.

7.10. Safety Improvement Programmes

A safety improvements programme is a licensing requirement established in CNEN Regulation NE 1.26[10] as mentioned in 5.3.1. Additional details for individual plants are established in the licensing conditions.

Angra 1 has had many modifications as mentioned in item 2.1.1.1. Angra 2 has not yet had significant modifications during operation, but, as mentioned in item 2.1.2.1, its design has been upgraded constantly during its long construction period, in accordance with modern German requirements for the reference plant.

7.11. Continuous Safety Review and Updating of Safety Analysis

In Brazil the Final Safety Analysis report is a living document which is periodically updated as the plant is being modified during operation. These revisions have a character of continuous updating taking into account the operational experience, both at the plant and from similar facilities, changes in licensing requirements, and new safety research results.

Additionally, a comprehensive review of the entire FSAR will be conducted at the occasion of the 10 –year Periodical Safety Review (PSR) of Angra1.

7.12. Containment Function Improvements

Both Angra 1 and Angra 2 have full containment design to withstand the design basis accident (DBA). In addition, both plants have redundant containment spray system, although for Angra 2 it has been demonstrated that the system is not necessary for the plant to cope with the DBA. Both plants have also redundant Hydrogen recombiners for containment atmosphere control under DBA.

Studies are under way with respect to the capacity of the containment to survive beyond design basis accidents (BDBA), but no decision has been reached yet about the necessity to install a filtered containment venting system.

7.13. Probabilistic Safety Assessment (PSA)

As mentioned in 3.3, risk management is a requirement of CNEN Regulation NE 1.26[10]. For Angra 1 a preliminary level 1 PSA was performed in the eighties, which supported the decision to add two new Diesel generators. A detailed level 1 PSA, completed in 1998 followed this former study. A brief description of the methodology utilized and some highlights of the results and of the plant upgrading resulting from this study are presented in section 4.5.

The revision 1 of the Angra 1 Level 1 PSA has incorporated the improvements as mentioned in section 4.5, besides others subjects that impact the

Core damage Frequency (CDF) quantification. The net effect was a reduction in the CDF of about 3 to 4 times the previous value (revision 0).

For Angra 2, probabilistic studies have been carried out using the insights of the German Risk Study, as mentioned in 4.5, and a Level 1 PSA is in the planning stage.

7.14. Periodic Safety Review (PSR)

A 10 year PSR is a requirement of Regulation CNEN-NE-1.26[10] as mentioned in Chapter 6. Accordingly, the next review is due in 2004. At the moment, CNEN and ELETRONUCLEAR are trying to define the basis and scope of the review, which will use the guidance provided by the IAEA Safety Series 50-SG-O12 - Periodical Safety Review of Operational Nuclear Power Plants.

7.15. Collective Doses Trends

The collective radiation dose is monitored at the power plant as mentioned in item 4.6, and reported periodically to CNEN. Results of individual doses for the year 2000 are presented also in Figure 10 of item 4.6.

The histogram of collective doses in the Angra 1 plant is shown in the Figure 11 of item 4.6, demonstrating a strong correlation with refueling and maintenance activities.

7.16. Effluent Releases Trends

The effluents of the plant are monitored constantly and reported on a semi-annual basis to CNEN, as described in item 4.6. The result of the environment monitoring programme has demonstrated that the impact of these effluents in recent years are negligible (see Figure 11).

Recent trends have shown no significant variation of the total amount of radioactive effluents, which remains well bellow permissible limits.

7.17. Emergency Exercises National and International

Emergency exercises are conducted on a periodical basis as described in item 4.7. Brazil has also participated in some international exercises, such as the Joint International Emergency Exercise 1 (JINEX-1), jointly coordinated by the IAEA, NEA and WMO, conducted in May 2001.

Chapter 8. FINAL REMARKS

At the time of the first review meeting of the Nuclear Safety Convention, Brazil has demonstrated that the Brazilian nuclear power programme and the related nuclear installations met the objectives of the Convention on Nuclear Safety. During the period of 1998 / 2001, Brazil has continued the operation of Angra 1 in accordance with the same safety principles.

In the year 2000, Angra 2 plant has been incorporated in the Brazilian grid, increasing the net nuclear installed capacity from 626 MWe to 1901 MWe. The new plant is up-to-date as far as technical and safety standards are concerned, and this has been demonstrated by the excellent results of commissioning tests and initial operation.

