FOURTH
NATIONAL REPORT
OF
BRAZIL

FOR THE

NUCLEAR SAFETY CONVENTION

SEPTEMBER 2007

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 Second and Third National Reports of Brazil were prepared to update the information provided in the previous Reports with information related to the period 1998/2001 and 2001/2004, respectively.

This Fourth National Report is a new update to include relevant information for the period of 2004/2007.

The authors decided to prepare the Fourth National Report of Brazil as a self-standing document, with some repetition of the information provided in the previous National Reports so that the reviewers do not have to consult frequently the previous document. The most relevant new information refers to the operation of the two Brazilian nuclear power plants during the period.

Following the recommendation of the previous meeting, the relevant new information is clearly identified in the report by the use of different font or a separate new section. According to the amendment to the Guidelines Regarding National Reports (INCIRC/572), an additional section was added to each relevant article to cover activities, achievements and concerns regarding the improvement of safety. An additional chapter was included to address to specific issues raised during the third Review Meeting.

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.

O Segundo e Terceiro Relatórios Nacionais do Brasil foram preparados para atualizar a informação contida nos relatórios anteriores com dados relativos ao período 1998/2001 e 2001/2004, respectivamente.

Este Quarto Relatório Nacional do Brasil atualiza a informação para o período de 2004/2007.

Os autores decidiram preparar o Quarto Relatório Nacional do Brasil como um documento completo, com alguma repetição das informações contidas nos outros Relatórios Nacionais de maneira que os revisores não tivessem que consultar freqüentemente os relatórios anteriores. Seguindo as deliberações da última Reunião de Revisão, as informações novas são claramente identificadas pelo uso de uma fonte diferente no texto, ou pela inclusão de uma seção específica em separado.

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 as fases de localização, projeto, construção e operação. De acordo com as recomendações da Segunda

Reunião de Revisão, foi adicionada para cada artigo uma sessão relativa a atividades, realizações e preocupações relacionadas com a melhoria da segurança. O capítulo 6 contém as perguntas mais relevantes feitas ao Brasil na revisão do Terceiro Relatório Nacional com as respectivas repostas, e informações adicionais em tópicos específicos, conforme recomendado pelo relatório da Terceira Reunião de Revisão de Abril de 2004. O capítulo 7 faz considerações finais sobre o grau de cumprimento das obrigações da Convenção sobre Segurança Nuclear pelo Brasil.

As considerações finais apresentadas no capítulo 7 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. Conseqüentemente, o Brasil alcançou os objetivos da Convenção sobre Segurança Nuclear.

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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 2005/2010 (Plano Plurianual de Ciência e Tecnologia - PPA 2005/2010), which establishes quantitative targets that define the Government strategy[2]. Among these targets one can mention 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 protection of 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.

1.2. The Brazilian nuclear program

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

[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).
[2] *New information is presented in Italics in this report*

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.

Currently, Brazil has two nuclear power plants in operation (Angra 1, 657 MWe gross/626 MWe 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 but the re-start of the construction has been recently decided by the Federal Government.* 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 Eletrobrás Termonuclear S. A. (ELETRONUCLEAR), a heavy components manufacturer, Nuclebrás Equipamentos Pesados (Nuclebrás Heavy Equipment - NUCLEP), a nuclear fuel manufacturing plant (Fábrica de Combustível Nuclear - FCN) and a yellow-cake production plant belonging to Indústrias Nucleares do Brasil (Nuclear Industries of Brazil - INB). Brazil has also the 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.

1.3. Structure of the National Report

This Fourth National Report was prepared to fulfill one of 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 the safety of the installations during siting, design, construction and operation. According to the amendment to the Guidelines Regarding National Reports (INFCIRC/572)[2], an additional section was added to each relevant article to cover activities, achievements and concerns regarding the improvement of safety. Chapter 6 presents the relevant question and answers related to the Third National Report and also addresses questions raised during the third review meeting [3] and for which additional information was requested from the Parties to the Convention. Chapter 7 presents final remarks related to the degree of compliance with the Convention obligations.

The *Fourth National Report of Brazil* has been prepared as a self-standing document, with some repetition of the information provided in the previous Reports [4, 5, 6] so that the reviewers do not have to consult frequently the previous documents. *According to the recommendation of previous review meeting, the new relevant information is clearly identified by the use of italic font in the text, or the addition of a separate section*.

Since Brazil has only two nuclear installations in operation, 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 includes two annexes providing more detailed information on 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 MWe net, 2-loop PWR and Angra 2, 1345 MWe gross/1275 MWe net, 4-loop PWR). *A third plant (Angra 3, 1345 MWe gross/1275 MW net, PWR, similar to Angra 2) had the construction temporarily interrupted, but a recent Governmental decision has been taken to restart the implementation of the project.* Angra 1, 2 and 3 are located at a common site, near the city of Angra dos Reis, about 130 km from Rio de Janeiro. More details about these units can be found in Annex 1 or in the PRIS [7], available through the Internet as well as at 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. These 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 Elétricas 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.

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 absorbed all the operating personnel of FURNAS, and part of its engineering staff, and the personnel of the design company Nuclebrás 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 programs in maintenance, chemistry and better planning of reload down times are reflected in the plant performance of the last years (2001- to 2006) shown in Table 1 below, as measured by the WANO Plant Availability indicator.

Table 1 - Angra 1 Plant Availability

Year	Energy Generation (MWh)	Accumulated Energy (MWh)	Plant Availability (%)
2001	3.853.499,20	37.499.392,40	82,94
2002	3.995.104,00	41.444.496,40	86,35
2003	3.326.101,30	44.770.596,70	73,30
2004	4.124.759,20	48.895.356,90	90,05
2005	3.731.189,70	52.626.546,60	81,61
2006	3.399.426,40	56.025.973,00	74,88

It has to be observed that the operation constraints imposed by the program for preservation of the plant steam generators, which are reaching end of their useful life, implicate in limitations to plant performance which can only be eliminated after their replacement planned to start in September, 2008. The availability of the plant was further negatively affected during the year of 2006 by a vibration problem in the electric generator, which caused several forced plant shutdowns before being eliminated (for more details see subsection 5.3.3.1).

2.1.1.1. Recent 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 upgrading has been carried out during the life of the installation.

As in the previous review period, the main safety concerns were related to operation with degraded Steam Generators (SG) and with obsolescence. The several programs for improvement of safety and reliability listed in the previous

National Reports, and confirmed by the results of the Angra 1 Periodic Safety Review (PSR), were continued in this period, as follows:

- *Follow up of condition, preservation and development of the activities for replacement of the plant Steam Generators;*
- *Follow up of condition, preservation and planning for replacement of the Reactor Pressure Vessel (RPV) head;*
- *Reduction of generation and volume, as well as enlargement of storage capacity for radioactive wastes;*
- *Addition of depleted Zinc to the reactor coolant, for dose reduction;*
- *Implementation of Leak Before Break (LBB) concept to the primary circuit;*
- *Reduction of snubbers;*
- *Replacement/qualification of mechanical/electrical components inside containment required for post-accident conditions;*
- *Obsolescence related activities, such as modernization of I&C and modernization of fire detection system;*
- *Monitoring of maintenance efficiency.*

In addition, a major program for evaluation and monitoring of thickness of secondary energy-carrying piping, as well as replacement of deteriorated pipe sections, was implemented in the review period, for both plants.

More details on these programs are provided in chapters 4 and 5.

Some selected plant modifications, important for safety and/or reliability implemented in the period were:

- *Installation of new fire alarm and detection system;*
- *Major upgrade, including increase of redundancy, of the compressed air supply system (for instruments and equipment), as result of PSA evaluation;*
- *Continuation of substitution of obsolete instrumentation (Foxboro controllers) and electrical components (switches, relays, etc);*
- *Continuation of upgrading of the containment instrumentation for design basis accident (DBA) conditions;*
- *Upgrade of the reactor inventory monitoring system;*
- *Continuation of substitution of obsolete mechanical equipment (essentially valves, safety and non safety related);*
- *Major Main Control Room upgrade (layout, work stations and furniture);*
- *Enlargement and modernization of the installations of the Control Point to the radiation controlled area;*
- *Installation of additional chilled water supply unit for cooling down of containment during outages;*

On the analysis side, the Angra 1 level 1 PSA study was updated to level 1+, and continues to be revised, taking into account actual plant data, developments in human reliability analysis and in models. A Fire PSA study, being performed under advice and with participation of the US Electric Power Research Institute (EPRI) has been started. More details are given in section 4.5 (article 14).

The 10 year Periodic Safety Review (PSR) for the Angra 1 plant was completed; the main result of this review was that no outstanding safety issues were identified that could impede the continued safe operation of the plant. As a result of the Angra 1 PSR, the need for an extensive review of the Final Safety Analysis Report (FSAR) was identified and is under way. The results of the PSR also identified gaps in information concerning the plant design bases; accordingly, work on the compilation of the plant design bases has been started (more details in section 4.5).

As previously reported, a comprehensive set of performance and safety indicators, in addition to the WANO ones, as well as a system of "system health indicators" have been developed and continue to be applied. More details are given in section 5.3.

2.1.2. Angra 2

In June 1975, a Co-operation 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., later SIEMENS/KWU nuclear power plant supplier branch, at present Framatome ANP.

Considering that one of the objectives of the Agreement was a high degree of domestic participation, Brazilian engineering company Nuclebrás 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 dedicated to qualify Brazilian engineering firms and local industry to comply with the strict standards of nuclear technology.

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.

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. *Due to legal constraints imposed by the Brazilian Public Ministry related to the environmental licensing (see 3.1.2.1), the Angra 2 still does not have a formal Authorization for Permanent Operation (AOP). The plant has been operating based* *on an Authorization for Initial Operation (AOI) that has been extended for periods of 8 months.*

Angra 2 operational record for the period 2003/2006, as measured by the WANO Availability indicator, is shown in Table 2 below.

Table 2 - Angra 2 Plant Availability

Year	Energy Generation (MWh)	Accumulated Energy (MWh)	Plant Availability (%)
2001	10.498.432,70	13.121.084,70	93,90
2002	9.841.746,20	22.962.830,90	91,50
2003	10.009.936,10	32.972.767,00	91,30
2004	7.427.332,20	40.400.099,20	74,60
2005	6.121.765,30	46.521.864,50	64,50
2006	10.369.983,90	56.891.848,40	89,00

As reported in the previous National Report, Angra 2 had a very good performance in its first three years of operation (2001-2003). In 2001 the Angra 2 plant ranked 16th in the world in energy generation. In the three subsequent years, period of the present review, the plant performance has substantially deteriorated due to a series of problems with major secondary side components. In this period the plant was shut down several times due to problems with the main transformer as well as with a cooling water leak in the rotor of the main electric generator which led to an extended down time, with negative impact in the availability factors for 2004 and 2005.

Furthermore, the plant had to be de-rated several times due to problems with the motors of the main circulating water pumps and condenser tube leakage. These problems have been addressed, their root causes have been identified and measures for their elimination have been or are being implemented. A positive trend resulting from the actions taken is reflected in the availability factor for the year of 2006 (more details in subsection 5.3.3.2).

2.1.2.1. Recent safety improvements at 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.

As already indicated in section 2.1.2 above, in the period 2003/2006 the main activities at the plant dealt with problems in major non-safety equipment/components. Safety and safety related equipment performed well during the review period.

Some selected modifications, important to safety and/or reliability, implemented in the period were:

- *Installation of alternative power supply to the pressurizer heaters from the Diesel generators;*
- *Installation of system for monitoring thermal stratification conditions in the primary coolant piping;*
- *Upgrading of internals material of the secured service water pumps and of the sealing water circuit of the high pressure safety injection pumps;*
- *Further work on the isolation valves of the residual heat removal system to improve leaktightness;*
- *Continuation of the checking of the "as built" condition of supports, with corrections were needed;*
- *Exchange of the plant process computers with duplication of the acquired variables (obsolescence);*
- *Implementation of program for exchange of low power switches and sensing devices of the primary coolant system leakage monitoring system (obsolescence);*
- *Installation of main transformer parameter monitoring system;*
- *Installation of cathodic protection for the secondary side piping and components;*
- *Major overhaul of the plant chlorination system.*

On the analysis side, a contract for performance of a level 1+ PSA study was signed in end of 2004 with an international contractor. The study is well advanced with completion date established as end of 2007. More details are given in section 4.5.

Also in the period of this Report, work was started on the implementation of the Maintenance Rule (Numarc 93-01) to the Angra 2 maintenance program.

As for Angra 1, a comprehensive set of performance and safety indicators, in addition to the WANO ones, as well as a set of "system health" indicators have been developed and continue to be applied. More details are given in section 5.3.

2.1.3 Angra 3

Recently (June 2007), the Federal Government through its National Council for Energy Planning approved the restart of construction of Angra 3 after a 23-year interruption.

But, even before construction authorization for Angra 3 was given, some progress has been made. In 2005, following authorization for site preparation work, the rock excavation for the plant foundation was cleaned up and stabilized. Engineering work was continued with adaptation for Angra 3 of Angra 2 material and equipment specifications, upgrading the design with basis on the Angra 2 and international operational experience as well as continuation of contacts with the potential equipment suppliers. An important formal step on the Government side was inclusion, in March 2006, of Angra 3 in the Electric Energy Expansion Decennial Planning, covering the period 2006 – 2015, following a detailed evaluation of the Brazilian viable energy generation alternatives.

Concerning Angra 3 economics, the calculated cost of its MWh competes with the cost of energy from new hydro plants and is lower than gas or coal generation, as it has been shown in the last auction of future energy market.

Most of its components of imported scope are already in Brazil and the site is ready for concrete pouring. All the required engineering is essentially available since for economy and standardisation reasons Angra 3 is to be as similar as possible to Angra 2. This concept has been submitted to and accepted by CNEN, proposing "Angra 2 as-built" as the reference plant for Angra 3.

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 program, continue to be applied for the Angra 3 components stored at the site.

For the actual restart of construction two licenses are still required: the Construction License from the Nuclear Regulatory Body – CNEN, based on the acceptance of a Preliminary Safety Analysis Report (PSAR) and the Installation License from the Environmental Regulatory Body – IBAMA, based on the acceptance of an Environmental Impact Assessment (EIA).

The Preliminary Safety Analysis Report (PSAR) for the Nuclear Licensing process is under review by ELETRONUCLEAR to be delivered to CNEN. CNEN has already conducted a preliminary evaluation and identified to ELETRONUCLEAR the necessary modifications for further review.

The environmental licensing has proceeded with preparation and submission of the Angra 3 Environmental Impact Assessment (EIA) to IBAMA. Still in the frame of the environmental licensing process, public hearings to inform the population on the contents of the EIA were held in all counties with borders within the emergency planning zones of the Plant.

Plant construction is planned for a 66 months duration, from starting of reactor annulus slab concrete work up to the end of power tests and start of commercial operation.

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 materials 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 was already under construction. Therefore, licensing procedures for these power plants followed slightly different procedures, as described below.

The relation amongst regulatory organizations and operators is shown in Figure 1.

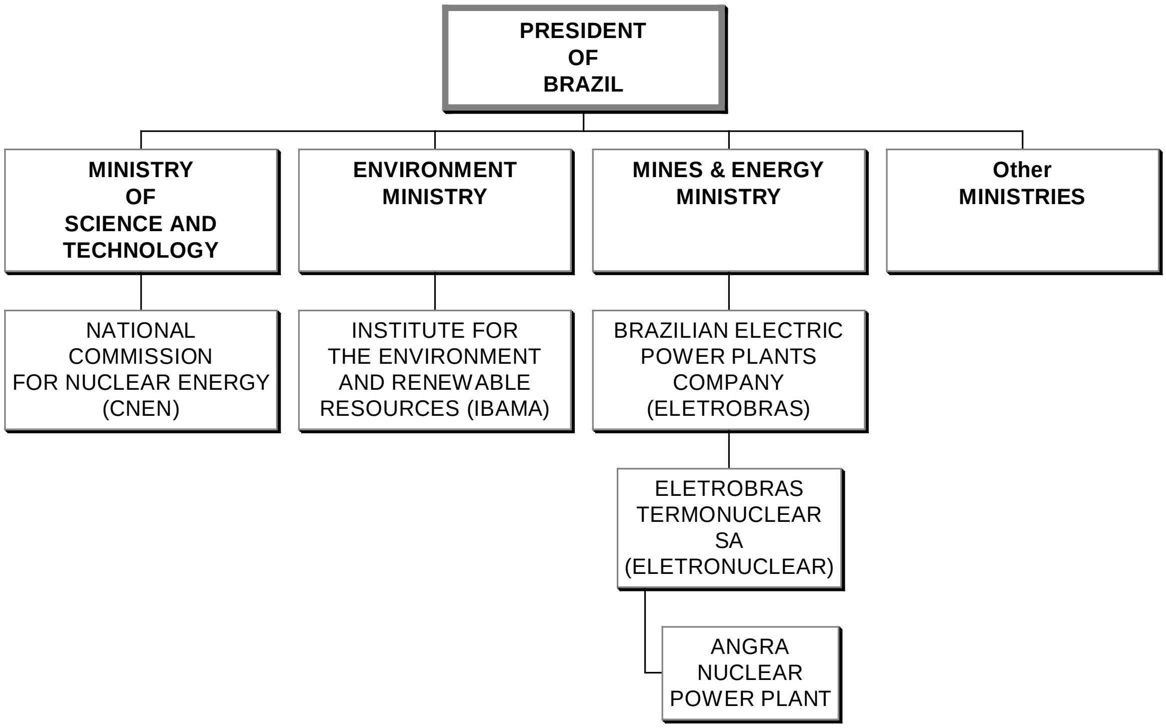


Fig. 1 – Brazilian organizations involved in nuclear power plant safety

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:

- 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 A 2.3 for a list of CNEN regulations).

