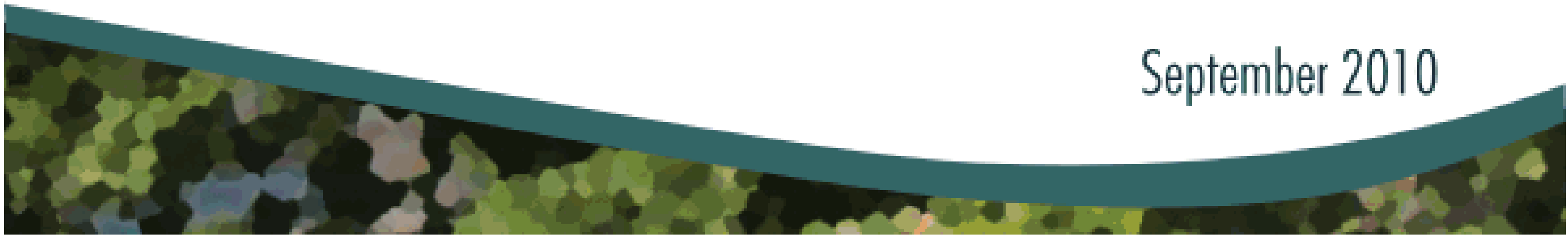
FIFTH NATIONAL REPORT OF BRAZIL

FOR THE

NUCLEAR SAFETY CONVENTION

September 2010



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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 program, 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, Third and Fourth National Reports of Brazil were prepared to update the information provided in the previous Reports

This Fifth National Report is a new update to include relevant information for the period of 2007/2009.

The authors decided to prepare the Fifth 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 information is provided according to the new Guidelines Regarding National Reports (INFCIRC/572.Rev3), which established a different structure for the Report. In spite of that, some basic information contained in previous Reports is repeated here, for completeness.

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 o objetivo 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, Terceiro e Quarto Relatórios Nacionais do Brasil foram preparados para atualizar a informação contida nos relatórios anteriores com dados relativos aos respectivos períodos.

Este Quinto Relatório Nacional do Brasil atualiza a informação para o período de 2007/2009.

Os autores decidiram preparar o Quinto 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 são apresentadas segundo o novo Guia para Elaboração dos Relatórios Nacionais (INFCIRC/572.Rev3) que modifica um pouco a estrutura usada nos relatórios anteriores.

No sumário executivo no princípio do Relatório, faz-se considerações sobre o grau de cumprimento das obrigações da Convenção sobre Segurança Nuclear pelo Brasil. As considerações apresentadas 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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A. Introduction

A.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 (Plano Plurianual de Ciência e Tecnologia - PPA), which establishes quantitative targets that define the Government strategy. 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.

A.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 amendments determined by Laws 6189/74 and 7781/89. Thereafter, CNEN became the Regulatory Body in charge of regulating, licensing and controlling nuclear energy, and the nuclear electric generation was transferred to the electricity sector.

Currently, Brazil has two nuclear power plants in operation (Angra 1, 640 MWe gross/610 MWe net, 2-loop PWR and Angra 2, 1345 MWe gross /1275MWe

[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).

net, 4-loop PWR), and one under construction (Angra 3, 1312 MWe gross/1229 MW net, 4-loop PWR). Angra 3, after the construction was temporarily interrupted in 1991, has restarted the construction activities in 2009 following a decision of the Federal Government. 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.

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.

Recent energy studies carried out by the Energy Research Enterprise (Empresa de Pesquisa Energética – EPE) and published in the Decennial Energy Plan 2007-2016 have led to the decision to start working in the site and construction of new nuclear power plants in Brazil. The proposed program anticipates, besides the completion of Angra 3, the construction of additional two reactors of about 1000 MWe in the Northeast of Brazil, by the end of this decade, and possible another two reactors of the same size in the Southeast region. Preliminary site and feasibility studies are under way.

Also, a Committee for Development of the Brazilian Nuclear Program (Comitê de Desenvolvimento do Programa Nuclear Brasileiro – CDPNB) was established, with the participation of 12 ministries. This Committee has approved proposals in the areas of electric energy, fuel cycle, nuclear waste, medical, industrial and agricultural applications, organizational structure, human resources and international cooperation. These proposals include, among others, the construction of the additional 4 reactors beyond Angra 3, the self sufficiency in the fuel cycle by 2014, the construction of a waste repository for medium and low level waste by 2018, the design of a long term repository for irradiated fuel and the creation of a fully independent regulatory agency separating the regulatory and promotion activities of CNEN.

A.3. Commitment to the Nuclear Safety

Brazil was always committed to conduct its nuclear program in compliance with its own safety regulations and best international practices. Brazil has participated actively in the development of the Convention on Nuclear Safety, and has signed, ratified and implemented it since the first review meeting.

The National Reports already presented have demonstrated compliance with the Convention objectives. The reviews, comments and recommendations in the various review meetings have assisted Brazil in improving even further the level of safety.

Due to this approach, the Brazilian plants have never had a serious safety problem, although several operational problems have, in the past, caused a relatively weak operational performance.

However, some minor safety concerns still remains to be solved as reported further in this document, such as:

- The creation of a fully independent regulatory agency;
- The issuance of a permanent operation license for Angra 2 plant;
- The full approval and utilization of Probabilistic Safety Assessment (PSA); and
- The full consideration of severe accidents in the plant analysis and procedures.

A.4. Structure of the National Report

This Fifth National Report was prepared to fulfill one of the Brazilian obligations related to the Convention on Nuclear Safety[1] and in accordance with the new Guidelines Regarding National Reports (INFCIRC572/Rev3/Sept2009)[2].

Part B presents a summary of the national report, highlighting the main safety issues, and addressing to recommendations from previous meeting to all Parties and especially to Brazil. Part C presents an article-by-article review of the situation in Brazil, highlighting the new information related to the period 2007-2009. But the Fifth National Report of Brazil has been prepared as a self-standing document, with some repetition of the information provided in the previous Reports [3, 4, 5, 6] so that the reviewers do not have to consult frequently the previous documents.

Since Brazil has only two nuclear installations in operation, more plant specific information is provided in the report than is recommended in the new 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.

B. Summary

B.1 Important safety issues

At the time of the previous meeting, the main safety concern was related to Angra 1 steam generators. These steam generators have been now successfully replaced and the plant have returned to present a good operational performance.

B.2. Future safety activities

Future safety activities relate mainly to the design and construction of Angra 3 power plant and the associated licensing process. Since the plant was original designed in the 1970´s, the evaluation of the plant design against current safety requirements may pose a great challenge to both the operator as well as to the regulators. Additionally, the implementation of new digital instrumentation and control, for the first time in Brazil, may require additional detailed industrial standards, and additional training of designers and reviewers.

B.3. Topics from previous meeting

Important topics from previous meetings that have some implication for Brazil are:

- The independence of the regulatory body: this topic has been dealt with by a proposal to reorganize the nuclear activities in Brazil. A draft legislation has been prepared and is under review by the relevant ministries. However, the implementation of the proposed solution depends on a decision by the Brazilian Congress on the draft legislation.
- The assessment of safety culture: this assessment has been carried out periodically by ELETRONUCLEAR, since they were the first company to this kind of assessment in 2002, with the assistance of the IAEA.
- The maintenance of adequate staffing and its competence: this has been a constant concern of ELETRONUCLEAR and CNEN, specially now with the decision to restarting the nuclear program. New hiring has taken place and new training programs are under way as described in Article 11(2).
- Probabilistic Safety Assessment (PSA): progress has been achieved in this area, both in further PSA development as well as in its utilization on daily activities.
- Periodical Safety Review (PSR): in this respect, Angra 1 PSR was evaluated and the corresponding Action plans are under implementation, as described in Article 14(1). The PSR for Angra 2 is due in the near future, since the plant is completing 10 years of operation.
- Ageing management and life extension: programs for ageing management are implemented in both Angra 1 and Angra 2. Especially for Angra 1, the replacement of the steam generators, will certainly contribute to the possibility of life extension, with a possibility of a power uprating.

- Emergency management: progress in this area was always a continuous accomplishment after each exercise. Recently the System of Protection of the Nuclear Program (SIPRON) has been moved to the Presidency and reorganized, as detailed in Article 16(1).