Based on the safety performance of nuclear installations in Brazil, and considering the information provided in this National Report, the Brazilian nuclear organizations consider that its nuclear programme has:

- achieved and maintained a high level of nuclear safety in its nuclear installations;
- established and maintained effective defenses in its nuclear installations against potential radiological hazards in order to protect individuals, the society and the environment from harmful effects of ionizing radiation;
- prevented accidents with radiological consequences and is prepared to mitigate such consequences should they occur.

Therefore, Brazil considers that its nuclear programme related to nuclear installations has met and continues to meet the objective of the Convention on Nuclear Safety.

REFERENCES

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[15].Quality Assurance for Safety in Nuclear Power Plants and Other installations - CNEN-NN-1.16 - September 1999.
[16]Qualification of Independent Technical Supervisory Organizations in Nuclear Power Plants and Other Installations - CNEN-NE-1.28 - September 1999
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[18] General Norm for Planning of Response to Emergency Situations – SIPRON – NG–02 - 1996
[19] Directive for the Preparation of Emergency Plans related to the Unit 1 of Almirante Alvaro Alberto Nuclear Power Plant – SIPRON Directiva Angra – 1997.
[20] Report on the Emergency Planning Exercise at Angra - IAEA - BRA/9/042 - June 1997.
[21] General Norm for Establishing Public Information Campaigns about Emergency Situations – SIPRON - NG-05 – 1997.
[22] Maintenance of Nuclear Power Plants - CNEN-NE-1.21 - August 1991.
[23]In-service Inspection of Nuclear Power Plants - CNEN-NE-1.25 - September 1996.

Annex 1

EXISTING INSTALLATIONS

1.1. Angra 1

Thermal power	1876 Mwth
Gross electric power	657 Mwe
Net Electric power	626 Mwe
Type of reactor	PWR
Number of loops	2
Number of turbines	1 (1High Pressure/2Low pressure)
Containment	Dry cylindrical steel shell and external concrete building.
Fuel assemblies	121
Main supplier	Westinghouse El. Co.
Architect Engineer	Gibbs & Hill / Promon Engenharia
Civil Contractor	Construtora Norberto Odebrecht
Mechanical Erection	Empresa Brasileira de Engenharia
Construction start date	March 1972
Core load	20 September 1981
First criticality	13 March 1982
Grid connection	1 April 1982
Commercial operation	1 January 1985

1.2. Angra 2

Thermal Power	3765 MWth
Gross electric power	1345 Mwe (as measured during commissioning)
Net electric power	1275 Mwe (as measured during commissioning)
Type of reactor	PWR
Number of loops	4
Number of turbines	1 (1High Pressure/3Low pressure)
Containment	Dry spherical steel shell and external concrete building.
Fuel assemblies	193
Main supplier	Siemens KWU
Architect Engineer	ELETRONUCLEAR/Siemens KWU
Civil Contractor	Construtora Norberto Odebrecht
Mechanical Erection	Unamon
Construction start date	1975
Core load	30 March 2000
First Criticality	14 July 2000
Grid connection	21 July 2000
Commercial operation	January 2001

1.3. Angra 3

Thermal Power	3765 MWth
Gross electric power	1309 MWe
Net electric power	1229 MWe
Type of reactor	PWR
Number of loops	4
Number of turbines	1 (1High Pressure/3Low pressure)
Containment	Dry spherical steel shell and external concrete building.
Fuel assemblies	193
Main supplier	Siemens KWU
Architect Engineer	ELETRONUCLEAR/Siemens KWU
Civil Contractor	na
Mechanical Erection	na
Construction start date	1978
Core load	2005 (to be confirmed)
First Criticality	2005 (to be confirmed)
Grid connection	2005 (to be confirmed)
Commercial operation	2006 (to be confirmed)

Annex 2

LIST OF RELEVANT CONVENTIONS, LAWS AND REGULATIONS

2.1. RELEVANT INTERNATIONAL CONVENTIONS OF WHICH BRAZIL IS A PARTY

Convention on Civil Liability for Nuclear Damage (Vienna Convention). Signature: 23/12/1993. Entry into force: 26/06/1993.

Convention on the Physical Protection of Nuclear Material. Signature:15/05/1981. Entry into force: 8/02/1987.

Convention on Early Notification of a Nuclear Accident Signature: 26/09/1986. Entry into force: 4/01/1991.

Convention on Assistance in Case of Nuclear Accident or Radiological Emergency. Signature: 26/09/1986. Entry into force: 4/01/1991.

Convention on Nuclear Safety. Signature: 20/09/1994. Entry into force: 24/04/1997.

Convention n. 115 of the International Labor Organization. Signature: 7/04/1964.

2.2. Relevant National Laws

Decree 40.110 of 1956.10.10 - Creates the Brazilian National Commission for Nuclear Energy (CNEN).