The licensing regulation CNEN NE 1.04[8] establishes that no nuclear installation shall be constructed or operated 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 [9], 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 program 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-NN-1.01 [10]. 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 programs which should be kept active during operation, such as the radiological protection program, the physical protection program, the quality assurance program for operation, the fire protection program, the environmental monitoring program, the qualification and training program, the preventive maintenance program, the retraining program, etc. Reporting requirements are also established through regulation CNEN-NN-1.14 [11]. 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 Programs 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 (Política Nacional do Meio Ambiente - 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 (Sistema Nacional do Meio Ambiente - 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, programs and projects including measures that 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 initial 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 status reported in the previous National Report[6] was that procedures had been agreed with the Federal and State environmental agencies for performance of the environmental licensing of both plants, and that issuance of the respective licenses was expected in the short term. This expectation did not materialize.

In beginning of 2001 IBAMA, following intervention of the Public Ministry, (Ministério Público – MP), a peculiarity of the Brazilian legal system), informed ELETRONUCLEAR that the Angra 2 environmental operating license could not be issued before fulfillment of a “Term of Conduct Adjustment ” (Termo de Ajuste de Conduta - TAC), that specifies compensations for the environmental effects caused by the presence of the plant.

This TAC covers regularization of the environmental licensing of Angra 1, of new interim radioactive waste storage facilities and pending IBAMA and MP requirements relative to issuance of the permanent environmental license for Angra 2.

In the case of the Angra 1 Plant, already in commercial operation since 1985, the terms of agreement for an “adaptive licensing” procedure developed to allow adjustment of the plant to the new environmental regulation, and which defined the necessary environmental studies to justify the issuance of an operating license, was signed in 2002 with the Federal and State environmental Agencies, FEEMA and IBAMA and the Nuclear Regulator, CNEN. This process was halted by an Act of the Public Ministry (MP) in beginning of 2003, which required an additional “Term of Conduct Adjustment” (TAC). *Since then, IBAMA issued a Term of Reference for an Environmental Control Plan (Plano de Controle Ambiental) in 2006. This term allowed ELETRONUCLEAR to initiate the preparation of the required Environmental Control Plan, to be implemented by the end of 2008.*

The environmental licensing situation for Angra 2 is similar, in spite of the fact that the plant had both the Environmental Impact Assessment (EIA) and a Report on Environmental Impact (RIMA) prepared before applying for its Environmental Operation License.

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 programs detailed in a Basic Environmental Project (Projeto Básico Ambiental - PBA), to be carried out by the licensee.

The RIMA served also as a basis for the two public hearings about Angra 2 environmental 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.

As previously mentioned, as a precondition for the environmental license in addition of the EIA and RIMA reports, a TAC was requested for Angra 2, which started operation on a Provisional Environmental License and a nuclear Authorization for Initial Operation (AOI) in beginning of 2001. This TAC specified improvements of roads and sheltering to be made by ELETRONUCLEAR relative to emergency planning, environmental compensation to be applied to the Serra da Bocaina Natural Reservation and others.

An additional public hearing was conducted at the Public Ministry in 2003 for checking of fulfillment of the requirements of the TAC. Presently ELETRONUCLEAR is waiting for the closure of the Angra 2 TAC process to be able to apply for the permanent environmental and nuclear permanent operating licenses.

With respect to Angra 3, IBAMA proposed in 1999 the Terms of Reference for the preparation of the development of the EIA/RIMA. ELETRONUCLEAR submitted *this EIA/RIMA to IBAMA in May 2005 and in June 2007three public hearings were conducted by IBAMA, in the neighboring cities of Angra dos Reis, Paraty and Rio Claro, as part of the Pre-installation Licensing process. A Hearing Report will be submitted to IBAMA in the near future.*

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 in 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 Program (SIPRON) by the Law 1809 from 7 October 1980. The subsequent Decree 2210 from 22 April 1997 established 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.

Since 2000, 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 Programs of MCT.

The Decree 2210 also establishes a Commission for the Coordination of Protection of the Brazilian Nuclear Program (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 Transport Infrastructure Department (DNIT), the National Army, Navy and Air Force, and representatives of the Ministries of Health, Foreign Relations, Justice, Finance, Planning and Budget, Transportation and Communications.

SIPRON guidelines, issued by COPRON (see Annex 2, item A.2.5), require that ELETRONUCLEAR and the Municipal and State Civil Defenses 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 complementary emergency plans, as well (See additional details in item 4.7).

3.1.4. Activities, achievements and concerns regarding the improvement of safety

The main concern refers to the situation of the environmental license, which is now under the control of the Public Ministry (MP).

CNEN has issued enough regulations to allow the effective control of the licensing process. However it is recognized that revision and updating of these regulations are still necessary.

Regarding emergency planning regulations, a proposal for review of Law n. 1809 and Decree n. 2210 was submitted to the Presidency in the end of 2003. In January 2004 the review was sent to the final approval of the Congress. It includes modifications due to restructuring of the Brazilian Government and increases the strength of SIPRON, involving more agencies in COPRON and extending SIPRON focus to all Brazilian nuclear organizations.

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 1).

The structure of CNEN is presented in Figure 2. 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 are performed mainly by the Reactor Coordination (CODRE) of the General Coordination for Reactors and Fuel Cycle (CGRC). CODRE is also in charge of regulatory inspection of nuclear power plants, which includes a group of resident inspectors at the Angra site (SEIRA). 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, established and managed by the Norms Division (DINOR).

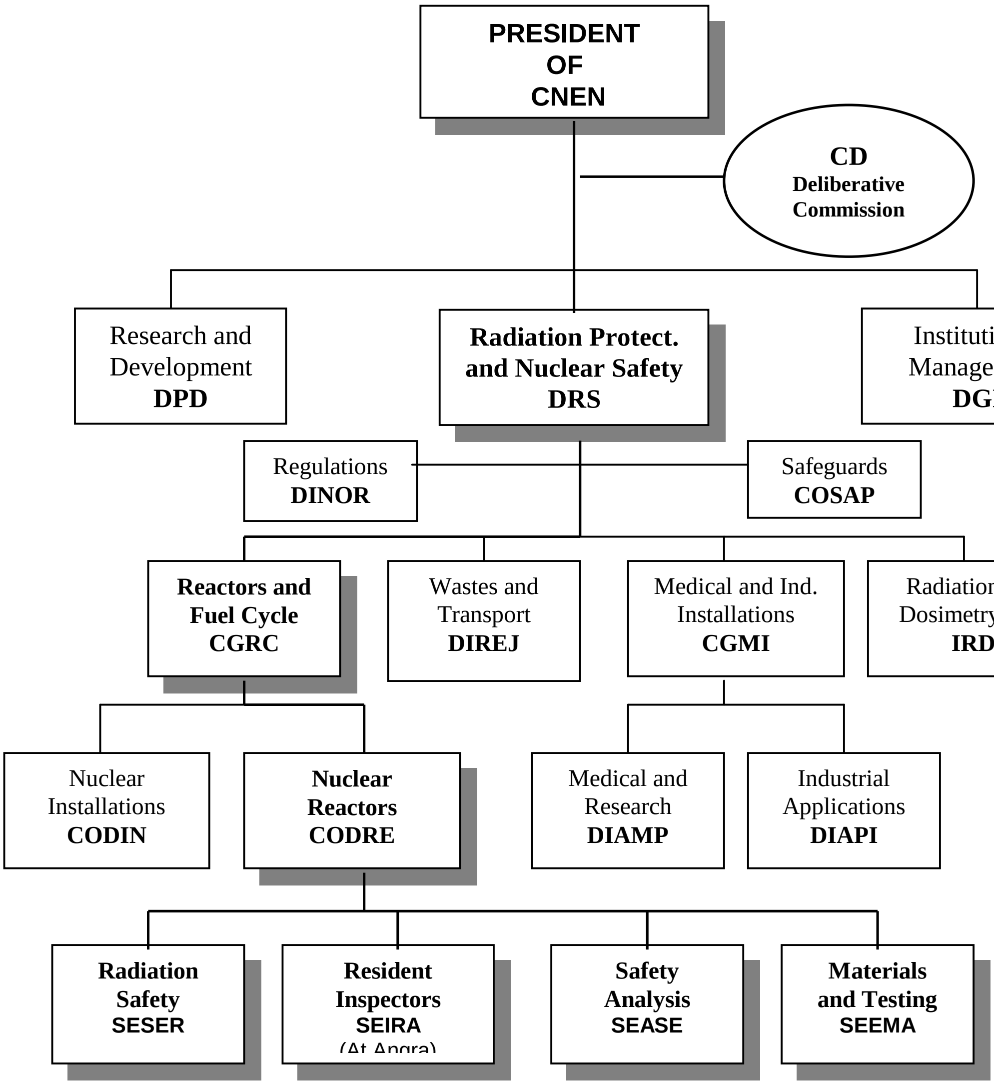


Fig. 2 – CNEN Structure (simplified)

Adequate human resources are provided to CNEN. A total staff of 2657 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, 16% having a master degree and 15% having a doctoral degree. CGRC itself comprises 86 people, 75 of which are technical.

CODRE, the unit directly involved with nuclear power plants licensing and control, has a staff of 52, of which 48 are technical, with 19 possessing a doctoral and 23 a master degree in nuclear science or engineering. Presently, 5 persons are involved in a doctorate program and 2 persons are involved in a master program.

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 2003-2006, CNEN conducted 29 inspections in Angra 1, 29 in Angra 2 and 27 related to the whole plant organization. Complementary to field activities, operation follow up is performed also based on licensee reports, as required by regulation CNEN-NN.1.14 [11].*

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.

CODRE personnel also attended, during the year of 2006, several external training courses.

Also during the year of 2006, several technical visits were conducted by CODRE personnel, including a long period training on the ARGOS computer program in Denmark, and the participation in the Technical Working Group on Nuclear Power Plant Control and Instrumentation in Vienna.

In the period of 2004 - 2006, CODRE received 4 technical assistance missions from the IAEA, 3 of them from experts of Gesellschaft für Reaktor Sicherheit – GRS (Germany).

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.

Salaries of CNEN staff are subjected 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 close to retirement age; ii) the salaries are lower than those of equivalent utility personnel.

3.2.2. IBAMA

The licensing structure of IBAMA is presented in Figure 3. The environmental licensing 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 about 50 professionals, some of which are dedicated to the licensing of nuclear power plants.*

For the environmental 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.

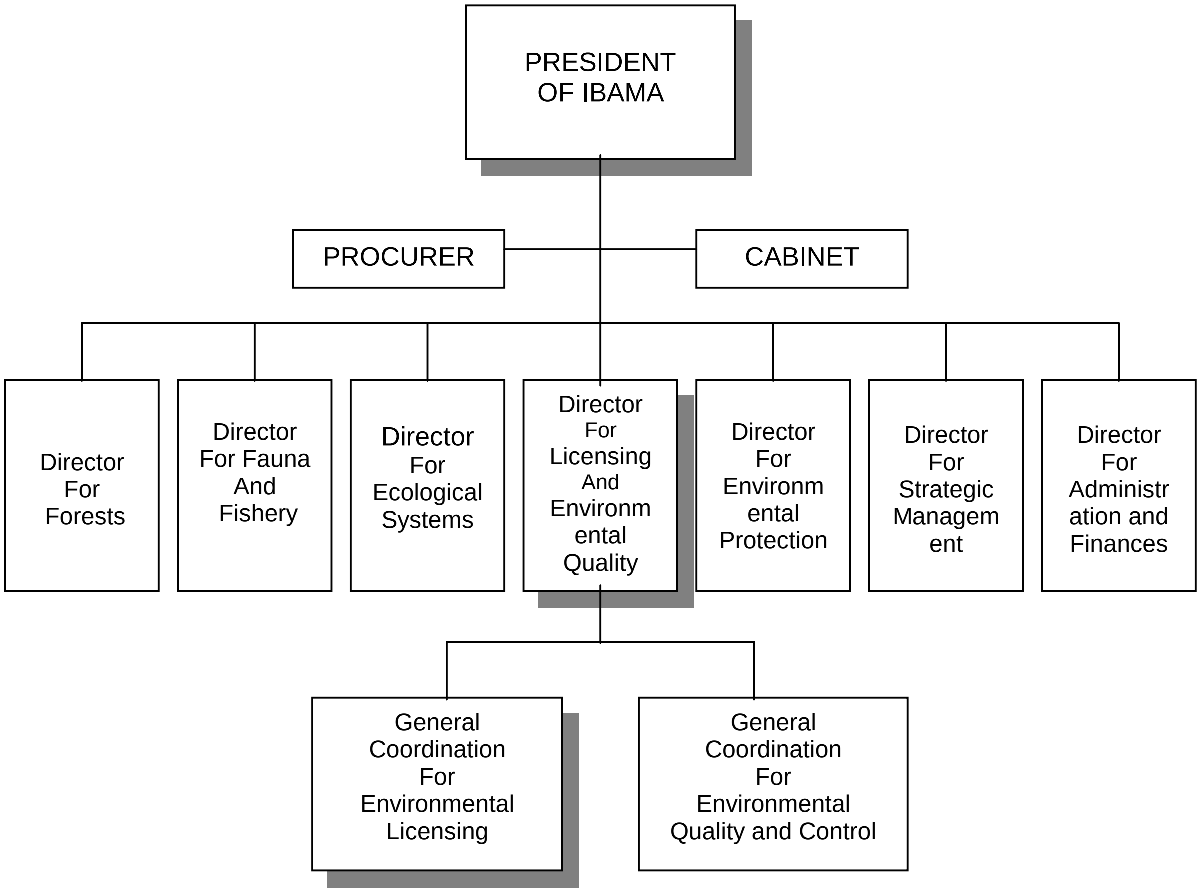


Fig. 3 – IBAMA structure

3.2.3. Activities, achievements and concerns regarding the improvement of safety

The main concerns are related to the lack of personnel and the high average age of existing qualified personnel. *These were partially overcome by hiring new personnel through national public contests, which took place 2004*. *However, this required a comprehensive training program in all organizations to qualify the new staff and to effectively transfer the knowledge of experienced personnel to the new comers.*

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 [12] 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 safety policy since its foundation, occurred in 1997, stating its commitment to safe operation (see previous National Reports [3,4,5]. This policy was revised in 2004, becoming an “Integrated Safety Management Policy”, as follows:

“Eletrobrás Termonuclear S.A. - ELETRONUCLEAR is committed to clean power generation and high safety standards.

Therefore, its staff's commitment to perform all safety-related activities in an integrated manner is essential, laying emphasis upon Nuclear Safety, which includes Quality Assurance, Environment Occupational Safety, Occupational Health and Physical Protection.”

This is expanded in 6 principles, the first of them stating:

“1. Nuclear Safety is a priority, precedes productivity and economic aspects and should never be impaired for any reason”.

.

CNEN, through the licensing process, and especially through its regulatory inspection program, 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 [11]. 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.

3.3.1. Activities, achievements and concerns regarding the improvement of safety

Evaluation of safety culture within ELETRONUCLEAR organization was performed by a formal pioneering program with support of IAEA in 2000. The action plan resulting from this evaluation was implemented in 2001 and has been monitored ever since. Also OSART and WANO missions have evaluated these aspects of management responsibility, which have been considered adequate, although some opportunities for improvements have been identified by some missions.

Chapter 4. GENERAL SAFETY CONSIDERATIONS

4.1. Article 10. Priority to safety

4.1.1 At CNEN

CNEN has issued a safety policy [13] and quality assurance policy statements[14] in December 1996, which is based on the concept of Safety Culture. *In 2000, a working group was constituted to coordinate the implementation of this policy in the licensing and control activities. However, further activities were not undertaken. Now a new effort is underway to establish a more uniform licensing process through the increased use of a computerized process, the conduct of internal audits and the possible creation of an Ombudsman Office.*

CNEN has established in its regulatory standards requirements to be met by the applicants or licence holders based on safety principles, defense-in-depth and ALARA concepts, quality assurance and human resources management. According to regulation CNEN-NE-1.26 [12] 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.

CNEN organized the 1st. National Regulatory Information Meeting (I ENIR 2005) from 1 to 2 December 2005 in Rio de Janeiro. This meeting was successful in promoting the communication between CNEN and its stakeholders, specially the licensees, seeking dynamism, transparency and effectiveness of the regulatory functions. This event was part of the stakeholder interaction strategy, which includes making information about the regulatory activities understandable, accessible and useful and using survey methods to identify areas for improvement. The conclusions of the meeting as well as the results of the opinion survey are available at http://www.cnen.gov.br/hs_enir2005/Default.asp.