B.4. Responses to recommendations from fourth review meeting to Brazil.

The main challenges to Brazil identified in the in the previous meetings relate to:

- The replacement of the steam generators of Angra 1: this was successfully accomplished as described in Article 6.
- The situation of Angra 2 authorization for permanent operation; this has not been resolved yet, since it does not depend on CNEN or ELETRONUCLEAR actions, but rather on a decision of the Public Ministry, as detailed in Article 7 (2).
- The situation of PSA of Angra 1 and Angra 2: this item has progressed significantly, as described in Article 14(1). But still further work related to Angra 2 PSA needs some time to be finished.
- The implementation of a quality management system at CNEN: this issue had little progress in the period. There is still significant work to be performed to establish an integrated program, although some of the elements of quality management are already implemented since many years.
- The situation of INB under CNEN: this issue had some progress in terms of the proposals related to the creation of an independent regulatory agency and the reorganization of the nuclear activities, however a concrete solution has not been implemented yet.

B.5. Responses from recommendations from fourth review meeting.

No concrete general recommendations were identified on the Fourth Review Meeting Summary Report. However, the topics identified in the report and the specific recommendations to Brazil during the review process were dully addressed as mentioned in items B.3 and B.4 above, and further detailed in this Fifth National Report of Brazil.

B.6. Conclusions

At the time of the fourth 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 2007 – 2009, 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 Fifth 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.

C. Reporting article by article

Article 6 Existing nuclear installations

Brazil has two nuclear power plants in operation (Angra1, 640 MWe gross/610 MWe net, 2-loop PWR and Angra 2, 1345 MWe gross/1275 MWe net, 4-loop PWR). A third plant (Angra 3, 1312 MWe gross/1229 MW net, PWR, similar to Angra 2) had the construction temporarily interrupted, but a Governmental decision has been taken to restart the implementation of the project, and construction activities have restarted in 2009. The Angra 3 final construction nuclear license granted by CNEN was issued in May 2010. In addition, the governmental decision included the launch of the search for a new Nuclear Power site that would add up to 4.000 MWe to the national electrical grid up to the year 2030. 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, as well as at the ELETRONUCLEAR home page .

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.

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, with 657 MWe gross nominal power.

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 limitations imposed by operation of the Plant with Steam Generators (SG) nearing end of life, including limiting power to 80% to slow down tube degradation, had been affecting negatively the plant performance in the past years as it can be seen by the trend of the WANO Availability indicator in Table 1 below.

In 2009 the Angra 1 SGs have successfully been replaced after a 5-month outage. The subsequent physical and efficiency tests indicated a new gross unit power of 640 MWe**.** The plant returned to the grid in mid June, after successfully completing the commissioning phase. Since then the Plant has been operating well without any problems associated with operation with the new SG.

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
2007	2.708.724,00	58.734.697,00	60,65
2008	3.515.485,90	62.250.182,90	77,49
2009	2.821.494,71	65.071.677,61	58,01

Recent safety improvements at Angra 1

The most significant modification in the Angra 1 plant was the replacement of its steam generators in 2009. The original generators, a Westinghouse D3 model, presented progressive tube degradation. Nearly twenty percent of the tubes were plugged at the time of replacement. This problem required periodic ECT inspections of all generators tubes and repair (sleeving) or plugging of tubes, which yielded longer refueling outages or additional outages specifically for tube testing and repair.

The new steam generators were designed by Westinghouse and assembled at the Brazilian company NUCLEP. They are larger than the old ones, have 5428 tubes each instead of 4674 and were manufactured with Inconel 690 instead of Inconel 600. The feedwater nozzles were moved to the upper part of the steam generators and the thermal power output was increased from 941 to 1000 MWth per unit.

The replacement required associate modifications on the water hammer system, on the level control, on the purges system and on the snubbers supporting the steam generators. Additionally the process required the opening of the concrete shield building and of the metallic containment, dismount, withdrawal and transport the old steam generators as well as the entrance and mounting of the new generators, reestablishment and integrity test of these buildings.

Owing to design differences of the replacement steam generators and the associate plant modifications, a revised safety analysis was performed. Also alteration of set points, alteration and inclusion of alarms and revision of some items of the technical specifications was necessary. This revised analysis included the possible power increase of the plant and the use of the new Westinghouse fuel named 16NGF. Also the concept of leak before break was credit for in this analysis.

One of the CNEN requirements for the replacement process was a specific radiation protection plan for the activities. Several inspections and audits were conducted on site during the replacement period with emphasis on the occupational and environmental aspects.

The General Coordination of Reactors and Fuel Cycle (CGRC) of CNEN, through its technical divisions, carried out safety assessments and inspections on the whole replacement process. To document the result of these licensing activities, that accepted the modifications, several technical and inspection reports were issued.

In addition to the Steam Generator replacement, several programs for improvement of safety and reliability listed in the previous National Reports, and confirmed by the findings of the Angra 1 Periodic Safety Review (PSR), were continued in this period, as follows:

- Program to minimize Inconel 600 alloy stress corrosion cracking problems, substituting or repairing/reinforcing equipment/components using Inconel 600 in welds or parts, as for instance follow up of condition, preservation and planning for replacement of the Reactor Pressure Vessel (RPV) head;
- Reduction of generation and volume of radioactive waste, as well as enlargement of storage capacity for this waste;
- Addition of depleted Zinc to the reactor coolant, for dose reduction;
- 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.
- Evaluation and monitoring of thickness of secondary side energy-carrying pipes.

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

- Continuation of the installation of new fire alarm and detection system; installation of water fog system to protect the safety power cable trays needed for safe hot shutdown;
- Upgrading of the emergency diesel generators instrumentation;
- Leak-Before-Break (LBB) concept for the Main Coolant piping applied and licensed leading to elimination of the main coolant pipes whip restraints;
- Installation of a new Leakage Monitoring System to comply with the requirements resulting from the adoption of the LBB concept for the main coolant pipes;
- Plant modifications associated with SG replacement (instrumentation, piping layout, new platforms, etc)
- Partial replacement of the primary and secondary sides insulation by cassette type insulation;
- Replacement of the Loose Parts Monitoring system by an improved version;
- 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;
- Continuation of substitution of obsolete mechanical equipment (essentially valves, safety and non safety related);
- Substitution of the Inconel 600 core guide tube support pins;
- Application of weld overlay technique to the pressurizer Inconel 600 welds.

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. The Plant Fire PSA study, being jointly developed with the US Electric Power Research Institute (EPRI) using the state-of-the-art methodology of NUREG/CR - 6850 is nearing completion. More details are given in Article 14.

To cope with beyond design events, besides the existing Symptom Oriented Emergency Procedures based on critical safety function monitoring, the development with Westinghouse of a set of Severe Accident Management Guidelines (SAMG) has been completed, to cover the severe accident range. The next step is the establishment of the initial and periodical training of the crisis team on the use of the generated SAMG.

As reported in the previous National Report, 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 affect the continued safe operation of the plant. A set of opportunities for improvement has been identified for which action plans have been prepared and submitted to the Brazilian Regulator, as Plant commitments, such as the need to review of the plant Final Safety Analysis Report (FSAR), filling in the documentation gaps related to the plant design basis, establishment of a formal Probabilistic Safety Assessment program, among others. The status of these action plans depends on the time needed to complete the respective activities: some are completed, some are near completion and some are in development. More details are presented in Article 14(1).

The operating experience evaluation and feedback area has been restructured and upgraded.

Establishment of human performance follow-up and improvement committees and extensive training on the use of human performance improvement and error prevention tools have been done in this review period.

More details on these two items are given in Article 12.

Still in the area of human factors and taking advantage of the recent cooperation agreement signed between Brazil and the European Community (EC) to foster development of the energy sector, which also includes improvement of nuclear safety, a joint program for assessment of the Human Factor Engineering aspects of the Angra 1 control room is being established.

As previously reported, 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 continues to be applied.

Upon the successful completion of the SG replacement and the resulting expectation of plant life extension, the activities for installation of a full scope plant specific simulator for the Angra 1 plant have been restarted. More details are presented in Article 11(2) and Artilcle 12.