Law 4118/62 of 1962.07.27 - Establishes the Nuclear Energy National Policy and reorganizes CNEN.

Law 6189/74 of 1974.12.16 - Creates Nuclebras as a company responsible for nuclear fuel cycle facilities, equipment manufacturing, nuclear power plant construction, and research and development activities.

Law 6.453 of 1977.10.17 - Defines the civil liability for nuclear damages and criminal responsibilities for actions related to nuclear activities

Decree 1809 of 1980.10.07 - Establishes the System for Protection of the Brazilian Nuclear Programme (SIPRON).

Law 6938 of 1981.08.31 - Establishes the National Policy for the Environment (PNMA), creates the National System for the Environment (SISNAMA), the Council for the Environment (CONAMA) and Brazilian Institute for the Environment (IBAMA).

Law 7781/89 of 1989.06.27 - Reorganizes the nuclear sectors.

Decree 99.274 of 1990.06.06 - Regulates application of law 6938, establishing the environmental licensing process in 3 steps: pre-licence, installation licence and operation licence.

Decree 2210 of 1997.04.22 - Regulates SIPRON, defines the Secretary for Strategic Affairs (SAE) as the central organization of SIPRON and creates the Coordination of the Protection of the Brazilian Nuclear Programme (COPRON).

Law 9.605 of 1998.02.12 – Defines environmental crimes and establishes a system of enforcement and punishment.

Decree 3719 of 1999.09.21 – Regulates the Law 9.605 and establishes the penalties for environmental crimes..

Law 9.765 of 1998.12.17 – Establishes tax and fees for licensing, control and regulatory inspection of nuclear and radioactive materials and installations.

Decree 3833 of 2001.06.05 – Establishes the new structure and staff of the Brazilian Institute for the Environment (IBAMA).

2.3. CNEN Regulations

NE 1.04 - Licenciamento de instalações nucleares - Resol. CNEN 11/84 - ***(Licensing of nuclear installations).***

NE 1.14 - Relatórios de operação de usinas nucleoelétricas - ***(Operation reports for nuclear power plants).***

NE 1.16 - Garantia de qualidade para a segurança de usinas nucleoelétricas e outras instalações - Resol. 15/99 - ***(Quality assurance for safety of nuclear power plants and other installations).***

NE 1.17 - Qualificação de pessoal e certificação para ensaios não destrutivos em itens de instalações nucleares - ***(Qualification and certification of personnel for non-destructive tests in nuclear power plants components).***

NE 1.18 - Conservação preventiva em usinas nucleoelétricas - ***(Preventive conservation of nuclear power plants).***

NE 1.19 - Qualificação de programas de cálculos para análise de acidentes de perda de refrigerante em reatores a água pressurizada - Resol. CNEN 11/85 - ***(Qualification of calculation programs for the analysis of loss of coolant accidentes in pressurized water reactors).***

NE 1.20 - Aceitação de sistemas de resfriamento de emergência do núcleo de reatores a água leve - ***(Acceptance criteria for emergency core cooling system for light water reactors).***

NE 1.21 - Manutenção de usinas nucleoelétricas - ***(Maintenance of nuclear power***

plants).

NE 1.22 - Programas de meteorologia de apoio de usinas necleoelétricas - ***(Meteorological programme in support of nuclear power plants).***

NE 1.25 - Inspeção em serviço de usinas nucleoelétricas - ***(In service inspection of nuclear power plants).***

NE 1.26 - Segurança na operação de usinas nucleoelétricas - ***(Operational safety of puclear power plants).***

NE 1.28 - Qualificação e atuação de órgãos de supervisão técnica independente em usinas nucleoelétricas e outras instalações - Resol. CNEN-CD N^{o}.15/99 de 16/09/1999- ***- (Qualification and actuation of independent technical supervisory organizations in nuclear power plants and other installations)***

NN 1.01 - Licenciamento de operadores de reatores nucleares - Resol. CNEN 12/79 - ***(Licensing of nuclear reactor operators).***

NN 1.06 - Requisitos de saúde para operadores de reatores nucleares - Resol. CNEN 03/80 - ***(Health requirements for nuclear reactor operators).***

NN 1.12 - Qualificação de órgãos de supervisão técnica independente em instalações nucleares - Resol. CNEN 16/85 - Revisada em 21/09/1999 ***- (Qualification of independent technical supervisory organizations for nuclear installations).***

NN 1.15 - Supervisão técnica independente em atividades de garantia da qualidade em usinas nucleoelétricas - ***(Independent technical supervision in quality assurance activities in nuclear power plants).***