4.1.2. At ELETRONUCLEAR

ELETRONUCLEAR is a company resulting from the merger, in 1997, of the nuclear portion of the electric utility FURNAS and the nuclear design and engineering company NUCLEN, both with more than 20 years of experience in their field of activities. Both companies had already policies aiming at giving priority to nuclear safety. *The current organization structure of ELETRONUCLEAR is presented in Figure 4, which is essentially the same as presented in the previous National Report.*

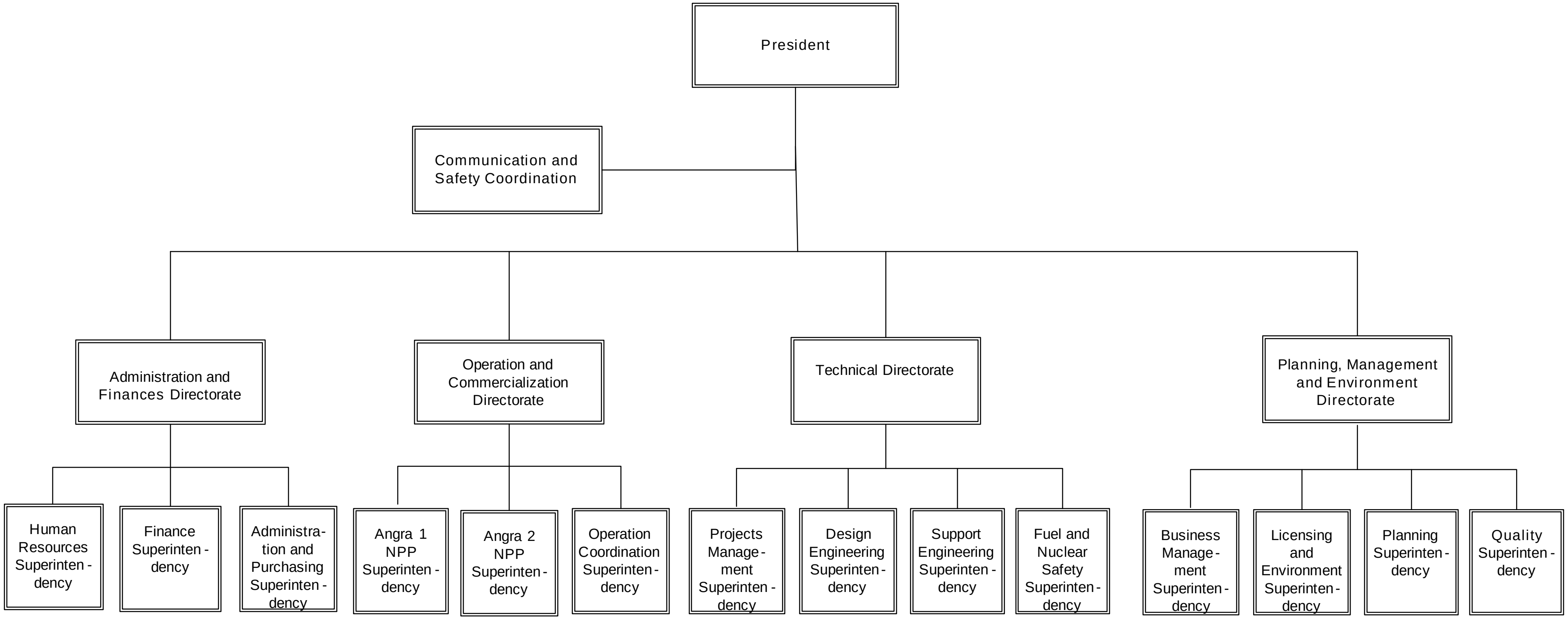


Figure 4. ELETROBRAS TERMONUCLEAR S.A – ELETRONUCLEAR Organization Chart

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 policy, where, as mentioned in section 3.3. stated its commitment to safe operation. This policy was revised in December 2004, becoming an "Integrated Safety Management Policy", stating that the "Nuclear Safety is a priority, precedes productivity and economic aspects and should never be impaired for any reason."

This policy is observed consistently by ELETRONUCLEAR Committee for Nuclear Operation Analysis (CAON), the supervisory committee with the responsibility to review and approve all important aspects related to the plants safety. The members of this Committee are the Plants Managers and the Heads of Engineering, Safety, Licensing, Quality Assurance and Training, under the coordination of the Site Superintendent (SC.O). The CAON meets regularly once a month.

Following the line of the merged companies, a strong Quality Assurance (QA) unit was established at ELETRONUCLEAR, from the beginning in 1997, at the level of superintendence with the responsibility of monitoring all design, construction and operation activities and coordinating/supervising the plants nuclear and environmental licensing. This superintendence responded formally to the Technical Director at headquarters. With start of operation of the second Plant, in December of 2000, it was identified the need of a Quality Assurance unit inside the Operation organization. To meet this need the original QA superintendence was split in two units in 2003, one at headquarters, under the Technical Director and one on site, under the Operation and Production Director. This area was reorganized in 2007, keeping its previous characteristics of one unit at the Site and one unit at Headquarters, however now subordinated to a single Directorate independent of the production areas, the Planning, Management and Environment Directorate (see ELETRONUCLEAR Organization Chart, Fig. 4).

4.1.3. Activities, achievements and concerns regarding the improvement of safety

In practice, even if the resources are available, a safety police can only be fully effective if all employees are aware and convinced that safety is the priority. By its own initiative ELETRONUCLEAR has engaged, since beginning of 1999, in a pioneer program of safety culture "self assessment" 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 assessment was completed by the end of 2000. A satisfactory overall safety culture level was obtained, as the average of all safety culture aspects considered in the survey. However some safety culture aspects were identified as only regular. In mid 2001 the development of an action plan for enhancement of the safety culture aspects was issued. This action plan has been implemented and its development is being followed up since then.

Internal and external reviews are also a frequently used means to verify compliance with priority to safety at ELETRONUCLEAR. At about every three years each plant has been submitted to an OSART or WANO peer review (see section 5.3.7).

Self-assessments have been performed in most of the Operation Directorate organizational units, and additionally, since 2005, in the Technical Directorate.

Safety Culture has also been included in several training programs, such as General Employee Initial Training and retraining.

Additionally, a Safety Culture Presentations Program is implemented, since 2001, where safety related themes are discussed. This presentations program is voluntary and has been attended by more than 5000 employees over a period of 4 years.

In particular the start, development and application of a comprehensive safety culture assessment and enhancement program was rather unique at the time. As a result of this, the IAEA decided to host an International Conference on Safety Culture Programs for Nuclear Power Plants, in the city of Rio de Janeiro, in December 2002, with ELETRONUCLEAR as the co-host.

The current organization structure of ELETRONUCLEAR (presented in Figure 4) is essentially the same as presented in the Third National Report. Minor changes refer to relocation of the Quality Assurance Area, which moved from the Technical and Operation Directorates into the Planning, Management and Environment Directorate.

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 electricity, originally the energy from Angra1 (626 MW of net capacity) and since 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 113,23 R$/MWh as compared to 78,41 R$/MWh in 2003. This long-term contract is not subjected to the ongoing liberalization of the Brazilian electricity market. The tariff variation accounts for increase in nuclear fuel prices and actual increase in electricity prices with incorporation of new hydro and gas plants with higher generation costs to the Brazilian electricity market.*

Adequate funds for operation and maintenance of Angra 1 and Angra 2 plants continue to be made available, as it can be seen from the examples presented in Table 3, where a comparison of the detailed budgets for the years of 2003 and 2006 are presented.

Table 3. Comparison of ELETRONUCLEAR Budget for the years of 2003 and 2006. Values in million US$ (R $).

BUDGET	***YEAR***	
	2003	*2006*
Primary Costs		
Personnel (salaries + benefits)	*66 (198)*	*105 (213)*
Other costs (subcontractors, insurance, Office rent, equipment, consumables, etc.)	*79 (237)*	*143 (287)*
TOTAL	***145 (435)***	***249 (500)***
Investment		
Angra 1 (O&M, fuel and upgradings)	*21 (63)*	*105 (210)*
Angra 2 (O&M, fuel and upgradings)	*35 (105)*	*69,5 (139)*
Angra 3 (engineering)	*2 (6)*	*34,5 (9)*
Infrastructure	*2 (6)*	*4,5 (9)*
TOTAL	***60 (180)***	***213,5 (427)***

NOTE: *Ratio US$/R$: in 2003 = 1/3; in 2006 = 1/2.*

The apparently large increase of the 2006 budget relative to 2003, when using US$ values, is due to the strong depreciation of the US$ relative to the Brazilian Real (R$).

When comparing the 2003 and 2006 budgets in R$ (values in parenthesis) it can be seen that the Primary Costs have remained essentially the same after 3 years (the 14% increase is basically the inflation in the 3-year period). On the other hand the 2006 Investment value has more than doubled in comparison to 2003, the largest increase being for Angra 1 (basically new Steam Generator fabrication costs and plant upgrade program) and Angra 3 (site preparation work – see 2.1.3). Angra 2, being a new plant, remained at about the same upgrade investment level of 2003; the budget increase for 2006 is essentially due to fuel escalation costs.

The financial agreements for Angra 3 are still to be defined following the recent government approval for restart of construction.

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 plants (3.3%/year). The decommissioning costs are being re-evaluated; preliminary results confirm the former estimated values of 200 million dollars for Angra 1 and 240 million dollars for Angra 2.

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 2194 employees on its permanent staff and a few long-term contractors, which supply additional personnel.

Due to government policy the number of subcontracted persons is being drastically reduced and replaced by newly hired personnel. At present there are 53 subcontracted persons working for ELETRONUCLEAR, down from the 251 reported in the previous National Report.

Of the total of ELETRONUCLEAR employees 847 (39 %) have a university degree, 1030 (47%) are technicians and the remainder 317 (~14%) are administrative personnel. The personnel turn over of the company in the review period, resulted on the ingress of 339 new employees and 134 leaving the company, most of them to other companies related to the oil industry.

As it is happening worldwide in the nuclear industry, ELETRONUCLEAR work force is aging and close to retirement. Furthermore, a considerable number of experienced personnel was lost due to Government early retirement policies. New people have been hired but they need time and adequate training to acquire the required experience. To allow the company administration to develop strategic guidelines to, at least, minimize the consequences of this situation, a project for determination of the technical know-how of ELETRONUCLEAR was developed in the 2001-2005 period, as reported in the previous National report, consisting of three phases:

- *Survey for identification of the extent and location of the existing competences, with existing and future gaps in the essential competence being identified and evaluated; collect this data in a data bank; develop a software to select the required information from the data bank and issue it in form of reports;*
- *In-depth analysis of the results, with proposals for fill-in of the competence gaps in the short and long term;*
- *Establishment of measures to make knowledge management a permanent activity in the company; develop methods for eliciting tacit knowledge from retiring specialists.*

Furthermore it was reported that an additional software was developed based on the Competence Tree method, with the purpose of identifying, collecting, filing and retrieving the detailed individual competencies existing in the company. This method is complementary to the one previously described.

The above-referred Knowledge Management development has been accomplished and applied, with exception of the eliciting of tacit knowledge from retiring specialists. The results are available for routine use by the different technical organization units of the company.

Although this work was performed internally, contacts with persons and institutions knowledgeable in application of this field to the nuclear area were very important for the implementation of the project. In particular, cooperation with EPRI (Electric Power Research Institute) and the IAEA Division of Nuclear Power was very instrumental to the attainment of its objectives.

An important new activity in the context of Knowledge Management is the involvement of ELETRONUCLEAR in the development, conducted by the holding company Eletrobrás, of a Corporative University that will serve the several affiliated utilities.

4.2.2.1. Training of plant personnel

Activities related to qualification, training and retraining of plant personnel are performed by the Training and Simulator Department of ELETRONUCLEAR, which reports to the Site Superintendent (Plant Coordination Superintendent in Fig.4).

Three main facilities are available for training in the Plants personnel residential village, located at about 14 Km from the site: a general training center, a training simulator for Angra 2, and a maintenance training center. An Interactive Graphic Simulator (IGS), which models Angra1 plant, was incorporated to the Training Center in 2005. This simulator runs a complete plant model, identical to the one of a full scope simulator, and use "soft" panels for interaction operator-plant model. Training of instructors in the use of the equipment and developing of the lesson plans were done during 2005/2006, with actual use for operator initial training and retraining initiating in May 2007.

ELETRONUCLEAR has decided to install the IGS as a complementary operator training means to full scope simulator training, presently performed abroad, while an Angra 1 specific full scope simulator is not available on site.

As indicated above, Angra 1 has no plant full scope simulator on site. Operator classroom-training is done at ELETRONUCLEAR Training center and simulator training is performed abroad. Angra 1 operators have been trained in simulators of similar plants in the USA (Ginna Simulator), Spain (Tecnatom Simulator) and, more recently in Slovenia (Krsko Simulator). The installation of a full scope specific simulator for Angra 1 by 2004, as informed in the previous National Report[6], was delayed, by decision of ELETRONUCLEAR management board. The company decision was to condition acquisition of the simulator to the solution of the SG replacement issue (See section 5.3). Presently Angra 1 SG replacement process and the SG fabrication are under way, with the actual replacement planned to start in September 2008. The restart of the simulator acquisition process will be defined after clarification of availability of resources.

In the period under review 17 new operators have been trained and qualified for Angra 1.

An Angra 2 full scope simulator is available on site for operator training since *beginning of 1985. Due to the long delay in the Angra 2 construction schedule, a program for selling simulator training services was set up and pursued until start of training of the first group of Angra 2 operators, in 1995. In the meantime instructors from ELETRONUCLEAR have ministered classroom and practical training for operators, managers and licensing specialists from Germany, Spain, Argentina and Switzerland. The first group of Angra 2 control room operators was licensed in the beginning of 2000.*

In the period under review 18 new operators have been trained and qualified at the Angra 2 simulator.

Simulator training load is 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 license), a Shift Foreman (also a SRO), a Reactor Operator (who must hold a Reactor Operator – RO license) and a Balance of Plant Operator (also a holder of a RO license). Although not required by CNEN, all Angra 1 and 2 Shift Supervisors are graduated engineers with five years of academic education.

The requirements for organization and qualification of the entire Angra 1 and Angra 2 staff are established in Chapter 13 "Conduct of Operations" of the respective FSAR. Implementation and updating of these requirements are the subjects of CNEN audits of the licensee training and retraining program and the examination of new operators to comply with the regulations NE1.01 [10] and NE-1.06 [15]. According to the Brazilian Regulator guideline, besides the Control Room shift personnel, the Head of the Operation department must also hold an SRO license.

Aside from the requirements of the law, it has been a permanent policy of the Operation and Production Directorate to occupy important management positions at the plants with licensed or former licensed operators. In particular, the Plant Manager, the Deputy Plant Manager, the head of Operation Department and the heads of Technical Support and Maintenance for both Plants are currently licensed SRO. Furthermore, key engineers belonging to Technical support and Outage Planning are receiving SRO training and certification with the dual purpose of acquiring a better knowledge of the Operation processes and improving of interfaces between these areas and Operations.

Additionally, Radiation Protection Supervisors must also hold a special license issued by CNEN, according to regulation CNEN-NE-3.03[16].

Specialized training is also provided to the personnel working in the different plant disciplines. Maintenance technicians follow a qualification program 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 program 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. One such practice resulting from external review recommendation was the start in 2002 of a long term Systematic Approach to Training (SAT) program. *Due to the comprehensiveness and the necessary use of discipline-specific human resources this program ended up requiring a long time for implementation. To date the Chemistry Department for both plants has completed the process, the Maintenance Department of Angra 1 is well advanced, followed by the Maintenance and System Engineering departments of Angra 2. Operation and System Engineering of Angra 1 have just started, still remaining the Operation Department of Angra 2 to join, to complete the planned scope of implementation of the SAT for both Plants.*

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 program 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 [10] and their medical qualification[15]. CNEN conducts written and practical examinations (oral and at the simulator) for Reactor Operators and Senior Reactor Operators before issuing each individual authorization.

During the period 2003-2006, for Angra 1 power plant, 11 new senior reactor operator licenses (SRO) and 6 reactor operator (RO) licenses have been issued. For Angra 2, in the same period, 11 new senior reactor operator licenses (SRO) and 7 reactor operator (RO) licenses have been issued. With the biannual renewal of licenses, the total number of licensees at the end of 2006 was 79; In Angra 1, 32 SROs and 9 ROs; in Angra 2, 25 SROs and 13 ROs.

Certification of Radiation Protection Supervisors is done in accordance with regulation CNEN – NN 3.03 “Certification of the Radiation Protection Supervisor Qualification” [16]. With the beginning of Angra 2 commissioning tests, Radiation Protection Supervisors had to be trained for their qualification also in this unit. *In 2003-2006, 4 new Radiation Protection Supervisors were qualified for Angra 1 and Angra 2.*

4.2.3. Activities, achievements and concerns regarding the improvement of safety

As informed in the previous National Report, due to more flexible policies concerning staffing of Government owned companies in the late nineties, ELETRONUCLEAR has been able to hire new personnel to compose the Angra 2 staff and gradually replace losses of Angra 1 personnel resulting from transfers to

Angra 2 and by retirement The intensive training program put in place for preparation of new operators has allowed replacement of essentially all retired operators that were temporarily re-hired to complete the Angra 1 shifts vacant positions left from operators transferred to Angra 2. Presently Angra 1 and Angra 2 have already their shifts composed by ELETRONUCLEAR employees only. Furthermore, continuing to pursue the goal of having enough licensed operators to cover not only the shifts but also other important operation positions, some 10 engineers coming from system and support engineering, maintenance, core physics and training have also been licensed as SRO.

The Systematic Approach to Training (SAT) program, started in the previous review period and planned to cover all plants areas, resulted to be a lengthy process, being still under way, with some areas already applying the methodology and some still working on its development.

The main concern relative to maintaining an experienced work force continues to be the systematic loss of young well-trained personnel to the oil industry. The measures put in place by the company, involving an increased effort in identifying the know how losses and hiring and training the new personnel, have allowed the substitution of the personnel lost, but can not replace the experience lost. This has forced the company to intensify work supervision and practically stop the program of substitution of specialized subcontractors.

Regarding financial resources, the main concern refers to the lack of a formal legislation related to the provision of decommissioning funds, although ELETRONUCLEAR has voluntarily established such reserves based on international practices.