The renewal of the Angra 1 plant Operating License for 10 additional operation years has been issued in early 2010 based on the results of the plant Periodic Safety Review (PSR) completed in mid 2005 and satisfactory development of the program of safety related improvements identified in this PSR.

Angra 2

In June 1975, a Cooperation Agreement for the peaceful uses of nuclear energy was signed between Brazil and the Federal Republic of Germany. Under that agreement Brazil accomplished the procurement of two nuclear power plants, Angra 2 and 3, from the German company, KWU - Kraftwerk Union A.G., later SIEMENS/KWU nuclear power plant supplier branch, at present Areva 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 branch 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 Article 7(2), 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 2001/2009, 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
2007	9.656.675,00	66.548.523,40	85,73
2008	10.488.288,9	77.036.812,30	90,11
2009	10.153.593,49	87.190.405,79	92,24

As reported in the previous National Reports, and illustrated in the table above, Angra 2 had a very good performance in its first three years of operation. In the three subsequent years, the plant performance has substantially deteriorated due to a series of problems with major secondary side components, such as main transformer, electric generator, main condenser and the motors of the main recirculating water pumps.

As indicated in the fourth National Report (2004-2006), these problems have been addressed, their root causes have been identified and measures for their elimination have been or are being implemented. The positive trend resulting from the actions taken is reflected in Table 2 above by the plant availability factor, which has shown steady improvement beginning in 2006 reaching values of the best operating plants in 2009.

Recent safety improvements at Angra 2

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 program 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 above, in the period 2007/2009, the main activities at the plant were dedicated to implementation of measures for improvement of performance of major non-safety equipment/components.

Safety and safety related equipment performed well during the review period.

Several programs for improvement of safety and reliability being conducted at the Angra 2 Plant are:

- Evaluation and planning for substitution of electrical and I&C equipment due to obsolescence;
- Improvement of operating performance of major plant equipment including identification and elimination of design and maintenance weaknesses;
- Evaluation and monitoring of thickness of secondary side energy-carrying pipes;
- Improvement of human performance with emphasis in error reduction;
- Improving and expanding the use of internal and external operational experience.

Some selected modifications, important to safety and/or reliability, in different stages of implementation in the period are:

- Interconnection of the bus bars of the Emergency Power Supply D2 (power supply by small Diesel Generator set) with the bus bars of the Emergency Power Supply D1 (power supply by the large Diesel Generator set). This was a recommendation derived from the Angra 2 level 1+ PSA;
- Replacement of two battery banks of the Uninterrupted Secured Power Supply system nearing end of life;
- Installation of a Main Transformer Monitoring and Diagnosis system;
- Overhaul of the water intake internal surfaces, structures and equipment by installation of corrosion protection and replacement, where possible, of metallic structures by fiberglass ones;
- Development and installation of new bearing lubricating oil seals for the Cooling Water motors;
- Installation of covers for protection of the condenser tubes rows subjected to accelerated water drop impingement.
- Continuation of the checking of the “as built” condition of supports, with corrections where needed.

On the analysis side, a level 1+ PSA study was completed and reviewed internally, providing several important insights for design improvements. More details are given in Article 14(1).

Furthermore, taking advantage of the recent cooperation agreement signed between Brazil and the European Community (CE) to foster development of the energy sector, which also includes improvement of nuclear safety, a program for development of Severe Accident Management Guidelines (SAMG) for the Angra 2 plant is being established.

Also in the period of this Report, work for the development of a Reliability Centered Maintenance program for the Angra 2 plant incorporating and expanding the concepts of the Maintenance Rule (Numarc 93-01) was completed and is under implementation.

In the Operational Experience area the systematic for collection, trending and reporting of minor events and quasi-events has been developed and implemented for both Plants.

WANO sponsored best practices from the nuclear industry, such as Operational Decision Making procedures, as well as comprehensive familiarization with human performance error prevention tools and training in their use have also been developed and implemented for both plants.

As for Angra 1, a plant human performance follow up and improvement committee has been established.

As previously reported, a comprehensive set of performance and safety indicators, in addition to the WANO ones, as well as a set of “system health” indicator have been developed and continues to be applied. More details are given in Article 19(7).

To improve the reliability of the equipment as well as to improve the flexibility and efficiency of the operators’ training, the Angra 2 full scope simulator is undergoing a major hardware and software upgrade, with substitution of the old hardware and of part of the models of the most relevant systems.

The Angra 2 Plant management has started the planning of its first Periodic Safety Review as the plant has reached its tenth year of operation in 2010.

Angra 3

In 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.

For the actual restart of construction, two licenses were 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) Report.

Concerning the Construction License, in accordance with the original concept, Angra 3 was planned to be a twin plant of Angra 2, using the same licensing bases. This concept had been submitted to and approved by the Brazilian nuclear licensing authority – CNEN, considering “Angra 2 as-built” as the reference plant for Angra 3. This concept was used by ELETRONUCLEAR as basis for preparation of the first version of the Angra 3 PSAR, submitted to CNEN.

Later in 2008, along the process of evaluation of the Angra 3 plant PSAR for issuance of the Construction License, the original licensing bases were questioned by CNEN, and a review of the applicable regulations was requested, with the goal of comparing the original requirements with the corresponding today requirements.

As a result of this review it was identified that in most of the cases the original requirements did not change; where there were changes, in most of the cases it could be shown that the design in accordance to the original requirements allowed sufficient margins to accommodate the new requirements; finally for a few cases the design had to be adapted to incorporate either new or more stringent requirements. These cases will be referred further to in the specific articles.

The PSAR has been revised to include the results of the regulation review and, after several rounds of evaluation, the plant safety concept was considered acceptable. Angra 3 Limited Construction License was issued by CNEN in 1st of July of 2009, with a list of conditionings to be met before Initial Operation. Some highlights of these of these conditionings are:

- Submittal of the detailed design for each of the safety related buildings, for CNEN approval and release before construction begins;
- Availability of an Angra 3 specific full scope simulator for operator training before core loading;
- Development of Angra 3 specific levels 1 and 2 PSA that shall be functional before Initial Operation;
- Submittal for approval of the concept for control of Severe Accidents.

As referred in the previous Report, the environmental licensing has proceeded with preparation and submission of the Angra 3 Environmental Impact Assessment (EIA) document to IBAMA, the Environmental Regulator, and 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.

After several rounds of questions and answers resulting from the IBAMA evaluation of the EIA report, the Preliminary Environmental License was issued in July 2008 and the Installation License was issued in March 2009.

Concerning the status of construction of the plant, as reported in the previous National Report, some progress had already been made, based on Government indication that approval for the restart of the project was near. Beginning in 2007, following Government and Regulator authorization for site preparation work, the rock excavation for the plant foundation was cleaned up and stabilized. Engineering work was continued with adaptation of Angra 2 material and equipment specifications for Angra 3, upgrading the design with basis on Angra 2 and international operational experience, as well as continuation of contacts with the potential equipment suppliers. The contract with the main civil work contractor was signed and the following work was done based on specific authorizations: preparation of the buildings foundations and impermeabilization of the concrete slabs on top of the foundations for all the buildings and work on the erection of the non safety related buildings.

First concrete for the reactor base plate was poured following CNEN issuing of the Construction License, on the 1st of June 2010.

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.

Contract negotiations with national and international suppliers for the remainder of the equipment and services are under way. As a highlight it can be mentioned the recent contracting of the supply of the steel plates for the containment.

Most of the required engineering is essentially available since for standardisation reasons Angra 3 is to be as similar as possible to Angra 2.

Plant construction is planned for a 66-months duration, from reactor base plate first concrete to the end of the power tests and start of commercial operation.

Article 7 Legislative and regulatory framework

Article 7 (1) Establishing and maintaining a 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 A.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.

Brazil has also signed several international conventions (see Annex 2) that, once ratified by the National Congress, become national legislation, and are implemented through detailed CNEN regulations.

Article 7 (2) (i) National safety requirements and regulations

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 under 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 relevant CNEN regulations).

The licensing regulation CNEN NE 1.04[7] 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.