NE 2.01 - Proteção física de unidades operacionais da área nuclear - Resol. CNEN 07/81 - ***(Physical Protection in operational units of the nuclear area).***

NE 2.03 - Proteção contra incêndio em usinas nucleoelétricas - Resol. CNEN 08/88 - ***(Fire protection in nuclear power plants).***

NE 3.01 - Diretrizes básicas de radioproteção - Resol. CNEN 12/88 - ***(Radiation protection directives).***

NE 3.02 - Serviços de proteção radiológica - ***(Radiation protection services).***

NE 3.03 - Certificação da qualificação de supervisores de radioproteção - Resol. CNEN 09/88 – Revisada em 01/09/95, Modificada em 16/10/97 e 21/09/99 - ***(Certification of the qualification of radiation protection supervisors).***

NE 5.01 - Transportes de materiais radioativos - Resol. CNEN13/88 - ***(Transport of radiaoctive materials).***

NE 5.02 - Transporte, recebimento, armazenamento e manuseio de elementos combustíveis de usinas nucleoelétricas - ***(Transport, receiving, storage and handling of fuel elemets in nuclear power plants).***

NE 5.03 - Transporte, recebimento, armazenagem e manuseio de ítens de usinas nucleoelétricas - ***(Transport, receiving, storage and handling of items in nuclear power plants).***

NE 6.05 - Gerência de rejeitos radioativos em instalações radioativas - ***(Radioactive waste management in nucelar installations).***

2.4. CONAMA Regulations

CONAMA – 01/86 - Estabelece requisitos para execução do Estudo de Impacto Ambiental (EIA) e do Relatótio de Impacto Ambiental (RIMA) - ***(Establishes requirements for conducting the environmental study (EIA) and the preparation of the report on environmental impact(RIMA)) -*** (23/01/1986).

CONAMA-28/86 - Determina a FURNAS a elaboração de EIA/RIMA para as usinas nucleares de Angra 2 e 3 - ***(Directs FURNAS to prepare an EIA/RIMA for the Angra 2 and 3 nuclear power plants) -*** (03/12/1986)

CONAMA-09/86 - Regulamenta a questão de audiências públicas - ***(Regulates the matters related to public hearings) -*** (03/12/1987).

CONAMA-06/86 – Institui e aprova modelos para publicação de pedidos de licenciamento - ***(Establishes and approves models for licensing application) -*** (24/01/1986).

CONAMA-06/87 – Dispõe sobre licenciamento ambienatl de obras de grande porte e especialmente do setor de geração de energia elétrica - ***(Regulates environmental licensing of large enterprises, specially in the area of electric energy generation) -*** (16/09.1987).

CONAMA-237/97 – Dispõe sobre os procedimentos a serem adotados no licenciamento ambiental de empreendimentos diversos - ***(Establihses procedures for environmental licensing of several types of enterprises) -*** (19/12/1997).

2.5. SIPRON Regulations

NG-01 - Norma Geral para o funcionamento da Comissão de Coordenação da Proteção do Programa Nuclear Brasileiro (COPRON) - ***(General norm for the Coodination Commission for the Protection of the Brazilian Nuclear Programme).*** Port. SAE 99 of 13.06.1996.

NG-02 - Norma Geral para planejamento de resposta a situações de emergência. ***- (General norm for planning of response to emergency situations).*** Resol.

SAE/COPRON 01/96.

NG-03 - Norma Geral sobre a integridade física e situações de emergência nas instalações nucleares - ***(General norm for physical integrity and emergency situations in nuclear installations).*** Resol. SAE/COPRON 01/96.

NG-05 - Norma Geral para estabelecimento de campanhas de esclarecimento prévio e de informações ao público para situações de emergência - ***(General norm for establishing public information campaings about emergency situations).*** Port. SAE 150 of 11.12.1992.

NG-06 - Norma Geral para instalação e funcionamento dos centros de resposta a situações de emergência nuclear - ***(General norm for installation and functioning of response center for nuclear emergency situations).*** Port. SAE 27 of 27.03.1997.

NG-07 - Norma Geral para planejamento das comunicações do SIPRON ***(General norm for SIPRON communication planning).*** Port. SAE 37 of 22.04.1997.

Diretriz Angra-1 - Diretriz para elaboração dos planos de emergência relativos a unidade 1 da Central Nuclear Almirante Alvaro Alberto - ***(Diretive for the preparation of emergency plans related to Unit 1 of Almirante Alvaro Alberto Nuclear Power Plant - Angra 1).*** Port. SAE 144 of 20.11.1997.

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