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 (SPDS) and a Critical Safety Function (CFS) monitoring program.

New process computer (more variables acquired) and improved SPDS have been installed in 2002.

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 program for team-work training and a Human Performance Enhancement System (HPES). Training related to Safety Culture aspects was also undertaken using IAEA guidelines.

Later, in 2004, a major overhaul of the Angra 1 control room was performed, improving ergonomics and implementing better physical separation of the work control area.

As partially reported in the previous National report, the historical development of HFE for the Angra 2 plant was as follows:

- CNEN required during the construction and licensing process, that an additional chapter (chapter 18) be included in the FSAR, addressing the Human Factor Engineering (HFE) aspects of plant design and operation. 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 areas of human factor review by an HFE management group in accordance with NUREG 711.

- ELETRONUCLEAR established a HFE Committee as part of the organizational structure, with the main responsibility to review the internal and external operational experience according to the areas of human factors defined in NUREG 711 and to evaluate any proposed man-machine interface modifications during the plant operational lifetime.

- ELETRONUCLEAR elaborated a Chapter 18, Human Factors Engineering (HFE), according to the philosophy recommended in NUREG-711 - Human Factors Engineering Program Review Model.

- Following review of the newly prepared Chapter 18, CNEN established a series of additional requirements as part of the process for concession of the Authorization for Permanent Operation (AOP). These requirements were fulfilled partly before the first criticality and partly to be fulfilled up to 4 years after initial operation, relative to management of the HFE program, operational experience review, analysis of functional requirements and function allocation, task analysis, qualification of personnel, human reliability (HR), man-machine interface, development of procedures, training programs and verification and validation of human factors.

- Part of these requirements has been later incorporated in a HFE verification program using the plant full scope simulator, agreed with CNEN. The results obtained by comparing the required and available times for manual operator action for a set of critical transients/accidents resulted in no operator overload, indicating the adequacy of the Angra 2 HFE design, including the main control room Man-Machine Interface (MMI). As the set of events analyzed were generic for the Angra 2 type of plants (1300 MWe PWR of Siemens-KWU design), some of analyses may have to be repeated depending on the results of the Angra 2 PSA. The presently remaining issues are the completion of the HRA being done together with the level 1+ Angra 2 PSA and clarification of same assumptions used in the evaluation of the Angra 2 MMI and operation procedures relative to the eventual occurrence of operator overloading.

Among the improvements of the man-machine interface that have been introduced relative to the original design, subsequently to commissioning, the most *important was the addition of a computerized system for extension of the scope of the plant Safety Parameter Display System and for monitoring of the Critical Safety Functions (CSF). This system is being further improved in the scope of the project for replacement of the plant process computers, which is in final phase of testing.*

Still in the context of the behavioural science, as mentioned in item 4.1.2, ELETRONUCLEAR has a Safety Culture Enhancement Program in place since 2001.

4.3.1. Activities, achievements and concerns regarding the improvement of safety

The activities in human factor and human factor engineering (HFE) for both plants have been reported above. In particular for Angra 2 it can be said that the scope of analytical work being performed in these areas is more detailed than usually seen in the nuclear industry. The results tend to confirm the robust HFE design of this plant.

CNEN is requiring the preparation of a chapter for HFE also for the Angra 1, of much older design, also based on NUREG 711, there are concerns regarding to how an old concept will match new guidelines.

4.4. Article 13. Quality Assurance (QA)

The requirements for quality assurance programs for any nuclear installation in Brazil are established in the respective licensing regulations. Specific requirements for the preparation and implementation of programs are fully described in the Standard CNEN-NN-1.16 "Quality Assurance for Safety in Nuclear Power Plants and Other Installations"[17], which follows the IAEA recommendations, with the addition of the concept of independent inspection and expertise.

ELETRONUCLEAR has established its quality assurance program for Angra 1 and Angra 2, in accordance with the above-mentioned requirements and with the Standard CNEN-NE-1.26 "Safety in The Operation of Nuclear Power Plants"[12]. The corresponding procedures have been developed and are in use. The program provides for the control of activities which influence the quality of items and services important to safety as: design, design modifications, procurement, fabrication, handling, shipping, storage, erection, installation, inspection, testing, commissioning, operation, maintenance, repair and training. The quality assurance program is described in Chapter 17 of the FSAR.

At present, the departments responsible for Quality Assurance belong to a Quality Superintendence, which reports to the Planning, Management and Environment Directorate. This Superintendence comprises two Quality Assurance Departments, one of them, the Institutional Unit is located in Rio de Janeiro, and the other, responsible for Quality Assurance in Operations, is located in the site, in Angra dos Reis.

The Quality Assurance Superintendence, according to its respective *attributions established in proper documents, are responsible for the verification of implementation of ELETRONUCLEAR Quality System, by means of internal and external audits, which are performed in accordance with written procedures. Audit reports are formally distributed to the organizations responsible for the areas object of the audits as well as to the Committee for Nuclear Operation Analysis (CAON).*

The QA system presently in use is planned to be extended also for activities non-safety related, e.g. for the commercial and human resources areas.

By recommendation of CNEN a large effort for development of a means to evaluate the efficacy of the present QA system as implemented is under way.

CAON is a collective body under coordination of the Operation and Commercialization Directorate, whose purpose is to examine, follow-up and analyze issues concerning Angra 1 and Angra 2 operational safety and to recommend measures to improve safety. Furthermore, each of the Plant Superintendences (SU.O for Unit 1 and SD.O for Unit 2) coordinates a Plant Operation Review Committee (CROU), whose responsibility is to review and analyze, on a closer basis, questions related to the operation of the Units 1 and 2.

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 2003-2006, CNEN conducted 29 inspections in Angra 1, 29 in Angra 2 and 27 related to the whole plant organization.

4.4.1. Activities, achievements and concerns regarding the improvement of safety

CNEN has monitored closely the quality assurance activities of Angra plant, trying to focus more on results than on the formalities. Special audits where carried out where quality aspects were discussed directly with the plant management, rather than with the QA group. These audits have identified some problems related to the lack of a grading system for the findings, both from CNEN inspections and ELETRONUCLEAR internal QA audits, a consequent lack of prioritization of their resolution, and a consequent long time for the closing of minor problems.

CNEN required ELETRONUCLEAR to establish and implement a System for Management of Corrective Actions as an additional license condition at the time of the renewal of the Authorization for Initial Operation (AOI). The follow up of related actions is now part of CNEN licensing and control activities.

4.5. Article 14. Assessment and verification of safety

A comprehensive safety assessment is a requirement established by the licensing regulation in Brazil[8].

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 Angra 1, after 10 years of commercial operation, a Periodical Safety Review (PSR) is due, according to CNEN regulations [12]. About two years of preparatory work were spent gathering and evaluating international experience on the subject before the final approach was selected.

The PSR was performed in-house based on the pertinent IAEA guidelines and international experience from similar plants in Spain and Slovenia, with initial guidance from an external experienced expert. About 30 man-year were spent in an 18- month period, from January 2004 to July 2005. Six main areas were evaluated:

- *State of the plant,*
- *Plant performance and operational experience,*
- *Behavior of systems, components and structures,*
- *Safety analysis,*
- *Radiation protection and waste management and*
- *Programs for safety improvement.*

These six main areas encompass all items of IAEA guide NS-G-2.10 and CNEN- NE 1.26, that is, plant design; systems, components and structures condition; equipment qualification; aging; safety analyses (deterministic and probabilistic); risk analysis (hazards); plant performance; operational experience (national and international); organization and administration; human factors; procedures; emergency preparedness; and radiological impact in the environment.

The main conclusion of the PSR was that "the Angra 1 plant has evolved in the last 10-year period by improving its processes and establishing new ones, when required by regulation or as result of evaluation of the national and international operating experience. From all the scope evaluated no deficiencies that could impede the continued safe operation of the plant were identified. Strong points and opportunities for improvement have been identified; for the latter action plans are to be established and their implementation remains a commitment of the Angra 1 plant for the next operation period."

The main strong points identified were:

- *Well established Configuration Control;*
- *Routine use of indicators for performance, safety and system condition; routine use of information from operational experience;*
- *In-service and periodical test programs well established and controlled;*
- *SG preservation program using state of the art techniques;*
- *Consistent Company safety policy adopted for more than 10 years;*
- *Well structured training organization and programs;*
- *Systematic process of internal and external reviews;*

- *Well developed Operation procedures;*
- *Well established Emergency Preparedness plan.*

The main opportunities for improvement identified were:

- *Comprehensive review of the FSAR;*
- *Complete the compilation of the plant design bases;*
- *Prioritize conduction of equipment Environmental Qualification program;*
- *Prioritize completion of development of Ageing Management program;*
- *Perform study on occurrence of tornados;*
- *Review internal flooding study;*
- *Perform a new Fire Hazard analysis; complete implementation of planned measures;*
- *Expand the scope of the probabilistic safety analyses;*
- *Establish a program for evaluation of isotopic content of the existing waste drums with view for final disposal;*
- *Implement and enforce fitness for duty guidelines.*

Action plans were already prepared for all the identified opportunities for improvement. The plans were submitted to CNEN. Work in most of the plans is in progress.

CNEN has already reviewed the PSR and identified to ELETRONUCLEAR the points where further details were necessary. A new version of the RPS document has been resubmitted to CNEN and is currently under review.

ELETRONUCLEAR is also planning to submit to CNEN approval the documentation relative to the placement of the Angra1 steam generators, the use of a new fuel design (Westinghouse 16x16 Next generation Fuel – 16NGF) and a power increase. All this major design changes will require a new safety analysis report.

For the Angra 2 plant, the licensing process was started in accordance to the German licensing procedure. Such process foresaw a series of partial approvals. For each step, a large amount of the actual design and licensing data is 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 US NRC 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 US NRC Regulatory 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 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.

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 mentioned conservative approach is the Angra 2 large break LOCA Analysis. Based 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 has been evaluated by CNEN with the assistance of two international consultants, the German institute GRS (Gesellschaft fur Anlagen und Reaktorsicherheit) and the University of Pisa. As a result, a preliminary safety evaluation report (SER) requested additional information, with a total of 27 questions to the applicant, each one classified according to their significance to safety. After the issuance of the preliminary SER, the importance of an independent regulatory calculation was recognized. Together with CNEN staff, the University of Pisa performed independent calculation. Based on its conclusions, three requests for additional information were issued to the applicant, mainly related to plant modelling, which has to be consistent with those used for validation calculations. Conclusions provided support to the acceptability of the actual safety margins of the Angra 2.

As future applications, CNEN has already been informed by ELETRONUCLEAR of its intention to increase the Angra 2 power (6%) together with a fuel design change for a high thermal performance fuel with M5 cladding. Re-analysis of the LB-LOCA with uncertainty quantification is foreseen.

Furthermore, for Angra 1 NPP steam generators replacement, the utility will submit a realistic evaluation model for the LB-LOCA, using the Westinghouse methodology that encompasses the WCOBRA/TRAC code with the ASTRUM methodology for uncertainty calculation. Additionally, an analysis supporting a power uprate of 5% will be submitted for a new fuel design, 16x16 Next Generation Fuel (16NGF), jointly development by Westinghouse, Korea Nuclear Fuel-KNFC and Indústrias Nucleares do Brasil (INB).

Although a full Probabilistic Safety Assessment (PSA) was not a formal licensing requirement at the time, a preliminary level 1 study was performed in 1983/85 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”. *This study was partially evaluated by CNEN, with the assistance of IPEN staff, and several new requirements were sent to ELETRONUCLEAR in the period 2003-2006.*

Several important findings, leading to upgrading of plant hardware and operational procedures, arose from this second PSA study.

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 10^{-5} per reactor.year.

This PSA is being continuously updated with new plant data and revised to incorporate advances in modeling. As an example of such revisions the incorporation of a state of the art model for analysis of the behavior of the pump seals in case of total loss of cooling led to an increase of the integral CDF from 3.5E-5/year to 4.7E-5/year and to an increase of the contribution of the initiating events “Loss of external power” and “station blackout” to the integral CDF.

As a further application, the Angra 1 level 1 PSA was 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.

As informed in the previous National report a programming of the planned PSA studies for both plants was done based on realistic evaluation of the timing and available resources. The scope, for both plants, includes PSA level 1+, including fire and internal flooding, shutdown and low power states and later a level 2 PSA.

The planning for completion of the whole program stretches to 2015. The main PSA development activities for the Angra 1 plant performed in the last review period were:

- *extension of the existing level 1 study to level 1+;*
- *work on model improvement for the above PSA study, including seal LOCA, review of reliability of HP safety injection valves, evaluation of reliability of the control room air conditioning;*
- *start of Fire PSA, being done jointly with EPRI, using the new methodology of EPRI TR-1011989(NUREG/CR-6850), EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities”,Sept. 2005.*

All the above work is following closely the program schedule.

A preliminary evaluation of the Angra 2 core melt frequency, as well as the probabilistic analysis support for development of Accident Management countermeasures and other evaluations requiring probabilistic insight have been done taking the German Risk Study (DRS) as well as PSA results of German sister plants, as a basis, and adapting their models for the main design differences between these plants and Angra 2. The validity of this approach is based on the similarity of the plant designs all belonging to the standard 1300 MWe German PWR design, as indicated in section 2.1.2.1.

The estimated Angra 2 core damage frequency (CDF) for internal events, obtained from this approach is on the range of 10^{-6} /reactor.year, compatible with the CDFs for 6 German sister plants, all in the 1 to 3 x 10^{-6} /reactor.year range.

A contract for performance of a complete level 1+ PSA for Angra 2 was signed with an experienced external contractor in the end of 2004. The work is mostly done and the study is expected to be completed until end of 2007.

The next PSA activity planned for Angra 2 is the performance of a Level 2 study to be started in mid 2008.

Also during 2006 the development of the Maintenance Rule for the Angra 2 plant was started led by the Maintenance department of the plant.

4.5.1. Activities, achievements and concerns regarding the improvement of safety

As reported above considerable amount of PSA development has been done in the period of the review as well as routine use of the available Angra 1 PSA. A large number of questions from CNEN have been answered. The concern is the difficulty to conduct the planned program and at the same time answer all the Regulator questioning arising from the work being performed.

Also, the Angra 1 PSA has not been formally approved by CNEN. This has limited its use for solution of some licensing issues, such as modifications of Technical Specification for Operation.

However, the daily use of Angra 1 PSA in several operational decisions has increased in recent years, what can be considered a good improvement. The use of PSA for on-line maintenance planning was considered a good practice in the Angra 1 OSART mission.

4.6. Article 15. Radiation protection

Radiation protection requirements and dose limits are established in Brazil in the regulation for radiation protection [18]. These requirements establish 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 Program 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 Program 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 as low as reasonably achievable (ALARA), taking into account technical and economical considerations.

The present annual dose limits to workers are 20 mSv for Effective Dose averaged over 5 consecutive years and a maximum of 50 mSv in any single year, an equivalent dose to the lens of the eye of 150 mSv in a year; and an equivalent dose to the extremities (hands and feet) or the skin of 500 mSv in a year.

These limits are established in the new Brazilian regulation CNEN–NN–3.01– Radiological Protection Basic Directives, based on the Safety Series n. 115– International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, jointly sponsored by FAO, IAEA, ILO, OECD/NEA, PAHO and WHO, and shall be fully implemented at ELETRONUCLEAR until January, 2008. Meanwhile, ELETRONUCLEAR has developed and is pursuing an action plan to make all the needed documentation changes and to fulfil the associated training requirements in order to meet the above referred deadline for transition from the former regulation to the new one.

The actual personnel radiation doses at Angra Nuclear Power Plants continue to be much lower than the established limits. The dose distribution for workers at the Angra site demonstrates an adequate radiological protection program, 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 in a single year). The annual collective dose for the last 3 years has usually been lower than 1.30 person.Sv and 0.20 person.Sv, respectively during a year with and without outage. Following strong efforts to reduce the collective dose by improving the ALARA planning of the activities, including source term reduction, additional shielding, and better use of human performance tools the collective dose for Angra 1 is being further reduced, in spite of the need of more and more SG inspection time at the outages; in 2006, the Angra 1 collective dose was 0.903 person.Sv. For Angra 2, the collective dose was 0.180 person.Sv, showing a performance compared to the top ten plants in her category in terms of radiation exposure. The actual dose distribution for the year 2006 is shown in Table 4.

Table 4. Distribution of Effective Equivalent Doses in 2006

Dose range (mSv)	*Number of workers*	
	Angra 1	*Angra 2*
> 0.00 < 0.20	*897*	*1253*
> 0.20 < 1.00	*382*	*213*
> 1.00 < 2.50	*192*	*31*
> 2.50 < 5.00	*84*	*0*
> 5.00 < 7.50	*14*	*0*
> 7.50 < 10.00	*3*	*0*
> 10.00 < 20.00	*0*	*0*
Total workers:	*1572*	*1497*
Average Dose (mSv):	*0.60*	*0.11*

Release of radioactive material to the environment is controlled by administrative procedures and kept below CNEN established limits. 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 Calculation Manual (ODCM), approved by CNEN. In this manual, the dose for the hypothetical critical individual is calculated.

According to the CNEN regulation[11], 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 2004-2006, this dose reached the average value of 4.5E-03 mSv/y, which is much lower* *than the 1 mSv/y value and the dose constraint value of 0.30 mSv/y, established in regulation CNEN-NN-3.01 [18].*

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 Program that describes procedures, methodologies, processes, tools and steps to be used in planning the work. The ALARA Program is continuously being revised and represents the best effort to minimize occupational doses.