Article 7 (2) (ii) System of licensing

The nuclear 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 [8], 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 [9]. 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 shall 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 [10]. 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 Gabinete de Segurança Institucional da Presidência da República (Institutional Cabinet of the Presidency of the Republic - GSI/PR) with respect to emergency planning aspects.

Environmental Licensing of Angra 1, 2 and 3.

In Brazil the environmental licensing for projects with potentially adverse effects on the environment, follow three main steps:

- Preliminary License– In general a Preliminary License is required for projects that need evaluation of environmental impacts. It specifies the obligations of the project Owner relative to mitigation of the eventual environmental impacts.
- Installation License – Characterizes the second phase of the Environmental Licensing, in which the executive plans for environmental impact control are analyzed and approved.

- Operation License– Authorizes beginning of operation and is issued after successful completion of the construction and commissioning activities, verification of the effectiveness of the adopted environmental safety measures and closing up of the conditionings of the Installation License.

The construction of Angra 1 and Angra 2 took place before the creation of IBAMA. The operation of Angra 1 started in 1981, before the current environmental regulation had been 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 on 15th of September 1981.

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, Angra 2 and Angra 3.

The updating of the environmental license of Angra 1, in accordance with the current IBAMA requirements, is being done through an "adaptive licensing" to adjust the enterprise to the environmental regulations. This process defines the necessary environmental studies to be carried out and submitted to IBAMA in order to justify the issuance of an Operating License. The report "Environmental Control Plan - PCA" was submitted to IBAMA in March 2009.

Although Angra 2 was already under construction, CONAMA determined that IBAMA should require from FURNAS, now ELETRONUCLEAR, the preparation of an Environmental Impact Study (EIA) and a Report on Environmental Impact (RIMA). These documents were submitted to IBAMA and formed the basis for IBAMA evaluation of the environmental impact. They also served as a basis to define environmental plans and programs detailed in a Basic Environmental Project (PBA), to be carried out by the licensee.

The EIA/RIMA served also as a basis for the two public hearings about Angra 2 impact, which took place in the surroundings of the plant in the period of 1999-2000. Based on these evaluations and taken into consideration the discussion during the hearings, IBAMA issued a special License for Initial Operation. As reported in previous National Reports, there is a legal issue concerning the environmental licensing of Angra 2, with involvement of the Public Ministry, which resulted in a series of conditions relative to Emergency Planning to be met by Eletronuclear, compiled in a document, "Termo de Compromisso de Ajustamento de Conduta – TCAC", which was signed by the three Parties, the Public Ministry, IBAMA and Eletronuclear, in March 2001.

In June of 2006, after evaluation of the status of completion of the conditions, IBAMA issued a report (Parecer Técnico Nº 015/2006 – COEND/CGENE/DILIC /IBAMA) concluding that, under the technical point of view, all of conditions compiled in the TCAC were met. Since then this report has been with the Public Ministry for evaluation.

With respect to Angra 3, IBAMA proposed in 1999 the Terms of Reference for the preparation of the development of the EIA/RIMA. Since CNEN has the technical competence for the evaluation of the radiological impact on the environment, IBAMA and CNEN have established a formal agreement to specify the respective scope of evaluations and to optimize both licensing processes.

The EIA/RIMA Reports for Angra 3 where prepared under the responsibility of ELETRONUCLEAR and submitted to IBAMA in May 2005.

The Preliminary License for Angra 3 was issued by IBAMA, through Preliminary License No. 279/08 of 24th of July 2008, subjected to 65 conditions, as follows:

- 5 conditions of general character, related to aspects of the project and obligations of the Owner, such as environmental monitoring, conservation areas, etc;
- 60 specific conditions, related to:
  - Support to the surrounding Counties directly affected by the project, in providing the infrastructure needed to accommodate the increase in permanent and variable population;
  - Submittal of the Basic Environmental Plan, that allows follow up of the construction activities relative to control and monitoring of the impacts of the construction on the environment;
  - Start up of the planning for development of a Final Radwaste Repository, to dispose the plant radioactive waste;
  - Submittal of a regional “Insertion Plan” of social character, with the goal of providing better living conditions for the population of the areas affected by the project.

The content of these conditions emphasizes planning and preparation for the project installation phase.

IBAMA issued the Installation License No.591/09 for the Angra 3 project in the 5th of March 2009, with additional conditions, as follows:

- 5 general conditions related to aspects of the project and obligations of the Owner (same as for the Preliminary License);
- 46 specific conditions related basically to meeting of the planning and deadlines presented by the Owner in response to the conditions of the Preliminary License.

The Brazilian environmental laws establish that at least 0.5% of the overall cost of a project with potential harmful effects on society and environment shall go to environmental compensatory measures. It is expected that of the order of 4-5% of the total cost of the Angra 3 project will be spent to comply with the above referred conditions.

Article 7 (2) (iii) System of regulatory inspection and assessment

The General Coordination for Reactors and Fuel Cycle (CGRC) is the CNEN branch responsible for the licensing and control of the Angra 1, 2 and 3 nuclear power plants. This branch is composed by four divisions in charge of the following areas: Resident Inspection, Engineering and Materials, Safety Analysis and Radiation Protection and Meteorology. With the advice of these divisions a regulatory inspection and audit program is established annually for each plant by CGRC.

The Division of Resident Inspection makes continuous verification of the plants compliance with its Technical Specifications (TS), which establishes the limiting conditions for operation of each plant. Strict adherence to these specifications is essential for operational safety. Additionally, the division makes use of a set of inspection procedures to inspect the plant periodic tests, maintenance activities and use of maintenance rule, housekeeping, inspection of control room, evaluation of operational significant events, aspects of radiological protection, management and generation of waste, among others. Every six months, an inspection report is prepared containing the main inspections findings for each plant. It also supports the inspection and audits performed by the other divisions at the plant.

The Division of Resident Inspection also elaborates safety evaluations, registered in technical reports, such as evaluations of design modifications, evaluation of licensee operational events evaluation, alteration or exception of Technical Specifications (TS) and licensing of the Angra 3 NPP.

The Division of Engineering and Materials performs inspections related to design modifications, evaluation of licensee operational events analysis, alteration or exception of TS and construction activities related to Angra 3.

The Division of Safety Analysis performs audits to verify the status of the PSA Programs of Angra 1 and 2. Also performs inspections on the conduction of operation of these plants as well as on the status of Actions Plan of the Periodic Safety Review.

The Division of Radiation Protection and Meteorology performs inspection and audits to verify that the work carried out by the NPP employees meets the radiation protection standards and rules. Regarding the Environmental Monitoring Program, CNEN is collecting twice a year a set of environmental samples that are analyzed at the Institute for Radiation Protection and Dosimetry of CNEN. This independent evaluation ensures that the plant operation is not causing any negative impact on the environment.

Article 7 (2) (iv) Enforcement of applicable regulations and terms of licences

Enforcement powers are included in the legislation that created CNEN (Law 4118/62 with alterations determined by Laws 6189/74 and 7781/89). These laws explicitly establish that CNEN has the authority “to enforce the laws and its own regulations”.

Enforcement mechanisms are included in CNEN regulations, such as the power to impose conditions, suspend activities up to withdraw a licence. However, due to the good and professional relations established with the licensee, up to now, no legal actions were required to ensure enforcement. Usually, CNEN establishes conditions which are met by the licensee in due time. CNEN monitors implementation of these conditions and whenever delays occur new evaluations are performed to ensure that safety is not been compromised.

Article 8 Regulatory body

Article 8 (1) Establishment of the regulatory body

As mentioned before, 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).

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".

The structure of CNEN is presented in Figure 1. 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. The General Coordination for Reactors and Fuel Cycle (CGRC) is the CNEN branch responsible for the licensing and control of the Angra 1, 2 and 3 nuclear power plants. This branch is composed by four divisions, in charge of the following areas: Resident Inspection, Engineering and Materials, Safety Analysis and Radiation Protection and Meteorology. With the advice of these divisions a regulatory inspection and audit program is established annually for each plant by CGRC.