A Radiological Environmental Monitoring Program, based on CNEN requirements, is conducted by ELETRONUCLEAR to evaluate possible impacts caused by plant operation. This program defines the frequency, places, types of samples (sea, river, underground and rain water, fish, beach sand, marine and river sediments, algae, milk, grass, airborne, banana and soil) and types of analyses (gamma spectrometry, beta counting and tritium) 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 program are compared with the pre-operational measurements taken, in order to evaluate any possible environmental impact. Annual reports are presented to CNEN. To date essentially no impact has been detected. Typical results are presented in Table 5.

Table 5 – Environmental Monitoring Program Results for 2004-2006

	Year		
	2004	*2005*	*2006*
	Measured values in mSv/30 days (E-2)		
I – Impact Area	*6.86*	*7.92*	*7.35*
C – Control Area	*5.73*	*6.98*	*6.26*

Impact Area: 37 measuring points within 10 km radius from the plant.
Control Area: 4 measuring points beyond 10km radius from the plant.

The average values for the Impact and Control areas measurements are statistically equivalent, indicating the absence of radiological impact from the power plants. Furthermore the initial operation of Angra 2, beginning in January, 2001, brought no increase whatsoever to the monitored local radiation values, when comparing the measured values reported for the last three National Reports covering the period of 1998 to 2006.

4.6.1. Activities, achievements and concerns regarding the improvement of safety

CNEN revised the previous Regulation NE 3.01 Basic Radiological Protection Directives to adequate it to the new recommendations of the IAEA Basic Safety Standards for Radiation Protection (Safety Series N.115 of 1996).

Provisions are in place to have all installations fully adherent to the new regulations, and January 2008 is the deadline established by CNEN by when the licensees shall be in conformity with the regulations requirements.

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 4 smaller zones with borders at approximately 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 (EPZ-1,5 up to ~1,5 km from the power plants). For these areas, the planning as well as all actions and protection countermeasures for control and mitigation of the consequences of a nuclear accident are under 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 is in place. Measurements of meteorological variables are installed and distributed at three levels in a 100 meters height tower (tower A). Wind speed and direction, temperature (DT) and humidity are measured at 10, 60 and 100 meters in this tower. Additionally, three 15 meters satellite towers (towers B, C and D), installed in the vicinity of the site, measure the wind data. Precipitation is also measured near tower A. All these data are send 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 performed.

The On-site Emergency Plan involves several levels of activation, from Facility Emergency, Alert as Facility, Site 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 Manager, ensures the prompt actuation of the Emergency Groups. Training and exercises (5 per plant) are performed yearly.

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 ELETRONUCLEAR through periodic campaigns, distribution of printed information, the local press and permanent information available in the Site Information Center.

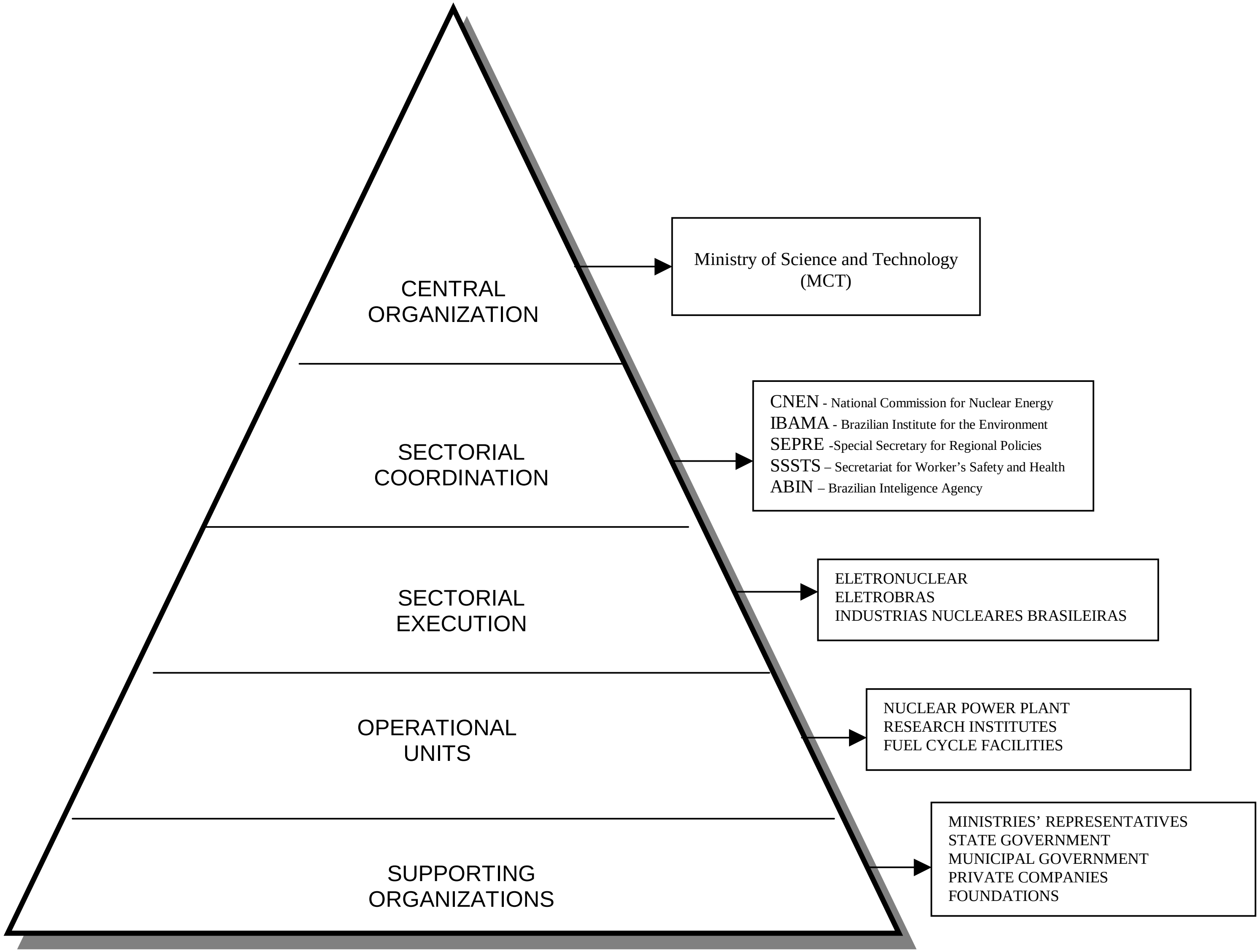
4.7.2. Off Site Emergency Preparedness

Brazil has established an extensive structure for emergency preparedness under the so-called System for Protection of the Brazilian Nuclear Program (SIPRON). This structure includes organizations at the federal, state and municipal levels 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 (See Fig. 5 and section 3.1.3).

Within SIPRON, the Central Organization issued a set of General Norms for Emergency Response Preparedness [19], consolidating all requirements of related national laws and regulations. These norms establish the planning, the responsibilities of each of the involved organizations and the procedures for the emergency management centers, communications, intelligence and information to the public (SIPRON General Norms are listed in item A.2.5 of Annex 2).

The approach to emergency preparedness is based on the application of local resources in 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.

Fig. 5. SIPRON STRUCTURE



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 site emergency, to a general emergency. Dedicated facilities at the plant site have been designated and the equipment for emergency response has been greatly upgraded.

At the off-site level, a National Center for Management of Nuclear Emergency (CNAGEN) has been created in Brasilia in the MCT. A State Center for Management of Nuclear Emergency (CESTGEN) has been established in Rio de Janeiro. A Center for Coordination and Control of Nuclear Emergency (CCCEN) and a Nuclear Emergency Information Center (CIEN) have been established in the city of Angra dos Reis. This centers' activities during an emergency have been established in SIPRON General Norms [19],[20] (See also A.2.5 of Annex 2) and in the revised Rio de Janeiro State Plan for External Emergency, approved by the state governor by Decree 26586 of 21 June 2000. A revision of the State Plan was carried out in 2006/2007.

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. CNEN Plan for Emergency Situation in Nuclear Power Reactors is currently being revised.

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, two partial exercises were performed in 2004 and 2006, and full-scale exercise was conducted in 2005 and another is scheduled for October 2007. During the full-scale exercises the activation of several shelters and the simulated evacuation of part of the population in the Emergency Planning Zone (EPZ) are tested. All exercises are prepared, conducted and evaluated under the coordination of the MCT.

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 campaigns combine information on both on-site and off-site emergency plans, including the population living in the 15-km area around the plant. These campaigns include 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.

At present, the siren system is tested every month, at 10:00 AM, every tenth day. The information about these tests was included in a calendar that is distributed to the whole population within the EPZ-5. The calendars also present the basic information on the emergency planning to the population. Also, 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.*

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.

4.7.3. Activities, achievements and concerns regarding the improvement of safety

With respect to emergency planning, a task force has been formed to introduce a quality assurance program for organizations involved in SIPRON, to the extent possible. *As a result, a manual containing quality assurance guidelines for emergency response planning has been issued and implemented in 2003.*

In order to comply with the Angra 2 TAC requirements relative to emergency planning (see section 3.1.2.1) ELETRONUCLEAR awarded a contract to the Federal University of Rio de Janeiro to develop a comprehensive study on evacuation and sheltering possibilities. This study addressed, through computer simulation, movement of people and vehicles in different evacuation scenarios. In addition, availability of sufficient transportation, training of drivers and suitability of sheltering installations were also evaluated. This study was completed in August 2002. The resulting recommendations were incorporated into an action plan, which is under implementation. For this purpose, 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 provided by ELETRONUCLEAR. The works, already finished, comprised 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 has installed an On-Line Radiation Monitoring System in the emergency planning zone (EPZ). The system is composed of 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.

A training course on emergency preparedness and response was created in 2000 and is carried out every year since then, 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*. In May 2004, a new two-week course was conducted.*

Chapter 5 - SAFETY OF INSTALLATIONS

5.1. Article 17. Siting

The Brazilian siting regulation, CNEN 09/69[9], 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 were further evaluated during the PSAR preparation and review, and have been 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.

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. In addition of the 1996 data, collected by ELETRONUCLEAR, new data on population density in the vicinity of the Site is available from the 2002 national census.

In the context of the Angra 1 PSR the external events assumed for the design of the plant structures have been evaluated. The original assumptions concerning seismic spectra, maximum floods and storms as well as off site explosions, were found to be still valid. A study on the frequency of tornados that could hit the site (not considered in the original design basis) demonstrated that the probability of occurrence of such event is negligible.

A recent comprehensive review of site conditions was carried out in preparation for the restart of Angra 3 construction.

5.1.1. Activities, achievements and concerns regarding the improvement of safety

Monitoring of Angra site, especially with the aim of improving emergency preparedness, is a continuous activity at ELETRONUCLEAR. As already reported, a wide range of activities have been and continue to be performed with this goal including improvements of road conditions, follow up of the demographics within the Emergency Planning Zones, provision of vehicles and infrastructure to the organizations involved in the External Emergency Planning, performance of studies for evacuation, refitting of public buildings in the neighboring communities to serve shelters and others.

A concern still exists regarding population growth around the site, what is somehow out of the control of ELETROUNUCLEAR. The creation and expansion of ecological protection areas in the Angra region, as part of the Basic Environmental Project (Projeto Básico Ambiental – PBA), has been used to prevent future problems.

A reevaluation of the site parameters as well as of the external events considered in the design of the existing plants, performed in the context of the Angra 1 PSR and preparation for restart of Angra 3, has confirmed the validity of the original assumptions.

5.2. Article 18. Design and construction

The design of the Brazilian nuclear power plants is based on established nuclear technology in countries with more advanced programs. The licensing regulation CNEN-NE-1.04[8] 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.

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 was performed through preparation of a PSAR and a FSAR, by FURNAS and its contractors, which were evaluated by CNEN during the licensing process.

Construction adopted a quality assurance program, which encompassed all activities related to safety conducted by FURNAS and its contractors and subcontractors. CNEN monitored the implementation of the quality assurance program through the regulatory inspection program 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 German counterpart assumed technical responsibility for the jointly built plant during construction up to initial operation.

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 program. 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.

After completion and initial operation of Angra 2 no other NPP design and *construction work has been done in Brazil except design modifications for the Angra 1 and 2 plants and some work of continuation of adaptation and upgrading of the Angra 2 design documentation to Angra 3 conditions. This part of the Angra 3 design and engineering work is assigned to ELETRONUCLEAR design and engineering Superintendence (see Fig. 4) under the Technical Directorate. With the recent approval of restart of construction for the Angra 3, this unit will have to be restructured and enlarged to be able to perform its scope of activities. One of the main results of the Knowledge Management program referred in section 4.2.2 was identification of the know-how gaps and number of personnel needed to carry out such a project.*

5.2.1. Activities, achievements and concerns regarding the improvement of safety

The concern relative to how much design capability remained within ELETRONUCLEAR following conclusion of the Angra 2 was addressed by the company Knowledge Management program referred in section 4.2.2. This program identified the several competency gaps resulting from lost personnel (retirement, change of company) as well as a large number of disciplines with know-how in danger (availability of only one specialist). It also identified the need to hire a substantial amount of new personnel to be trained on-the job by the experienced personnel still available.

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 (AOI) 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 (AUMAN), and a physical protection program 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 Authorization for Permanent Operation (AOP), 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 [12]. As indicated in section 3.1.2.1, legal disputes related to the environmental licensing are under way.

Because of that, the Public Ministry (PM) has ordered CNEN not to issue a formal AOP to Angra 2. Therefore, the existing AOI has been periodically renewed.

Operation is monitored by CNEN through an established system of periodical reports [11], 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 2003-2006, CNEN conducted 29 inspections in Angra 1 power plant, including the following areas: Conduct of Operations, Chemistry, Radiation Protection, In service Inspection, Physical Protection, Implementation of the Local Emergency Plan, Unusual Events Investigation, Event Analysis, Monitoring of the Radioactive Effluents Release, Waste Treatment System, Fire Protection and Operators Training.

During the period 2003-2006, CNEN conducted 29 audits and inspections activities in Angra 2, concentrated in the following areas: Radiation Protection, Physical Protection, Quality Assurance, Event Analysis, Monitoring of the Radioactive Effluents Release, Solid Waste Treatment System, Fuel Loading Cycles and Operators Training.

Additional inspection covered areas of the organization common to both units, such as Meteorology Systems, Emergency Planning, Physical Protection, Waste storage and Training.

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 and translated into Portuguese. As part of the Angra 1 improvement program, ELETRONUCLEAR has submitted this improved Portuguese version of the Technical Specifications to CNEN, which has evaluated and specified to ELETRONUCLEAR the modifications necessary for its formal approval.

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. Being a new document, the Angra 2 Technical Specifications are being verified in practice and several revisions have been implemented to date as the result of feedback from operation. *In the meantime the*

Specifications have been translated into Portuguese and this translation has been validated. The Portuguese version has been reviewed by CNEN and some modifications were required. ELETRONUCLEAR is at the moment performing the necessary modifications.

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. An 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 [12]. 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 Program. 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 - Organisation 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 Program.

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 organisation 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 that 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.

5.3.3.1. Angra 1 operation

As indicated in section 2.1.1.1 several programs for improvement of safety and reliability are being conducted for the Angra 1 plant. Most of these programs were already in place in the previous review period. The results of the Angra 1 PSR confirmed this program scope, emphasized the need of accelerating some of them and indicated the need of including a comprehensive verification of secondary side steam carrying piping thickness as an outage routine activity.

As in the previous review period, the main concern relates to the preservation of the 2 Steam Generators (SG) until their replacement, scheduled for end of 2008 and at the same time ensuring no degradation of the Angra 1 plant operational safety.

For this purpose, comprehensive tube testing and repair activities are performed at every outage, following international and local experience. Eddy current testing of 100% of the tubes, tube testing by SG secondary side pressurization and tube “in situ” pressure testing are routinely performed at every outage. Depending on *the remaining wall thickness the tubes can be repaired by reinforcement with short and long sleeves or plugged. The length of the next cycle is determined by the condition of the SG tubes at the end of a given cycle, as the allowable safe cycle length obtained from the evaluation of the test results at each outage. It is clear that such constraints influence negatively plant performance and cycle economics. In the mid 2006 outage 267 tubes have been fitted with sleeves and 84 tubes have been plugged. To date an average of 16,8% of the total number of tubes has been plugged. In accordance with the plugging trend, the 20% limit above which the plant cannot be operated at full power anymore will not be reached until SG replacement.*

An additional important negative contributor to the Angra 1 plant performance indicator in this review period was a sudden increase of vibration of the electric generator following a loss of the external grid. The excessive vibration led to initiation of cracks in the generator lead box with leakage of hydrogen. The elimination of this problem, after a few forced manual shutdowns, required a refitting of the generator anchoring and foundation as well as reinforcement of the lead box.

5.3.3.2. Angra 2 operation

In relation to Angra 2, the main concern during the review period was malfunction of major electrical and secondary side components, significantly affecting plant performance. The main downtime contributor was a small water leak in the electric generator rotor, which required long investigation time for its detection and subsequent replacement of the rotor. The root cause of the leak appears to have been material defect.

The plant main transformer was also a source of problems apparently due to a generic problem of presence of active Sulfur in some manufacturers transformer cooling oils, one of them used in the main transformer. This led to the burning of one phase and need for substitution or “passivation” of the oil for all phases. Problems arose also with the type of high voltage bushings being used, which, according to the manufacturer, were not reliable. The bushings have been replaced and an on-line multi-parameter transformer monitoring system has been installed to follow up transformer conditions.

Another source of problems was the set of motors of the main circulating water pumps and condenser leakage. The solution for the pumps motors was to modify or to replace them.