The Division o Resident Inspection, located at plant site, makes continuous verification of the plants compliance with its Technical Specifications (TS), which establishes the limiting conditions for operation of each plant. Strict adherence to these specifications is essential for operational safety. Additionally, the division makes use of a set of inspection procedures to inspect the plant periodic tests, maintenance activities and use of maintenance rule, housekeeping, inspection of control room, evaluation of operational significant events, aspects of radiological protection, management and generation of waste, among others. Every six months, an Inspection Report is prepared containing the main inspections findings for each plant. It also supports the inspection and audits performed by the other divisions at the plant.

The Division of Engineering and Materials makes continuous verification of compliance with regulatory requirements through development of safety assessments, documented in technical reports submitted by the licensee, as evaluations of design modifications, evaluation of licensee operational events analysis, alteration or exception of TS and evaluations for the licensing of the Angra 3 NPP.

The Division of Safety Analysis performs safety evaluations and regulatory inspections to verify the status of the PSA Programs of Angra 1 and 2. Also performs evaluations and inspections on the conduct of operation as well as on the status of Actions Plan of the Periodic Safety Review.

The Division of Radiation Protection and Meteorology performs safety evaluations, inspection and audits to verify that the work carried out by the NPP employees meet the radiation protection standards and rules. Regarding the Environmental Protection Program, CNEN is collecting twice a year a set of environmental samples that are analyzed at the Institute for Radiation Protection and Dosimetry of CNEN. This independent evaluation ensures that the plant operation is not causing any impact on the environment.

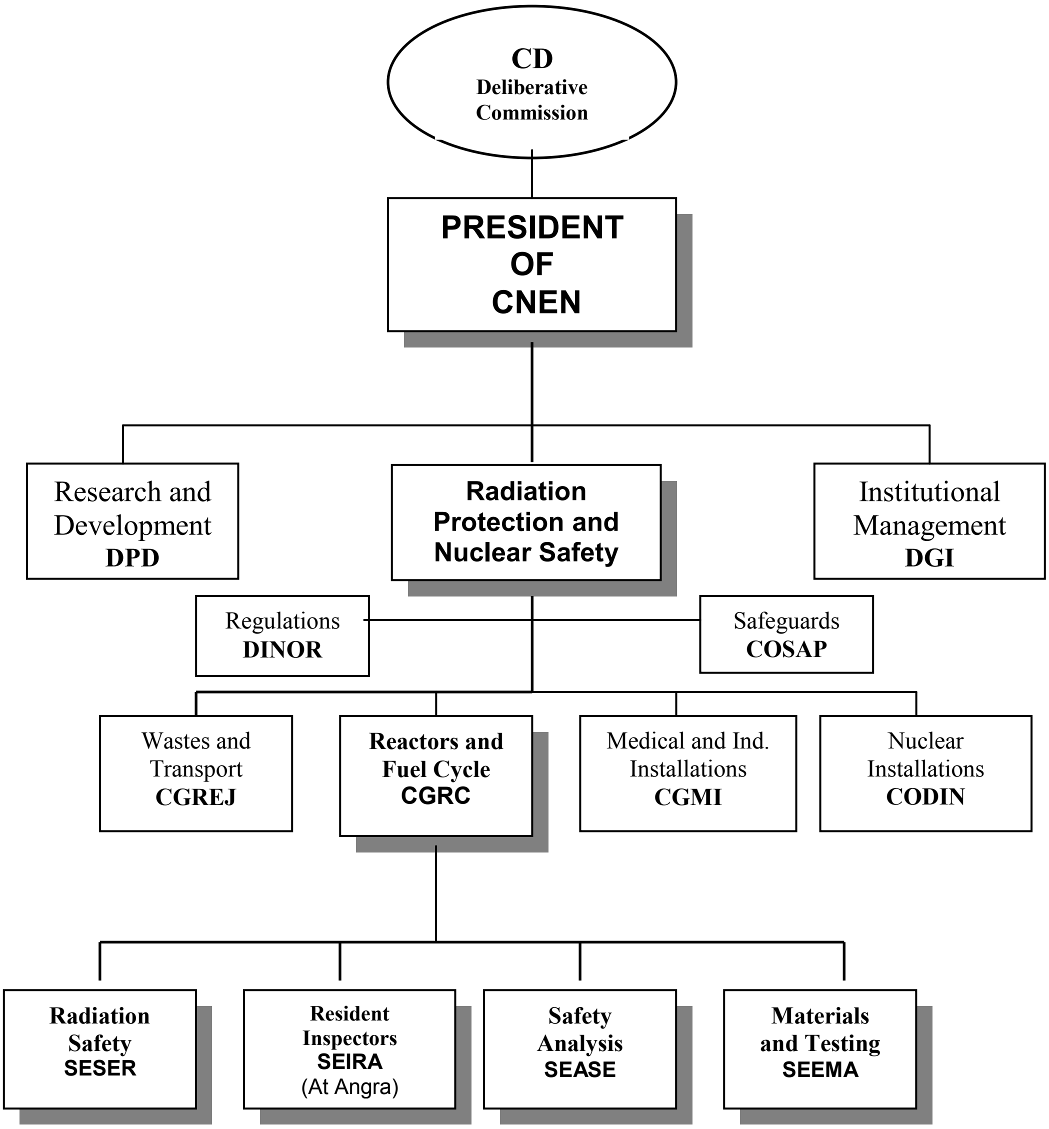


Fig. 1 – CNEN Structure (simplified)

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 52 people, 44 of which are technical.

In the period, CGRC staff registered a loss of four professionals, from 56 to 52, mostly due to retirement. By the end of 2009, the staff qualification shows 24 holding a Ph.D. degree or equivalent, 19 holding a M.Sc. in nuclear science or engineering, and 8 administrative.

The maintenance of the staff qualification has been attained through participation in workshops, training courses, and on technical committee meetings mostly sponsored by IAEA. CNEN is an active member of the IRS and IRSRR systems and contributes yearly with the presentation of events on the general meetings.

Also there is a technical cooperation agreement with German GRS to exchange information on the areas of operational events, PSA and Aging of nuclear plants.

On the area of emergency preparedness, CGRC is an active member of the ARGOS consortium and participate on the yearly seminar to share experience with other international users.

This year CGRC is expected to gain several new staff members, through the public service hiring process, to replace the past and near future retirement losses.

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 2007-2009, CNEN conducted 39 inspections in Angra 1, 14 in Angra 2, 3 in the preparatory work at Angra 3 and 9 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 [10].

CGRC 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.

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 is an important concern related to technical staff since most of the personnel is close to retirement age.

Article 8 (2) Status of the regulatory body

The relation amongst regulatory organizations and operators is shown in Figure 2.

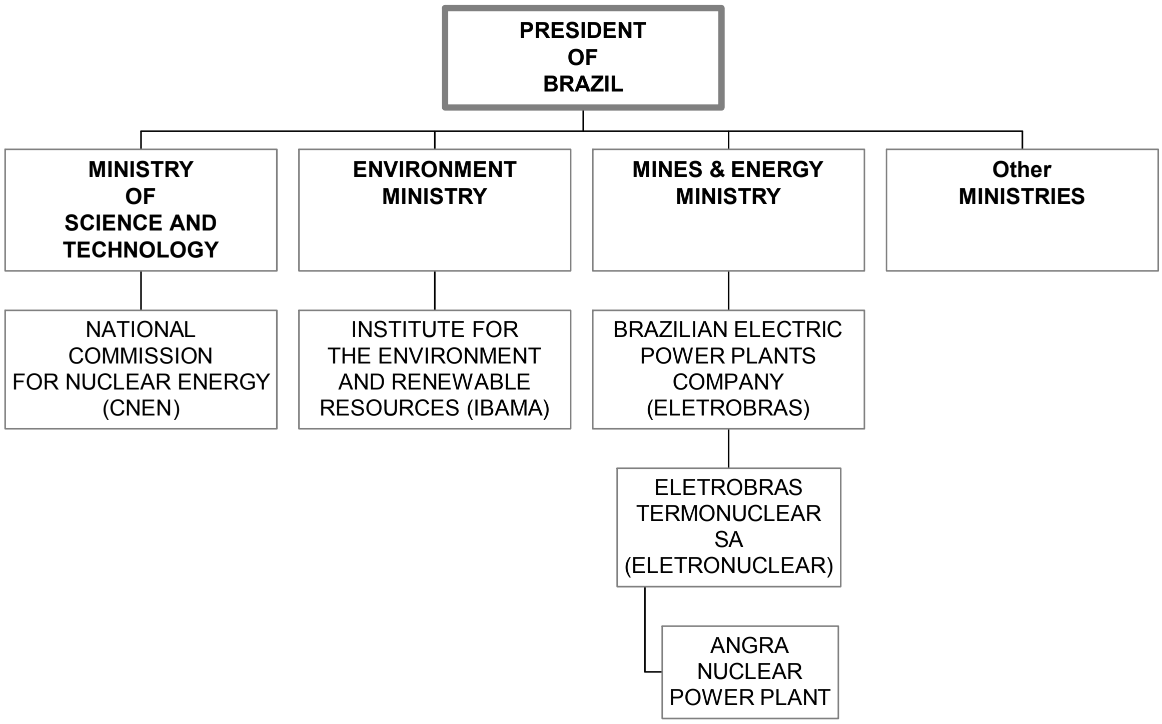


Fig. 2 – Brazilian organizations involved in nuclear power plant safety

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).