The main condenser, after about three years of operation started to present tube leakages, in spite of having being re-tubed with Titanium tubes before installation. The investigation of the cause of the damage to the tubes led to a condenser design problem by which the water droplets being carried in the steam flow reached velocities high enough to damage the external tube rows most exposed to the steam flow. The preliminary solution was to plug all the affected tube rows until a protection for these tubes can be installed.

As reported for the previous review period, an expanded set of plant safety *and performance indicators, as well as a color coded indicator system for follow up of system performance were implemented for both plants. These indicators are followed up routinely by the plants; once a month they are analyzed at the plants follow up meeting, coordinated by the Operations Director; and every quarter they are analyzed at the Plants Safety Committee, CAON.*

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 was concluded by the middle of 2002. This methodology allows optimisation of the plant maintenance programme by focusing maintenance work on the items important to safety and availability.

In 2006, the development of an equivalent Maintenance Efficiency Program has been started for the Angra 2 plant. The main incentive for this work is the possibility of reducing the extensive preventive maintenance program adopted in the German plants by focusing the maintenance effort on equipment and components important to safety and reliability.

At Angra 1, the maintenance risk is evaluated "on line," and controlled through a procedure called "6-week maintenance program". In this procedure maintenance activities are always planned 6 weeks ahead. The equipment unavailability associated to the planned activities are input to the Angra 1 Level 1 PSA model and the resulting risk for the different plant configurations is evaluated. For any configuration that exceeds specified risk limits the corresponding maintenance work has to be re-planned.

Operational safety is monitored by CNEN through the regulatory inspection program 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 reviews are conducted voluntarily by the operator, through the invitation of international review missions from INPO, WANO and the IAEA (see item 5.3.7, Table 6 for a list of international technical review missions conducted at Angra plant in 2003-2006).

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 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 are based 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 cannot 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.

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.

Integrated Computerized Systems, added to Angra 1 and Angra 2 after initial design, as a result o HFE evaluations (see section 4.3), 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 Computerised 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 Computerised 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.

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 [11]. Different types of reports are identified, such as periodical reports and reports of abnormal events. Immediate notification is required for events that 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. *No event of INES level 1 has been reported in 2004/2006. Angra 1 reported to CNEN 5 events of INES level 0 in 2004, 15 in 2005 and 5 in 2006. Angra 2 has reported 6 events of INES level 0 during 2004, 11 in 2005 and 10 in 2006*.

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.

At the utility the internal operational experience is collected and processed by specific groups inside the plants. External experience is handled by an Operational Experience Analysis group, belonging to the Plants Support Engineering. This group investigates relevant incidents occurred in the Angra Plants and in similar nuclear installations in order to make recommendations. A program to collect operating experience has been established using several sources of information, such as INPO, WANO and EPRI.

Especially for Angra 2, an agreement has been signed with VGB, the association of large electricity producers in Germany. Through this agreement ELETRONUCLEAR has access to relevant events already processed by a working group. This access can be through normal mail or by on line access to the complete VGB data bank.

To avoid the risk of insularity, due to the geographical location of the Brazilian plants, far away from the main nuclear centers, ELETRONUCLEAR has had from the beginning a policy of strong involvement with the nuclear industry.

Technical exchange visits, technical review missions, observer or expert missions, from other nuclear power plants or organizations to Angra and from Angra personnel to other nuclear power plants, when conducted periodically, provide a valuable source of information on other plant experiences. In 2004 the internal and external Angra plants assessment program, which had in the past been conducted in a non-systematic basis, was formalized with the establishing of the policy of a complete internal and external evaluation at 3-year cycles, alternating IAEA OSART and WANO Peer Reviews. Table 6 provides a list of such international review and technical support missions to Angra for the review period. For illustration Table 7 presents a list of international technical missions with participation of Angra personnel to other plants during the year of 2006.

***Table 6 . International Technical Missions to Angra Nuclear Power Plant in 2004/2006*.**

N.	Year	Mission	Subject
1	2004	IAEA	Angra 2 - OSART Follow up mission
2	2004	WANO	Angra 2 – Technical Assist Visit for Reactor Physics and Fuel
3	2005	IAEA	Angra 1 - OSART Follow up mission
4	2005	WANO	Angra 2 – Technical Assist Visit for Configuration Control
5	2006	WANO	Corporate Peer Review
6	2006	WANO	Angra 1- Technical Assistance visit for evaluation of SG replacement preparation status
7	2006	IAEA	Angra 1 – Pre – PROSPER mission
8	2006	WANO	Angra 2 – Peer Review mission

Table 7. Technical Missions of ELETRONUCLEAR *Personnel to other plants in 2006*

PERIOD	COUNTRY OF MISSION	PURPOSE
30.01 A 30.04.06	GERMANY	FRAMATOME ANP-Technical Information Contract – Development of Simulator procedures for the EPR
03.06 A 17.06.06	USA	INPO-Shift Manager Seminar
15.07 A 06.08.06	USA	Westinghouse Nuclear Engineering Course
07.08 A 17.0I8.06	USA	INPO-Shift Manager Seminar
19.08 A 27.08.06	USA	EPRI-Nuclear Advances Meeting
08.09 A 01.10.06	UK	WANO Peer Review – Fire Protection

22.09 A 15.10.06	*FRANCE*	*WANO Peer Review - Maintenance*
22.09 A 27.10.06	*UCRAINE*	*WANO Peer Review – Organization & Management*
02.10 A 19.10.06	*FRAN/RUS/FINL*	*WANO Governors Board Meeting/ Secondary Circuit of VVERs*
03.10 A 21.10.06	*USA*	*Follow up Steam Generator Replacement*
07.10 A 21.10.06	*USA*	*INPO- Maintenance Seminar*
07.10 A 21.10.06	*AUSTRIA*	*IAEA - Technical Meeting-PRIS*
20.10 A 29.10.06	*SOUTH KOREA*	*Water Chemistry Conference*
31.10 A 16,12.06 *31.10 A 16,12.06*	*ARGENTINA* *ARGENTINA*	*Outage Support Radiation Protection - Embalse NPP* *Outage Support Radiation Protection - Embalse NPP*
31.10 A 16,12.06	*ARGENTINA*	*Outage Support Industrial Safety - Embalse NPP*
03.11 A 26.11.06	*FRANCE*	*WANO Peer Review - Operations*
03.11 A 26.11.06	*UK*	*WANO Peer Review – Support engineering*
04.11 A 18.11.06	*GERMANY / FRANCE*	*Plant Managers meeting*
24.11 A 17.12.06	*FRANCE*	*WANO Peer Review - Operations*

CNEN has its own system for operational experience feedback, analyzing Angra 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 17 events to IRS, including one event for each year of 2004, 2005 and 2006. 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 1 m^3 liners. Compressed solid wastes may be conditioned in 200 liter drums and not compressed wastes 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.

An overall long-term program for reduction of production of new waste and reduction of existing waste in Angra 1 is under way.

The main activities implemented in the period comprise:

- *Upgrade of the evaporator package for Angra 1.*
- *Supercompaction.*
- *Decontamination of the metallic materials from Angra 1 in the decontamination system of Angra 2.*
- *Regeneration of the contaminated resins from Angra1 in Angra 2.*

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 immobilized in bitumen by means of an extruder-evaporator and the dry concentrate is conditioned in 200 liter drums. Spent resins and filter elements are also immobilized in bitumen and conditioned in 200 liter drums. Compactable solid wastes are conditioned in 200 liter 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 150 m 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 initial 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.

According to the Brazilian legislation [24] CNEN is responsible for the final disposal of all radioactive waste generated in the country.

Since no final radioactive wastes repository is available to date, the generated low and intermediate level wastes of Angra 1 are being stored in an interim waste storage facility located at the Angra site, while the Angra 2 waste drums are being stored in their specific storage area in the Reactor Auxiliary Building, within the plant.

At the moment, the Angra 1 Initial Waste Storage facility is composed of two units in operation, Unit 1 for drums and Unit 2a for liners and boxes, and two units under construction, namely, an expansion of Unit 2, Unit 2b, for drums and liners is essentially ready and a new unit, Unit 3, in final stage of construction.

As reported in the Third National Report, the continued operation of the Angra 1 Plant could become at risk because of lack of waste storage space, since the available storage facilities were becoming full and the work for Units 2b and 3 was halted because of environmental licensing issues.

To gain enough storage place to allow plant operation until availability of the above referred new storage units, an extensive drum super-compacting campaign was planned and executed in April and May of 2006, where 2027 compacted waste drums (200 liter drums) from Angra 1 have been super-compacted by an external contractor, at the plant site. The drum volume reduction resulting from this action, allowed extension of the operation of Unit 1 of the Angra 1 Initial Storage facility by additional five years.

During this review period the situation of the environmental licensing of the new waste storage units has improved. Unit 3, which already had its Environmental Impact Report (EIA) submitted to the Environmental Regulator, IBAMA, received the corresponding Installation License, and is presently under construction with May 2008, as expected date for initiation of operation.

For the expansion of Unit 2 (Unit 2b) ELETRONUCLEAR submitted a new EIA, which has recently been approved and the respective Installation License should be issued by July 2007. It is estimated that the construction work for this unit can be finalized until October 2007. Both units will still need an Operation License from IBAMA before being put into operation.

In addition, an agreement was signed in 2002 through which CNEN transferred to ELETRONUCLEAR the task of designing and building a Final Repository for low and intermediate level waste. Operation of this final repository, originally planned for 2009, has been postponed to 2012.

With respect to spent fuel storage, the Angra 1 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.

5.3.9. Activities, achievements and concerns regarding the improvement of safety

Activities by CNEN and ELETRONUCLER related to plant operations can be considered as always having a component of safety, and looking for continuous improvement.

As indicated in sections 2.1.1 and 2.1.2 both Plants had an average performance in the review period, the average WANO availability factors being about 82% for Angra 1 and 76% for Angra 2, basically due to restrictions imposed by operation with steam generators at end of life for Angra 1 and an unexpected number of problems with major electrical and secondary side equipment for Angra 2.

On the other hand expectations for near future are good: replacement of Angra 1 steam generators next year should result in substantial performance improvement for this plant; in the case of Angra 2 the plant effort to identify the equipment malfunction root causes and the countermeasures being taken have already succeeded in reversing the downward availability trend as demonstrated by an availability factor of almost 90% in 2006.

The critical situation of storage capacity for Angra 1 waste reported in the previous National Report has improved substantially, in near term by the performed super-compaction of existing waste drums and for the medium and long term by completion of construction of additional waste storage units.

The work on the development of a new Maintenance Program, based on the US NRC "Maintenance Rule" for the German-design Angra 2 plant, as already implemented for the Angra 1 plant, can be indicated as an important activity in this review period.

The safety record for both plants has remained good with almost faultless safety system performance as demonstrated by the plants safety indicators and by the low number and low safety importance of the reported safety related events. This has been also confirmed by the outcomes of the recent Angra 2 WANO peer review and by the Angra 1 and Angra 2 IAEA OSART follow up reviews.

Chapter 6 – TOPICS RAISED BY THE SUMMARY REPORT OF THE THIRD REVIEW MEETING

During the final discussions of the third review meeting of the Parties of the Convention on Nuclear Safety, held in Vienna in April 2004, some 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 Fourth 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.

Additionally the most important questions raised to the Third National Report of Brazil are presented in section 6.2, together with their answers.

6.1. Topics from the review meeting

In this section, the paragraph from the Summary Meeting report is reproduced with the original paragraph number before the related discussion.

6.1.1. Quality Assurance within Regulatory Body

25. While many Contracting Parties reported that they had begun the process of implementing quality management systems within their regulatory bodies, many also noted the challenges in these tasks. Accordingly, the implementation of quality management systems within regulatory bodies is expected to be reported upon at the Fourth Review Meeting.

As mentioned in item 4.1.1, CNEN has issued a Quality Assurance Policy [14], 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 Spanish Consejo de Seguridad Nacional.

The task force worked in defining the Quality Management model for CNEN but the implementation phase was not carried out. A new system will be proposed in the near future, which will relay heavily in the automation of the processes.

6.1.2. Self Assessment and Safety Culture

43. Into the future, the Contracting Parties are committed to ensuring that comprehensive safety management processes and self-assessments are undertaken by operating organizations. Many safety culture assessment tools and safety management systems, which will be reported at the Fourth Review Meeting, remain under development.

ELETRONUCLEAR has it own program on safety Culture, as described in item 4.1.3, as well as a formal external and internal assessment program which includes external WANO and IAEA-OSART peer reviews and internal self assessments (see section 5.3.7). ELETRONUCLEAR also makes extensive use of performance and safety indicators (see section 5.3.3.2) to support its safety management processes.

6.1.3. Analyzing Human Factors

47. Methodologies for analyzing human factor events are being further improved and reports on these improvements may be expected at the Fourth Review Meeting.

As reported in 4.3, ELETRONUCLEAR has established a Human Factor Engineering (HFE) Committee as part of the organizational structure, with the main responsibility to review the internal and external operational experience according to the areas of human factors defined in NUREG 711. The evaluation of Angra 2 was incorporated as chapter 18 of the Final Safety Analysis Report (FSAR).

Both plants have performed Main Control Room evaluation and modernization, although the major impact was in the older Angra 1 unit.

The most important modification was the addition of a computerized system for extension of the scope of the plant Safety Parameter Display System and for monitoring of the Critical Safety Functions (CSF) for both units.

6.1.4. Emergency Preparedness Information to Neighbouring Countries

53. Many Contracting Parties reported on further measures that they will be undertaking to enhance their emergency preparedness programmes, including modernizing emergency management centres and conducting broader emergency exercises. Contracting Parties were also encouraged to include in their National Reports to the Fourth Review Meeting how, in case of an emergency, information is transmitted in an expeditious manner to neighbouring and potentially affected countries.

Brazil has signed the Convention on Prompt Notification of Nuclear Accidents, and has a nuclear agreement with Argentina. However, due to the geographical location of Angra 1, in the East Cost in the middle of Brazil, it is not expected that even the worst credible nuclear accident in Angra will require emergency action in any neighbouring country.

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

54. The ALARA (As Low As Reasonably Achievable) principle and/or recommendations of ICRP 60 continue to be applied by Contracting Parties for controlling occupational doses and releases to the environment. In general, the information provided by Contracting Parties does show a reduction in collective doses and in releases to the environment. However, full implementation of the ICRP 60 recommendations remains to be completed in some Contracting Parties.

In the supplement to the second National Report of Brazil, it was reported that a working group had been formed to adapt the existing Radiation Protection Regulation [18] to the new requirements of the IAEA – Basic Safety Standards (BSS) for Radiation Protection (Safety Series 115).

As mentioned in Section 4.6, the work of the group was concluded and the new Regulation CNEN NN 3.01 has been issue on January 2006. The transitional clause of the regulation requires full implementation up to January 2008, although most of the licensees have already performed the required transition.

6.1. 6. Collective radiation doses

56. Some Contracting Parties did report relatively high collective doses. In most instances, these were connected with intensive inspection programmes, maintenance or extensive backfits to older nuclear power plants. These Contracting Parties undertook to reduce the collective doses arising from long periodic inspections and extensive maintenance activities. This remains an important area for reporting at future Review Meetings, particularly as Contracting Parties continue to upgrade their nuclear power plants.

ELETRONUCLEAR reports periodically to CNEN the radioactive dose to workers. Although no high doses have been reported, any increase of dose is clearly connected with the respective work in progress at the power plant. No abnormal trends have been identified.

It is expected that the future work related to the replacement of the two Steam Generators of Angra 1 will involve significant radiation dose to workers. ELETRONUCLEAR and CNEN are aware of the problem and specific evaluations are been carried out, based on the international experiences in other plants that have carried out similar replacement. This is an important item of the safety analysis that will be presented by ELETRONUCLEAR to CNEN for the approval of the replacement work.

6.1.7. Risk Informed Decision Making

60. Several Contracting Parties reported on the challenges posed by the introduction of risk-informed decision making. Experience with the implementation of risk-informed decision-making can be expected at the Fourth Review Meeting.

CNEN regulation is not risk based yet. The only regulation requiring some risk evaluation is Regulation CNEN NE 1. 26 Operational safety of Nuclear Power Plants. But this regulation is not specific on how the risk reduction measures should be taken into consideration.

6.1.8. Probabilistic Safety Assessment (PSA)

65. Contracting Parties will report on their experience with PSAs at the Fourth Review Meeting.

As mentioned in 4.5, risk management is a requirement of CNEN Regulation NE 1.26[12]. For Angra 1, a preliminary level 1 PSA was performed in the eighties, which supported the decision to add two new Diesel generators. A new detailed level 1 PSA, was completed in 1998, revised in 2002 and since then has been continuously updated.

According to the Angra1 Overall PSA Planning Program, submitted to CNEN, referred in section 4.5, several activities have been performed during the review period, the most important being the extension of the existing level 1 PSA to level 1+ and starting in beginning of 2007, of a Fire PSA in cooperation with the US Electric Power Research Institute (EPRI).

For Angra 2, the development of a level 1+ PSA is under way. In accordance to the Angra 2 Overall PSA Planning program, which is part of the scope of Angra 2 safety improvement programs agreed with CNEN, a contract with this purpose was signed in December 2004 with an experienced international contractor. This study is well advanced, with completion expected for end of 2007

6.1.9. Operational Experience Feedback

75. Progress on operational experience feedback can be expected at the Fourth Review Meeting.

Brazil has established a complete experience feedback system, composed of two levels. At the operator level, not only plant events are thoroughly analyzed, but also events from other plants, provided by several sources, such as owners´ group, INPO and WANO, are reviewed by the plants and the related lessons learnt are incorporated in the plant training and procedures.

At CNEN level, important plants events have to be reported to the regulator, and are therefore further analyzed for possible additional actions. Then most relevant event is further reported by CNEN to the IAEA-IRS. On the other hand, IRS international events are analyzed by CNEN e transferred to the operator if further actions are considered appropriated.

This system has been in operation since the beginning of operation and no significant progress need to be reported specifically for this period.

6.1.10. Severe Accident Management

76. Programmes for severe accident management are in various stages of development and implementation in many Contracting Parties. It was noted that different approaches are being considered to respond and mitigate beyond design basis events. Further information on the development and implementation of severe accident management programmes (SAMP) would be welcomed at the Fourth Review Meeting.

No specific requirements are established in the Brazilian regulations related to severe accidents and accidents beyond the design basis. However, several activities related to the subject have been conducted in the past. The control of Beyond Design Basis events, up to but not including core damage events (Severe Accidents) *is done for both plants through symptom oriented emergency procedures.*

Vendor generic recommendations related to severe accident prevention measures were implemented in both units. Also, PSA activities have identified main contributors to severe accident sequences and, in some cases, have led to plant modification to reduce the related risk.

However, plant specific severe accident mitigation analyses have still to be performed. This work is planned to be carried out in conjunction with the development of level 2 probabilistic analyses for both plants, which in accordance to the overall PSA development schedules are to be started in mid 2008.

6.1.11. Safety Improvement Programs

78. Further and more detailed information on the status of safety improvement programmes would be expected at the Fourth Review Meeting.

A safety improvements program is a licensing requirement established in CNEN Regulation NE 1.26[12] 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, and the replacement of the 2 steam generators is under planning. 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.

6.2. Main questions received by Brazil during the review of the Third National Report

The Third National Report of Brazil was reviewed by the Parties to the Convention and 2 comments and 77 questions were formulated by 12 countries during the review process. The questions were answered in writing through the Convention web site and by issuing a Supplement to the Third national Report. The mains questions were also addressed during the Brazilian presentation at the Third Review Meeting.

Most of the questions were asking for clarifications and these were provided and taken into account when writing this Fourth National Report. This section discusses some of selected questions considered most relevant to the current situation.

6.2.1. Question 2 from Country 3.
Ref. in National Report: 2.1.2 Angra 2 page 9
It is reported that for Angra 1 and 2, "a comprehensive set of performance and safety indicators, in addition to the WANO ones, as well as a system of "system health" indicators have been developed and applied". Could Brazil give more details about the "system

health" indicators?

Answer:

The "Systems Health indicators" system consists of a color-coded system with at-a-glance information developed for continuous evaluation, follow up and trending of plant system performance. This information is provided with different levels of detail: individual system, plant area (primary, secondary, auxiliaries, ventilation, electrical and I&C) and finally plant condition as a whole.

The performance of each individual mechanical, electrical and I&C system is evaluated against pre-defined goals relative to number of operator workaround, I&C simulations, temporary modifications, alarms permanently actuated in control room, equipment out-of-operation cards in control room, automatic controls in manual, leakages, Limiting Conditions for Operation (except the ones due to programmed maintenance), maintenance program performance and backlog of preventive and corrective maintenance. The resulting system performance is presented for the current and for the previous three months, together with the trend indication through a color code (red- large deviation from goal, yellow- deviation from goal, white- small deviation, green- goal achieved).

The averaging of the individual system performance information for a given area provides the indication of the performance of the corresponding area (e.g. primary circuit); the averaging of the areas give the overall plant performance as far as system condition is concerned.

6.2.2.. Question 2 from Country 4.

As mentioned in the report, the construction of Angra 3 was interrupted in 1991 and after more than 10 year the construction was restored. Can you describe the conservation of equipment and other measures taken to assure that the safety will not be deteriorated. In this connection it will be interesting to know how the CNEN did react to this situation?

Answer:

Most of the imported components for Angra 2&3 plants have been supplied in the 1982 to 1988 period. As the plants were designed to be twin plants with planned start of operation dates only 2 years apart, imported equipment was acquired for both plants at the same time.

In order to ensure equipment integrity over such long periods of time a conservation contract was signed with the main equipment supplier Siemens/KWU (now Framatome ANP) for maintenance of equipment warranty. The supplier responsibility comprises specification of storage conditions and follows up of equipment condition, including a 24-month inspection program to verify and confirm equipment conditions and replacement of degradable parts. Storage conditions vary from shelf-storage in warehouses with controlled atmosphere to sealed packages with inert gas atmosphere.

As mentioned in the Report, these measures have proven to be adequate as shown by the low equipment failure problems encountered in the Angra 2 first four years of operation.

CNEN inspects and audits ELETRONUCLEAR activities related to conservation of *stored equipment. In 1994 due to successive delays on Angra 2 construction, CNEN requested to IAEA specialized assistance to evaluate the equipment long-term storage. The IAEA sent a specialist from Spain who confirmed that the preservation program developed by ELETRONUCLEAR was in accordance with best international practices.*

6.2.3. Question 1 from Country 6.

Ref. in National Report: P9 Section 2.1.3

It is stated that following the original concept, Angra 3 is planned to be a twin plant of Angra 2 and this concept has been accepted by the CNEN proposing "Angra 2 as built" as the reference plant for Angra 3. Taking cognizance of the fact that construction of Angra 2 started in 1975 and the decision for installation of Angra 3 is yet to be taken by the Brazilian Government. Can Angra 3 really be a twin of Angra 2 even though there may have been design reviews and up-gradations in Angra 2?

Answer:

The concept of "reference plant" used in Brazil, does not correspond to the idea of a "twin plant", but rather to a plant which has many features in common with the plant being licensed. Of course the differences have to be identified and more carefully evaluated. Since Angra 2 has been constantly backfitted during the long period of construction, no major modification in the design will be necessary. However, it is expected that the instrumentation and control, that has not yet been purchase, will be the item with major differences.

6.2.4. Question 3 from Country 3.

Ref. in National Report: 3.1.4 page 17

It is reported that CNEN has issued enough regulation to allow the effective control of the licensing process. However it is recognised that revision and updating of these regulations are necessary. Why CNEN recognised that it is necessary the revision and updating of the regulations mentioned?

Answer:

It is a international practice to review existing regulations periodically, and revise them as necessary to incorporate technological development and operating experience. This was done recently with CNEN Regulation NN1.14 on Reporting Requirements [11], reissued in 2002 and CNEN Regulation NN 3.01 on Radiation Protection [18], revised in January 2005. However, other regulations have not been reviewed in the last decade, and it is believed that a comprehensive revision may incorporate useful new features to these regulations.

6.2.5. Question 4 from Country 3.

Ref. in National Report: 3.3.1 page 23.

It is reported that related to safety culture evaluation some improvements were suggested by both OSART mission and CNEN with respect to the high number of minor problems waiting for resolution for long times. Besides, CNEN monitors closely the requested action to the plant management but does not want to regulate in detail management activities. What are the improvements suggested and why CNEN does not want to regulate in detail the related management activities?

Answer:

CNEN has requested, and ELETRONUCLEAR has developed a prioritization procedure to try to solve in a timely base the existing minor problems. CNEN believes the solution of these problems is not a safety issue, but rather a good practice of a good Management System. However, CNEN does not want to regulate in a prescriptive way, how the licensee manages the plant, considering the principle of "responsibility of the licence holder."

6.2.6. Question 5 from Country 4.

Different vendors supplied Angra 1 (USA) and Angra 2 and 3 (Germany). How CNEN has accommodated rather different safety principles of the above mentioned vendors?

Answer:

The safety principles of USA and Germany are not different; they follow international practices. The real differences appear in the implementation of these principles in the design, and in the way the documentation of the design is presented in the licensing process.

Since each design was analyzed under the general CNEN regulations and with the assistance of more specific industrial standards of each supplier country, no major difficult was encountered.

Regarding the format of the documentation, the adoption of the US NRC Reg, Guide 1.70 Standard Format has greatly facilitated CNEN staff work in the safety evaluation of Angra 2 FSAR.

6.2.7. Question 1 from Country 1.

Ref. in National Report: Paragraph 3.1.1 Status:

There is a very brief mention of enforcement mechanisms under the licensing regulation CNEN NE 1.04. Does this apply only to failure to fulfil licensing conditions, or does it also apply to wider offences related to non-compliance with safety regulation or failure to meet the obligation on the licensee to act safely? What offences can be committed, what penalties are available (in addition to revocation of the licence, which is mentioned) and what authority or power has CNEN been given in regulations? Can CNEN enforce penalties directly or through criminal or other courts?

Answer:

The nuclear regulations still do not contemplate monetary penalties in case of non compliance, but penalties could be imposed through the normal courts of law, although this has never happened.

CNEN is preparing a draft legislation which contemplates fines and penalties, but that has still to be submitted to the National Congress.

For minor items of non-compliance, CNEN can issue official letters, imposing further requirements or giving order to curtail activities.

In the case of authorized personnel (plant operators and radiological protection supervisors) CNEN can withdraw their certification in cases of inappropriate conduct.

6.2.8. Question 2 from Country 5.

In 2001, the Public Ministry intervened in order to push IBAMA not to issue the Angra 2 environmental licence before a "Term of Conduct Adjustment" be fulfilled. Why was the intervention necessary? Please give more details on the "Term of Conduct Adjustment" and explain the repartition of competences defining the dialogue of CNEN and IBAMA.

Answer:

A peculiarity of the Brazilian legal system is the opening of an enquiry by the Public Ministry (MP) in attendance of any questioning or suspicion of irregularity by individual or organization. Under this process, the MP, considering the new environmental regulation, decided to conduct a public hearing related to Angra 2. As a conclusion of the hearing the MP proposed the establishment a "Term of Conduct Adjustment"(in Portuguese, Termo de Ajuste de Conduta -TAC). The TAC is juridical instrument of the Brazilian Civil Code created for use in case of conflict of competence, or adjustment to new legislation.

In the TAC of Angra 2 ELETRONUCLEAR committed itself to several actions according to IBAMA requirements. These includes several actions related to emergency planning, such as improvements in the evacuation routes, which were already completed, and others related to improvement of the ecological stations, which are long term activities. For these reasons IBAMA environmental licensing has been delayed.

Although the nuclear license is independent from the environmental license, the MP included in the TAC a clause that prevent CNEN to issue the Authorization for Permanent Operation (AOP) before the TAC is considered "closed" by the MP.

IBAMA and CNEN were created through federal laws, with the same level of competence and specific objectives that were licensing and supervision of, respectively, conventional and nuclear installations. Through a later decree, in 1989, IBAMA was given the power to actuate also in the environmental licensing of nuclear installations. In this new function IBAMA is the coordinator of the environmental licensing process, which involves the estate and county environmental agencies and CNEN, which provides the expertise for the nuclear safety part of the environmental licensing.

6.2.9. Question 2 from Country 2.

Ref. in National Report: §3.1.2.1 – p. 16.

The report mentions (§3.1.1 - p.13) the licensing regulation establishes that no nuclear installation shall be constructed or operated without a licence and (§3.1 – p.11) that licensing of NPPs are subject to both a nuclear licence by CNEN and an environmental licence by IBAMA. The previous national reports (p.15) had stated that environmental licenses were not yet granted but their issuance was expected in the short term. In the statement made in this report (p.16) it is mentioned that the granting of the environmental licence for both Angra 1 and 2 units are still pending an additional "Term of conduct adjustment" work. Does the Brazilian regulation provide for any deadline for using a provisional operating authorisation? How long can be operated a nuclear power plant in Brazil without being granted with a Permanent Operation licence?

Answer:

The Regulation CNEN-1.04 [8] sets a limit of two(2) on the number of renewals of "Initial Operation Authorization"(AOI), but let the question open in cases of "external factors" which may require further renewals. In the case of the intervention of the Public Ministry, this "external factor" does exist, since the situation is out of the control of CNEN. Since there is no unresolved safety question involved, CNEN has decided to issue the renewal of the AOI, expecting that the question of the "Term of Conduct Adjustment"(TAC) be resolved in the near future.

6.2.10. Question 3 from Country 9.

Ref. in National Report: Sec 3.1.2.1 P15,16.

The report indicates that the Angra 2 plant environmental operating license could not be issued before fulfillment of a "term of Conduct Adjustment" (TAC) to improve roads and sheltering related to emergency planning. The report indicates that an additional TAC is also required for Angra 1 plant. Please provide the status and the schedules for resolving those TAC issues.

Answer:

The TAC for Angra 2 will be considered "closed" by the Public Ministry (MP) when all its clauses have been fulfilled. In that sense CNEN has sent recently a report to MP confirming that all requirements related to the nuclear license have been fulfilled.

ELETRONUCLEAR has also reported to the MP that it considers that all clauses have been fulfilled.

IBAMA however has not issued its report yet.

Regarding Angra 1, the schedule for elaboration and implementation of a TAC is still under negotiation between ELETRONUCLEAR and IBAMA.

6.2.11. Question 8 from Country 4.

Due to the geographical location of Brazil there are limitations of direct contacts with foreign operators and regulators. On the operational side the contacts are performed via WANO, EPRI, IAEA and VGB. But during 2001-3 only one contact with winning plant Grafenreifeld has been performed. The international contacts of CNEN are not, with exception of Iberian regulatory group mentioned. Provide, please more information about involvement of CNEN in international regulatory exchange of information and experience.

Answer:

CNEN has several bilateral agreements with regulatory bodies in developed countries.

The agreement with GRS in Germany includes the exchange of operational experience of Siemens/KWU NPPs. This agreement began on 1998 and until now there were four meetings in Brazil and one meeting in Germany.

Junior staff is usually trained in regulatory bodies in these countries with support from the IAEA. Senior staff usually participates in scientific visits to other regulatory bodies. CNEN also receives both visitors and trainees form other regulatory bodies, especially from Latin America.

Furthermore, CNEN staff participates in many IAEA activities, including representatives in the Safety Standard Commission and all 4 Standard Committees

(NUSSC, RASSC, WASSC and TRASC). CNEN also reports to INES (events above level 1), IRS and PRIS.

6.2.12. Question 2 from Country 1.
Ref. in National Report: paragraph 3.2.1
In the CNEN structure diagram reference is made to a "Deliberative Commission" (CD), but there is no further explanation of this body in the text. Is this an Advisory body to CNEN and/or Ministers? If so, are its members independent of CNEN and the Licensee, what are its terms of reference and how does it carry out its activities?

Answer:
The “Deliberative Commission” (CD) is a collegiate organ that approves all major decisions of CNEN. The CD is composed by the President of CNEN, its 3 Directors and an external member, all nominated by a decree of the President of the Republic.
The CD has periodical meetings called by CNEN President.
All major licensing decision are tabled by the Director of Radiation Protection and Safety (DRS), approved by CNEN President and ratified by the CD by consensus.
The CD also approves all CNEN regulations.

6.2.13. Question 4 from Country 9.
Ref. in National Report: S3.3,4 P23,28,34,35.
(Article 9, Reference: Article 9, Section 3.3.1, page 23, Article 10, Section 4.1.3, page 28, and Article 12, Section 4.3, pages 34 and 35) Several sections in the report identify concerns relating to long delay in resolving safety problems and lack of prioritization of their resolutions. The report indicates that this situation has led to a delay of issuing an authorization for permanent operation for Angra 2 for almost four years. In addition, the report indicates that there is a considerable delay in the Human Factor Engineering Program procedure evaluation because the licensee has not answered completely some of the licensing requirements. However, the report does not appear to address how those concerns will be resolved. What restraints or sanctions does the regulatory body place upon the licensee when the licensee does not implement identified fixes to address safety issues in the agreed-upon time period?

Answer:
ELETRONUCLEAR has provided a report where a schedule to attend the Human Factor Engineering (HFE) program was included. In September 2004, based on this and other reports, the Reactor Coordination (CODRE) has recommended the issuance of the Authorization for Permanent Operation (AOP) for Angra 2, since all licensing requirements for HFE were considered under adequate control.
The HFE program will be comprise in three phases:
In the first phase (July 2004 to June 2005) the Operators actions for a selected group of Emergency Procedures and Malfunctions associated with or without failures in the automatic actions will be simulated. The operator cognitive workload will be evaluated using the methodology described the new Chapter 18 of the FSAR of Angra 2.
In the second phase (June 2005, the conclusion times depending on the results from first phase), improvements will be proposed for Man Machine Interface (MMI) and Emergency Operating Procedures (EOPs) that will be verified in the full scope

simulator and in the main control room.

In the third phase (beginning 2007, after the conclusion of Probabilistic Safety Analyses - PSA), the core melting frequency will be reevaluated, using the iteration among the HFE and PSA results.

CNEN will monitor the implementation of this program, and in the case of the licensee do not implement the proposed schedule, CNEN can apply some operational restriction.

6.2.14. Question 6 from Country 2.

Ref. in National Report: §4.1 – pp. 27-28.

The report mentions (p. 27) that an action plan for enhancement of the safety culture aspects considered below satisfactory was implemented by ELECTRONUCLEAR and followed-up since end 2001. The report mentions also (p. 28) that "however, concerns still exists relating to the large number of minor items waiting for closure for long time. These refer to both internal findings as well as CNEN requirements. This situation has lead to a delay of issuing a Authorisation for Permanent Operation for Angra 2 for almost 4 years". See also similar concerns expressed in §5.3.1 p. 19 about the missing of some answers to regulator's questions about the review of test results. Does it mean that the regulator has not sufficient enforcement capabilities for the compliance to regulation? Can an Initial Authorisation for Operation be prolonged indefinitely?