Notwithstanding that, a recent proposal has been made to create a independent nuclear regulatory agency within the discussion of the Committee for Development of the Brazilian Nuclear Program (Comitê de Desenvolvimento do Programa Nuclear Brasileiro – CDPNB), mentioned in A.2.

The reason for this proposal is not a deficiency in the existing regulatory system, but rather a perspective of expansion of the nuclear energy sector. The proposal is based on the existing structure of the Directorate of Radiation Protection and Nuclear Safety (DRS) of CNEN, adapted to the existing Law for Regulatory Agencies. This proposal was submitted to the various Ministries involved and the final proposal, consolidated by the Civil House of the Presidency will be sent to the National Congress for public discussion and approval.

After formal approval, it is expected that there will be a transition period in which the new Agency will act independently but may use CNEN staff and facilities.

One of the new features in the proposed legislation is the formal inclusion of sanction powers to the new agency, including financial sanctions. That was one of the main difficulties of the current situation when dealing with small non-compliances, since the only enforcement mechanism available has been the suspension or withdrawal of the licence.

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 [11] 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 [3,4,5,6]). 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 [10]. 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.

Article 10 Priority to safety

At CNEN

CNEN has issued a safety policy [12] and quality assurance policy statements[13] 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 [11] 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.

In 2005 CNEN organized the 1st. National Regulatory Information Meeting (I ENIR 2005). 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.

In 2009, the 2$^{nd.}$ National Regulatory Information Meeting (II ENIR 2009) took place promoting even further the communication of CNEN with its stakeholders.

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 3, which is essentially the same as presented in the previous National Report.

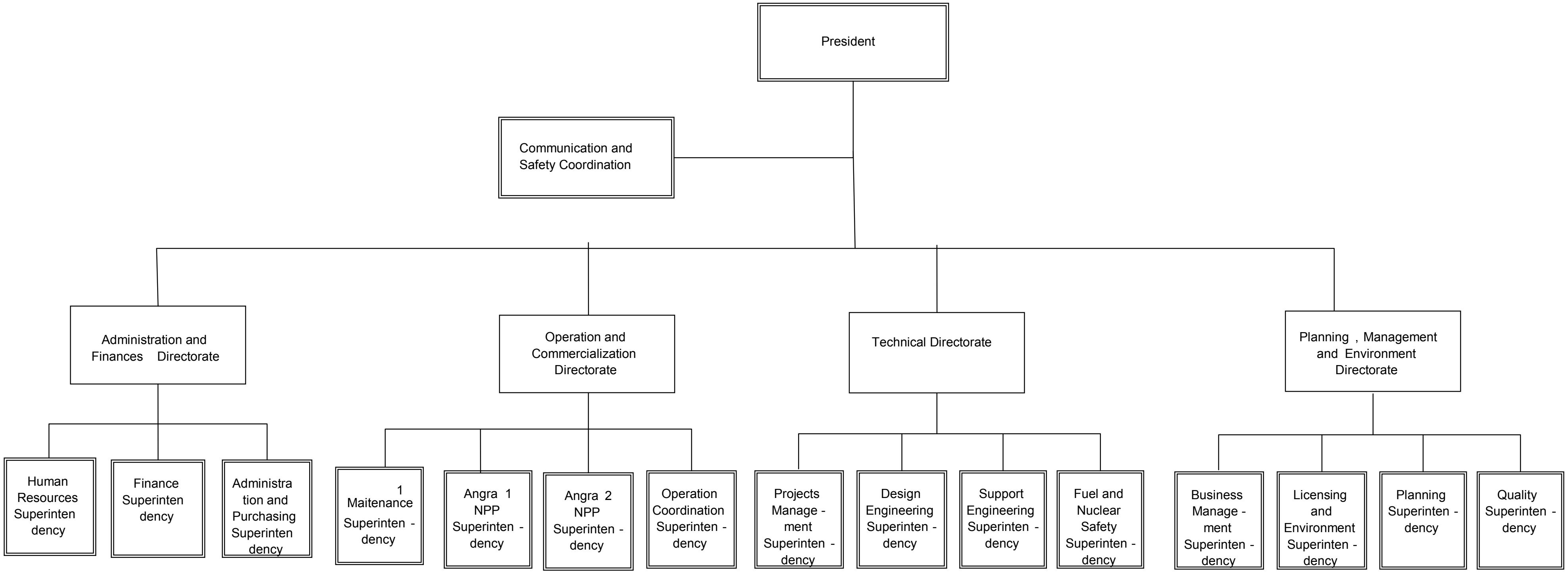


Fig. 3. ELETROBRAS TERMONUCLEAR S.A – ELETRONUCLEAR Organization Chart

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 Article 9, 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. 3).

Article 11 Financial and human resources

Article 11 (1) Financial resources

As a state 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, from both plants through a long term energy supply contract ending in 2012, with a guaranteed minimum rate of R$ 135.63/MWh, compared to R$113.23/MWh in 2006.

This long-term contract is not subjected to the ongoing liberalization of 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 2006 and 2009 are presented.

Table 3. Comparison of ELETRONUCLEAR Budget for the Years of 2006 and 2009. Values in million R $ (approximate million US$).

	YEAR	
	2006	**2009**
Primary Costs		
Anga1 & 2 Personnel (salaries + benefits)	178 (59)	241 (120)
Angra1 &2 Fuel	178 (59)	241 (120)
Other services, subcontractors and materials	290 (96)	324(162)
Investments		
Angra 1& 2Upgradings (including engineering)	102 (34)	164 (82)
Angra 3 Site Maintenance and Construction	75 (25)	162(81)
Angra 1 Setam generators (Fabrication ad Installation)	9 (3)	232(116)

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

The apparently large increase of the 2009 budget relative to 2006, when using US$ values (value in parentheses), is due to the strong depreciation of the US$ relative to the Brazilian Real (R$).

When comparing the 2006 and 2009 budgets in Real (R$), a meaningful increase in investments and primary costs are noted, mainly due to acceleration of the construction of Angra 3 as the several licenses were obtained, the upgrading in Angra 1 due to the ageing management program, including instrumentation modernization, waste management installations improvement, and substitution of parts as the main turbine rotor, a secondary heat exchange, Inconnel parts of the primary system, several valves and electrical penetrations. In Angra 2, the waste installations were also improved and several secondary system upgradings were done, e.g.: circulation water, service water and chlorination systems.

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 were re-evaluated and the results confirmed the former estimated values of 200 million dollars for Angra 1 and 240 million dollars for Angra 2.

Article 11 (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 were 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 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.

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.

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 full scope 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. 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.

Two additional blocks (~700 m^2) for classroom and mechanical, electrical and I&C maintenance labs training are being finished, to support identified needs of better practical maintenance training and additional classroom space for the Angra 3 personnel.

As reported in the previous Brazilian National Reports, Angra 1 does not have yet a plant specific simulator. Meanwhile, the Angra 1 operators have been trained in simulators of similar plants, initially in the USA (Ginna Simulator), a few times in Slovenia (Krsko simulator) and most of the time in Spain (Tecnatom Simulator).

Following the successful replacement of the Angra 1 Steam Generators completed in June 2009 and the possibility of extending the life of the plant, in operation since 1985, the original decision of installation of a plant specific simulator was confirmed by the Company Board.

To date the simulator technical specification was prepared and the resources for development of the project have been secured. The second half of 2010 will be dedicated to collection of the required data for the design of the hardware and software of the simulator and the launching of an international bid for selection of the simulator supplier The expected date to have this simulator operative on site is mid to end of 2014.

In the period, under review (2007 to 2009), the initial and re-qualification training programs, performed for the Angra 1 power plant operators, allowed 32 Senior Reactor Operators (SRO) and 24 Reactor Operators (OR) licenses to be renewed and 2 SRO and 11 RO new licenses to be granted.

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. The first group of Angra 2 control room operators was licensed in the beginning of 2000.

This simulator, in operation since 1985, has undergone periodical partial upgrading of the hardware (basically the computers), about every 10 years, as well as adaptation of the models and control room to take in account changes in the Angra 2 plant. In spite of still providing a good simulation performance, its original software used for the plant modeling had considerable limitations compared to today software.

To improve the simulator capabilities a major software and hardware upgrade was launched in mid 2009, being presently underway, with completion planned for end of 2011.

In the period under review (2007 to 2009), the initial and re-qualification training programs performed for the Angra 2 nuclear power plant operators allowed 36 Senior Reactor Operator (SRO) and 18 Reactor Operator (OR) licenses to be renewed and 6 new SRO licenses to be granted.

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 licence), 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 RO). Although not required by CNEN, all Angra 1 Shift Supervisors are graduated engineers with five years of academic education.

The requirements for organization and qualification of the entire Angra 1 and 2 staff are established in Chapter 13 of the FSAR. Implementation and updating of these requirements are subject of CNEN audits of the licensee training and retraining program and examination of new operators to comply with the regulations CNEN NN 1.01 [9] and NE-1.06 [14].

According to regulation CNEN NN 1.01, besides the Control Room shift personnel, the Head of the Operation department must also hold an SRO license. Additionally, Radiation Protection Supervisors must also hold a special license issued by CNEN, according to regulation CNEN-NE-3.03 [15].

Aside from the requirements of the regulations, 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.

Specialized training is also provided for personnel belonging to the different plant areas. Maintenance technicians follow qualification and re-qualification programs tailored 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.

A detailed training program for the Angra 3 future staff was developed in 2008, as well as the planning for the needed training infrastructure. Hiring of personnel has started in beginning of 2009 followed by the implementation of the referred training program. To date about 100 new employees are in training. The training duration depends on the specific position to be occupied by the trainee, varying from 1-2 month up to 2 years for licensed operators.

Preparatory activities for acquisition of a simulator for the Angra 3 plant are under way. Since this simulator will probably be available for training only by mid 2014, that is, at the end of the present Angra 3 licensed operator training program (aim is to have licensed operators ready for Angra 3 core loading), all the systems and integrated plant operation training will be done in the Angra 2 simulator, taking advantage of the similarity between the Angra 2 and 3 plants. A final simulator training period will be applied in the new Angra 3 simulator, to allow the operators to familiarize themselves with the Angra 3 digital control room, which is the most important difference between the two plants.

Technical visits and reviews of ELETRONUCLEAR training programs 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) continue to provide valuable contribution to the identification and implementation of good practices of the nuclear industry for enhancing the quality of the training activities.

CNEN monitors the adequacy of the human resources of the licensee through the evaluation of its performance, especially through the analysis of the human factor influence on operational events. The training and retraining 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[9] and their medical qualification[14]. CNEN conducts written and practical examinations for Reactor Operators and Senior Reactor Operators before issuing each individual authorization.

Similarly, CNEN certifies the qualification of radiation protection supervisors (RPS) by issuing licenses with a validity of five years.

In the period 2007 – 2009, CNEN has issued a total of 69 licenses for Angra 1, 13 new operator licenses (11 RO and 2 SRO) and 56 renewals (24 RO and 32 SRO), and a total of 60 licenses for Angra 2, 6 new SRO licenses and 54 renewals (18 RO and 36 SRO). In the same period two new RPS licenses were issued.

As of April 2010, there were a total of 44 active licenses (23 SRO and 21 RO) and 10 inactive SRO licenses for Angra 1, as well as 36 active licenses (26 SRO and 10 OR) and 5 SRO inactive licenses for Angra 2. The standard CNEN-NN-1.01– Licensing of Nuclear Reactor Operators establishes the criteria for inactive or active licenses.

This certification process is representing a substantial demand on CGRC manpower and it will increase with the increasing number of operating plants.

Article 12 Human factors

The basic requirements concerning human factors and organizational issues important to safety for the Brazilian Plants are established in the different chapters of their Final Safety Analysis Reports (FSAR). Under “Conduct of Operations” and “Administrative Controls” the plants organization structure, qualification and training program requirements for plant personnel, types of procedures required, etc., are established. The consideration of Human factors in the design is treated in the FSAR I&C chapter, as for instance, implementation of automation to help and relieve operators from performing repetitive tasks or for allowing adequate time for complex actions as well as the design of the Man-Machine-Interface of the Main Control Room. Specifically for the Angra 2 Plant an additional chapter “Human Factor Engineering” was prepared, which details the several aspects of human factors taken into account in the design of this Plant.

These basic requirements contemplate Brazilian nuclear regulations and the regulations of the Country supplier of the Plant, when no specific Brazilian regulation exists. Complementation of these requirements to take into account newer knowledge or experience is achieved by internal programs for enhancement of safety culture and human performance, feedback from internal and external operational experience as well as from Regulator requests.

As reported in previous National Reports a safety culture (SC) enhancement program based on an IAEA supported in-house SC self assessment was developed beginning in 1999-2000 and has become a permanent program at Eletronuclear S.A. Training on SC concepts is provided since then on the New Employee initial training program and refreshed yearly in the in the periodic re-training for Plant access.

In mid 2007 an in-house Human Performance (HP) improvement program was launched having as main goals the reinforcement of safety culture and human performance fundamentals and reinforcement of training on the use of error prevention tools. After development of the training material along 2008 of the order of 80% of the site employees have been trained. To allow permanent monitoring of the level of HP in the Plants as well as to provide uniform guidance related to HP improvement actions, each Plant has established an HP committee. These committees, among other, evaluate events (minor and significant) arising from internal and external operating experience caused by human error and make recommendations, promote periodical discussion on HP concept and error prevention tools, suggest reinforcement of training for human error prone tasks.

HP training has been included in the initial training program for all new (technical and administrative) employees.

Self-assessments, including organizational aspects, are performed for all main Plant areas, in preparation for the external reviews, OSART or WANO Peer Review (WPR) at every 3-years, for each Plant (see Article 19(7)), where the managerial and organizational aspects at Plant management level, are also evaluated.

A WANO Corporate Peer Review was requested by Eletronuclear to evaluate managerial and organizational aspects of the Company as a whole, focusing on the level and adequacy of the alignment between the company headquarters in Rio and the plants Site, about 200 km away, at Angra. This Corporate WPR was performed in July 2007 with a follow up mission in 2009, (see Table on Article 19(7)).

Concerning human factor consideration in the design, the Angra 1 Plant, being an early Westinghouse two-loop PWR, 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 beginning of operation, a critical review of the Angra 1 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.

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.

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

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.

A long discussion with the CNEN has been taking place relative to the preparation of a Human Factor Engineering (HFE) chapter for the Angra 1 FSAR (Chapter 18 in accordance to the US guidelines for FSAR contents), as it is not clear to what extent an early design plant, such as Angra 1, would meet the American recent guidelines that regulate preparation of this chapter.

To attempt to comply with CNEN requirements, a program for evaluation of the Angra 1 HFE, with a duration of 2 years and involvement of the CNEN personnel, will be launched in the second half of 2010, taking advantage of a recently signed Cooperation Protocol between Brazil and the European Union, in which the EU provides funding for safety improvement projects.

As already 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.

- The later part of these requirements has been 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).

The above mentioned HFE verification program is not yet concluded, as there are still CNEN open questions concerning the HR analysis performed in the scope of the Angra 2 level 1+ PSA and operator behaviour in case of beyond design events.