Answer:

The fact that a large number of minor items remain open, but the plant remains in operation reflects the evaluation that none of these items is a major safety concern. Had any safety concern remained opened, CNEN would have the necessary enforcement power to order curtailment of activities, including shutting down of the plant.

Regarding the Initial Authorization for Operation (AOI), Regulation CNEN-1.04 [8] sets a limit of two(2) on the number of renewals of the AOI, but let the question open in cases of “external factors” which may require further renewals. In the case of the intervention of the Public Ministry, this “external factor” does exist, since the situation is out of the control of CNEN. Since there is no unresolved safety question involved, CNEN has decided to issue the renewal of the AOI, expecting that the question of the “Term of Conduct Adjustment”(TAC) be resolved in the near future.

6.2.15. Question 1 from Country 11.

Ref. in National Report: p. 24, 4.1.1.

CNEN has issued a safety policy and quality assurance statements. Further implementation of these polices has been delayed. Is it planned to strengthen the efforts again?

Which actions will be taken in what schedule in order to implement the existing policies?

Does CNEN intend to use the services for regulatory bodies offered by the IAEA?

Answer:

CNEN is planning to introduce a completely revised Management System. To accomplish that an external consultant is being contracted to assist in the identification of all processes, the establishment of indicators and an improvement in the Information Technology (IT) infrastructure to introduce electronic processes in all CNEN activities.

Together with this effort, it is expected that the existing safety policy will be revised, updated and further implemented.

CNEN was the first regulatory body reviewed by the IAEA, in 1990, even before IRRT was established as a formal Agency service. For 2005 a RASIA (Radiation Safety Infrastructure Appraisal) mission is schedule to visit CNEN to review the radiological installation area.

6.2.16. Question 5 from Country 9.
Ref. in National Report: Sec. 4.2.1 P28.
The report indicates that adequate funds are available for operation, maintenance, and plant upgrading program for Angra 1 and 2 plants. The report also indicates that the provision of funds for decommissioning activities is to be obtained from rate payers and is included in the tariff structure. However, the report does not appear to address the financial protection program for liability claims arising from accidents. Please provide information regarding governing documents and process that implement the requirements of the financial protection program for liability claims arising from accidents.

Answer:
Brazil is a signatory of the Convention on Civil Liability for Nuclear Damage (Vienna Convention) since 1993, as informed in the Annex 2 of the 3rd. National Report[6]. As such, the licensee is required to keep adequate insurance for possible claims arising from a nuclear accident. The fulfillment of such requirement is verified by CNEN at the time of the Authorization for Initial Operation (AOI), and periodically at each renewal of the insurance policy.

6.2.17. Question 7 from Country 11.
Ref. in National Report: p. 31, 4.2.2.1.
CNEN monitors the adequacy of the human resources of the licensee through the evaluation of its performance. On which indicators or other means is the evaluation based?

Answer:
Chapter 13 of the FSAR describes the training and qualification for the plant personal including the shift staff. There no specific performance indicators, but CNEN is developing a group of nuclear safety indicators, based in the IAEA-TECDOC-1141 (Operational Safety Performance Indicators for Nuclear Power Plants), which will include data from events where human failure has occurred.
For the reactor operators, there is a formal exam for initial licensing; and every two years a audit in the retraining program is done in order to re-qualify them. CNEN licensing board verifies the implementation of training programs, identifying eventual causes of deficiencies as for example, the lack of training modules.
Also, the daily presence of CNEN resident inspectors in the control room and in the plant is another way to monitor operators' performance, which serves also to evaluate even those people who are not formally licensed by CNEN.

6.2.18. Question 8 from Country 11.
Ref. in National Report: p. 33, 4.2.3.
The knowledge management program at ELETRONUCLEAR can be considered as good

practice. It would be appreciated if more information about this program were provided, especially about methods to transfer implicit knowledge from experienced experts close to retiring age to young professionals.

Answer:

ELETRONUCLEAR knowledge management (KM) program was reasonably detailed in section 4.2.2. More specifically, the methodology for collection of implicit (tacit) knowledge in an easy to transfer to new staff is still in the development stage.

Several approaches with the same purpose are in use or in development:

a) *Angra 1 and 2 Systematic Approach to Training (SAT) program: the most experienced personnel is working in the development of the training material for maintenance of sophisticated components. The resulting material provides a high level of detail, abundant video material of the different steps as well as special hints learned through years of practice.*
b) *Mentoring or tutoring: on-the-job training of new personnel working together with experienced personnel near retirement age.*
c) *Re-hiring of retired experienced personnel as consultants.*

A more advanced approach is being evaluated, which is planned to be developed with the support of the Electric Power Research Institute, which has developed the methodology [Capturing and Using High-Value Undocumented Knowledge in the Nuclear Industry: Guidelines and Methods, EPRI, Palo Alto, CA: 2002. 1002896]. The main line is to use "conceptual mapping" techniques to collect the pertinent information through interviews with the retiring experts.

6.2.19. Question 9 from Country 11.

Ref. in National Report: p. 35, 4.3.1.

Some recommendations of the study mentioned have not yet been implemented. Does CNEN require efficient implementation of these recommendations?

Answer:

ELETRONUCLEAR has provided a report where a schedule to attend the Human Factor Engineering (HFE) program was included. In September 2004, based on this and other reports, the Reactor Coordination (CODRE) has recommended the issuance of the Authorization for Permanent Operation (AOP) for Angra 2, since all licensing requirements for HFE were considered under adequate control.

The HFE program will be comprise in three phases:

In the first phase (July 2004 to June 2005) the Operators actions for a selected group of Emergency Procedures and Malfunctions associated with or without failures in the automatic actions will be evaluated in the Angra 2 NPP simulator. The operator cognitive workload will be evaluated using the methodology described the new Chapter 18 of the FSAR of Angra 2.

In the second phase (June 2005 on) improvements for Man Machine Interface (MMI) and Emergency Operating Procedures (EOPs), identified during the first phase of the work, will be proposed and verified in the full scope simulator and in the main control room.

In the third phase (beginning 2007, after the conclusion of Probabilistic Safety Analyses - PSA), the core melting frequency will be reevaluated, using the iteration among the HFE and PSA results.

CNEN will monitor the implementation of this program, and in the case of the licensee do not implement the proposed schedule, CNEN can apply some operational restriction.

6.2.20. Question 14 from Country 11.
Ref. in National Report: p. 38, 4.5.
To what extent are severe accidents (with core degradation) taken into account for accident analyses in Angra NPPs?

Answer:
The current accident analysis does not consider of severe accidents. ELETRONUCLEAR still does not have the capability to perform this type of analysis. CNEN already identified this limitation. This was also an issue addressed by OSART recommendations.
ELETRONUCLEAR is planning to develop severe accident management procedures using external support from EPRI and Westinghouse Owners Group.
CNEN is monitoring the advances of ELETRONUCLEAR in this area.

6.2.21. Question 13 from Country 11.
Which acceptance criteria have been used for the regulatory review of the radiological consequences of design basis accidents? Are these criteria related to releases or related to radiological exposures? If dose limits are applied, which are the parameters (e.g. exposure pathways, integration times, distances) considered for the calculation?

Answer:
The present criteria used by CNEN for Design Basis Accident are the ones described in CNEN regulations, in this specific case, CNEN Resolution no.09/1969, which defines a limit of dose for Exclusion Area Boundary (EAB) and Low Population Zone (LPZ).
The current limits are:

- *EAB: 300 rem thyroid, 2h release, any direction; 25 rem whole body, 2h release, any direction.*
- *LPZ, same limits as above for the entire period of plume passage over the LPZ (this usually ranges from an 8h release to a 72h release.*

This is not in prejudice of other analysis on site required by CNEN, as considered necessary, on a case by case basis, as stated by Brazilian general standards on nuclear safety.

6.2.22. Question 16 from Country 11.
Ref. in National Report: p. 44, 4.7.2.
In the text the Rio de Janeiro State plan is mentioned, but a regional or local plan (beyond the area of the site) could not be identified in this chapter. Please give additional information on how regional planning is implemented.

Answer:
The approach to emergency preparedness is based in a municipalization of the

response action to an emergency situation, utilizing mainly the resources local at the Municipality. The State and Federal Governments complement the local resources as necessary.
There is a Center for Coordination and Control of Nuclear Emergency Situation (CCCEN) and a Center for Information in Nuclear Emergency (CIEN) in the city of Angra dos Reis.

6.2.23. Question 1 from Country 12.
Ref. in National Report: page 13, line 34.
In some countries, such as America, the emergency preparedness is included in licensing of the authorization for initial operation and permanent operation. Is the emergency preparedness licensing matter for nuclear power plant in your country?

Answer:
Yes. Regulation CNEN NE 1.04 – Licensing of Nuclear Installations requires the presentation of a PSAR and later a FSAR. Both are presented according to the USNRC Reg.Guide 1.70 – Standard Format, which requires the presentation of Emergency Planing as part of Chapter 13.
The Emergency Plan is also a requirement according to SIPRON regulations (see item 3.1.3 (pag.17) of the Report. Furthermore, emergency planning considerations are part of the environmental licensing as mentioned in items 3.1.2.1 (pag16), 5.1(pag.49) and 5.1.1(pag.50) of the Report.

6.2.24. Question 7 from Country 6.
Ref. in National Report: P51 Section 5.2.
It is stated that Angra 2 has been designed and constructed with German technology within the framework of the comprehensive technology transfer agreement between Germany and Brazil. Since Germany has decided to phase out its nuclear power plants, how does Brazil plan to maintain adequate design knowledge in future?

Answer:
With the design and construction of Angra 2, Brazil has achieved a certain degree of autonomy in its nuclear capability. But some support form Germany is still necessary. In the utility side, existing commercial contracts involving technical support still exists and will continue to exist for some time.
The nuclear part of Siemens, the former NPP designer company KWU, which designed the Angra 2&3 plants, has merged with the French Framatome NPP designer, originating the Framatome ANP company, now part of the AREVA company, the largest NPP designer and supplier of components and services. Through a specific technology transfer contract all the pertinent design documentation relative to the 1300 Me Siemens/KWU standard PWR (Angra 2 + 3 family) has been transferred to ELETRONUCLEAR. Furthermore, about 200 ELETRONUCLEAR engineers have performed an average of 2 years of on-the–job training at the Siemens/KWU installations in Germany .The German plants phase out, even if completed, still has about 20 years of plant operation to go. There are other two Siemens/KWU PWRs of the same family of Angra 2, outside Germany, the Goesgen plant in Switzerland and the Trillo plant in Spain. Accordingly, the design capability and operational experience exchange for the standard SIEMENS/KWU

PWR will still be available in the future, even if the German plant phase-out takes place.

CNEN also maintains a cooperation agreement with the GRS. It is expected that these contacts will remain, in accordance with the spirit of item vii) of the Preamble of the Convention on Nuclear Safety.

6.2.25. Question 7 from Country 5.
The Grafenrheinfelde plant, the model for the Angra 3 installation, reached criticality in 1981. Which measures are taken in order to ensure that the technical standard of the latter is up-to-date, considering the long construction period? Is recent experience taken into account?

Answer:
Grafenrheinfeld was used as a reference plant for Angra 2. During the long construction time, the design of Angra 2 was kept up to date with the modifications introduced in Grafenrheinfeld, and even with most modifications introduced in KONVOI NPPs, which has a more modern design. These resulted from Designer development, operational experience and changes in the original safety standards.
As mentioned in the National Report, Angra 2 should be used as a reference plant for Angra 3. And further upgrades will introduced in the Angra 3 design as result of Angra 2 recent commissioning and operation experience.

Chapter 7. FINAL REMARKS

At the time of the third review meeting of the Nuclear Safety Convention, Brazil had demonstrated that the Brazilian nuclear power program and the related nuclear installations met the objectives of the Convention. During the period of 2003 - 2006, Brazil has continued the operation of Angra 1 and Angra 2 in accordance with the same safety principles.

Based on the safety performance of nuclear installations in Brazil, and considering the information provided in this Third National Report, the Brazilian nuclear organizations consider that its nuclear program 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 program related to nuclear installations has met and continues to meet the objective of the Convention on Nuclear Safety.

REFERENCES

[1] Convention on Nuclear Safety - Legal Series No. 16 - International Atomic Energy Agency - Vienna - 1994.
[2] Guidelines Regarding National Reports under the Convention on Nuclear Safety – INFCIR/572/Rev1 - 1997.04.24. – Revised on 10.06.1999.
[3] Report of the President of the Review Meeting – CSN-RM 2004/03 – Vienna – April 2004.
[4] National Report of Brazil – Convention on Nuclear Safety – Rio de Janeiro – September 1998.
[5] Second National Report of Brazil – Convention on Nuclear Safety – Rio de Janeiro – September 2001.
[6] Third National Report of Brazil - Convention on Nuclear Safety – Rio de Janeiro – September 2004.
[7] Power Reactor Information System - International Atomic Energy Agency (available through the Internet at http://iaea.or.at).
[8] Licensing of Nuclear Installations - CNEN-NE-1.04 - July 1984.
[9] Siting of Nuclear Power Plants - Resolution CNEN 09/69.
[10]Licensing of Nuclear Reactor Operator - CNEN-NN-1.01 - October 1979.
[11]Operational Reporting for Nuclear Power Plants - CNEN-NN-1.14 - 2002.
[12]Operational Safety in Nuclear Power Plants - CNEN-NE-1.26 - October 1997.
[13]Safety Policy of CNEN – Directive n.295 of 23 December 1996.
[14]Quality Assurance Policy of CNEN – Directive n.296 of 23 December 1996.
[15]Health Requirements for Nuclear Reactor Operators - CNEN-NN.1.06 - 1980
[16]Certification of Qualification of Radiation Protection Supervisors - CNEN-NN-3.03 - October 1997.
[17]Quality Assurance for Safety in Nuclear Power Plants and Other installations - CNEN-NN-1.16 – September 1999.
[18]*Basic Radiation Protection Directives - CNEN-NE-3.01 – January 2006*.
[19] General Norm for Planning of Response to Emergency Situations – SIPRON – NG–02 - 1996
[20] Directive for the Preparation of Emergency Plans related to the Unit 1 of Almirante Alvaro Alberto Nuclear Power Plant – SIPRON Directiva Angra – 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.
[24]Law 10.308 of 2001.11.20 – Rules for the site selection, construction, operation, licensing and control, financing, civil liability and guaranties related to the storage of radioactive wastes.

Annex 1

EXISTING INSTALLATIONS

A.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

A.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

A.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	Areva
Architect Engineer	ELETRONUCLEAR
Civil Contractor	na
Mechanical Erection	na
Construction start date	1978
Core load	(2013 - to be confirmed)
First Criticality	(2013 - to be confirmed)
Grid connection	(2013 - to be confirmed)
Commercial operation	(2014 - to be confirmed)

Annex 2

LIST OF RELEVANT CONVENTIONS, LAWS AND REGULATIONS

A.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.

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management – Signature 11.10.1997. Entry into force 16.04.2006.

A.2.2. Relevant National Laws

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

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

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

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

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

Law 6938 dated 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 dated 1989.06.27 - Reorganizes the nuclear sectors.

Decree 99.274 dated 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 dated 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 Program (COPRON).

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

Decree 3719 dated1999.09.21 – Regulates the Law 9.605 and establishes the penalties for environmental crimes.

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

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

Law 10.308 dated 2001.11.20 – Establishes rules for the site selection, construction, operation, licensing and control, financing, civil liability and guaranties related to the storage of radioactive wastes.

Decree 1.019 dated 2005.11.14 – Promulgates the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.

A.2.3. CNEN Regulations

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

NN 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 accidents 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 nucleoelétricas - ***(Meteorological program 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 nuclear 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).***

NN 3.01 - Diretrizes básicas de Proteção Radiológica - Resol. CNEN 48/2005 - ***(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 radioactive materials).***

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

A.2.4. CONAMA Regulations

CONAMA – 01/86 - Estabelece requisitos para execução do Estudo de Impacto Ambiental (EIA) e do Relatório 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 ambiental 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 - ***(Establishes procedures for environmental***

licensing of several types of enterprises) - (19/12/1997).

A.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 Coordination Commission for the Protection of the Brazilian Nuclear Program).*** 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-04 - Norma Geral para situações de emergência nas unidades de transporte - ***(General norm for emergency situations in the transport units).*** 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 campaigns about emergency situations).*** Port. SAE 150 of 11.12.1997.

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.

NG-08 - Norma Geral sobre o planejamento e a execução da proteção ao conhecimento sigiloso no âmbito do SIPRON ***(General norm for the planning and execution of the protection of the classified knowledge within SIPRON).*** Port. SAE 145 of 07.12.1998.

NI-01 – Norma Interna que dispõe sobre a instalação e o funcionamento do Centro Nacional para o Gerenciamento de uma Emergência Nuclear (***Internal Norm on the installation and operation of the National Center for the Management of a Nuclear Emergency*)**. Port. SAE 001 of 05.21.1997.

Diretriz Angra-1 - Diretriz para elaboração dos planos de emergência relativos a unidade 1 da Central Nuclear Almirante Alvaro Alberto - ***(Directive 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.

Comitê de Planejamento de Resposta a Situações de Emergência Nuclear no Município de Angra dos Reis – COPREN/AR ***(Committee for Nuclear Emergency Response Planning in the city of Angra dos Reis) –*** Port. MCT 777 of 10.30.2003.

Comitê de Planejamento de Resposta a Situações de Emergência Nuclear no Município de Resende – COPREN/RES ***(Committee for Nuclear Emergency Response Planning in the city of Resende)*** – Port. MCT 68 of 18.02.2005.

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