Among the improvements of the man-machine interface that have been introduced relative to the Angra 2 original design, 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 was done subsequently to the Plant commissioning.

This system was further improved, with a substantial increase in the number of monitored variables, following the replacement of the Angra 2 plant process computers, completed in this last review period. This improved version was also installed in the Angra 2 simulator.

The Periodic Safety Review of Angra 1 yielded several action plans in the area of Human Factors Engineering for non-licensed personnel. CGRC audit the following action plans in March 2010:

- Qualification Program for Engineering and Technical Support Staff;

- Implementation of the Job and Task Analysis Training based on the Systematic Approach to Training (SAT);
- Instructor Qualification and Managers Training Systematization

The implementation of these plans is ongoing and some of them are being reviewed.

In the area of Human Factors Engineering CNEN uses the NUREG-0711, "Human Factors Engineering Program Review Model, according to the USNRC Standard Review Plan (NUREG-0800). A specific chapter (Ch. 18) addressing Human Factors Engineering (HFE) is included in the FSAR of Angra 2. However, this chapter was not yet issued for the FSAR of Angra 1. The FSAR chapter 18 for Angra 3 was evaluated by CNEN and yielded several findings when compared to the acceptance and review criteria of the NUREG-0711 and German Standards. Particularly, the use of digital technology implies in several new safety issues compared to the technology utilized in the past. The computerized control room is much more integrated with the instrumentation and control systems and is necessary to investigate carefully the influence of the digital architecture on the staff behavior (human actions) during the operational events occurring in the control room. The CNEN review activities aim to verify that accepted HFE principles are incorporated during the design process and that the human-system interfaces reflect a state-of-the-art HFE design. The findings mentioned above need to be cleared to guarantee the commitment in the previous sentence.

In the case of Angra 2, the subjects related to the Cognitive Task Analysis (using the Angra 2 simulator to obtain the time spent to perform operational tasks) and Human Reliability Analysis has been analyzed by CNEN, according to the standards “Time response design criteria for safety-related operator actions”(ANSI/ANS 58.8 –1994), “Good Practices for Implementing Human Reliability Analysis ” (NUREG-1792, USNRC, 2005) and “Evaluation of Human Reliability Analysis Methods Against Good Practices” (NUREG 1842, USNRC, 2006).

The standard CNEN-NN-1.01 – Licensing of Nuclear Reactor Operators[9] requires the qualification of the simulators used in the training of nuclear reactor operators. Angra 2 has a specific simulator installed in the Training Center near the plant. The training of the Angra 1 operators is performed at the Almaraz plant simulator (TECNATOM, Spain) that was adapted to this task. The acceptance criteria from the standard ANSI/ANS 3.5 (1998) – Nuclear Power Plant Simulators for Use in Operator Training and Examination are adopted. In 2009, CNEN provided an evaluation of the documentation for the acceptance of the simulators according to this standard, and issued some requirements to be fulfilled by Eletronuclear (ETN). Differences between the Angra 1 NPP and the Almaraz simulator have been identified and yielded some regulatory requirements.

Severe Accidents Procedures are presupposed in the Standard CNEN-NE-1.26 – Safety in the Operation of Nuclear Power Plants[11]. This kind of procedure requires firstly an analysis of the design vulnerabilities to the severe accidents to be performed by means of a Probabilistic Safety Assessment (PSA) coupled with a Human Reliability Analysis (HRA). This requires in turn the elaboration of the FSAR chapter 19 - Severe Accidents for Angra 1, 2 and 3, according to the review and acceptance criteria described in the NUREG-0800 (march 2007) and NRC Regulatory Guide 1.200 (March 2009).

For the review of Operational Events involving Human Failures, CNEN has adopted the review process described in the NUREG/CR-6751 - The Human Performance Evaluation Process (HPEP): A Resource for Reviewing the Identification and Resolution of Human Performance, USNRC, 2001.

Organizational aspects have been addressed by CNEN using the HPEP method. In the Operational Experience area, CNEN has evaluated operational events to identify programmatic causes to determine whether a deficiency in a program, policy or practices for managing work activities allowed barriers to fail. Angra-1 and Angra-2 operators retraining program, which are approved and audited by CNEN in function of requirement in the standard CNEN-NN-1.01[9], incorporates this operational experience.

Article 13 Quality assurance

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”[16], which follows the IAEA recommendations, with the addition of the concept of independent inspection and expertise where applicable.

ELETRONUCLEAR has established its quality assurance programs for Angra 1 and Angra 2, in accordance with the above-mentioned requirements and with the Standard CNEN-NN-1.26 “Safety in The Operation of Nuclear Power Plants”[11]. The corresponding procedures have been developed and are in use. The programs provide 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 programs are described in Chapter 17 of the FSAR of each unity.

The quality assurance system in use is also extended for non-safety-related activities.

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, is responsible for the verification of implementation of ELETRONUCLEAR Quality System, by means of internal and external audits and surveillances, which are performed in accordance with written procedures. Audit and surveillance reports are formally distributed to the organizations responsible for the areas object of the audits/surveillances.

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 2007-2009, CNEN conducted 39 inspections in Angra 1, 14 in Angra 2, 3 in the preparatory work at Angra 3 and 9 related to the whole plant organization.

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.

Article 14 Assessment and verification of safety

Article 14 (1) Assessment of safety

A comprehensive safety assessment is a requirement established by the licensing regulation in Brazil[7].

As established by this regulation, 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 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 - 0800).

Licensing regulation CNEN NE 1.26, [11], requires that a Periodical Safety Review (PSR) be performed for each operating nuclear power plant at 10-year intervals.

The first Brazilian PSR was performed for Angra 1. About two years of preparatory work were spent gathering and evaluating international experience on the subject before the final approach for PSR development 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[11], 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:

- Need for a 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.

To date of the order of 70% of the Angra 1 PSR action plans have been completed. The remaining ones for which work is in progress refer essentially to long term action plans, as for example, development of new PSA studies, completion of implementation of fire protection measures and evaluation of isotopic content of existing radwaste drums.

In this review period an extensive scope of new deterministic safety assessments have been performed for the Angra 1 NPP, to support its steam generators replacement.

The whole Safety Analysis chapter of the Angra 1 FSAR, covering the plant transients and accidents, was revised. A new LB-LOCA analysis was performed, consisting in the development of 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.

ELETRONUCLEAR has also submitted to CNEN approval the documentation relative to the use of a new fuel design (Westinghouse 16x16 Next generation Fuel – 16NGF, jointly development by Westinghouse, Korea Nuclear Fuel-KNFC and Indústrias Nucleares do Brasil) and a power increase. All this major design changes required additional safety analyses. The evaluation process carried out by CNEN was finalized in 2009. The new fuel may be introduced in the core in the 2010 refueling outage.

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 has been 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.

The PSR for Angra 2, which completes its 10^{th} year of operation in 2010, is in the planning stage, to be started this same year. The methodology to be used will be the same developed for the Angra 1 PSR.

For the Angra 2 also, a major scope of deterministic safety assessments, covering plant transients and accidents, has been performed in this review period, to support the licensing of a 6% increase of Angra 2 power, together with a fuel design change (HTP - high thermal performance fuel with M5 cladding) . Reanalysis of the LB-LOCA with uncertainty quantification was part of the assessment.

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 2003-2009.

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 $3.5x10^{-5}$/year to 4.7 $x10^{-5}$/year and to an increase of the contribution of the initiating events “Loss of external power” and “station blackout” to the integral CDF.

The major routine application for this PSA is Configuration Risk Management

(CRM), which consists on the identification of the allowable plant configurations for on-line maintenance planning, based on evaluation of the risk rate and the weekly cumulative risk resulting from the different plant configurations associated with the maintenance program.

Another routine application is the evaluation of the impact on the overall plant risk of all proposed plant modifications.

As a further application, the Angra 1 level 1 PSA was used to support the development of the Maintenance Rule, which consists in orienting the maintenance program to emphasize maintenance of the components that have more influence on the plant risk, in accordance with the NUMARC 93-01 Revision 2.

In early 2006 a reprogramming of the planned PSA studies for both plants, based on CNEN requirements and recommendations of the Angra 1 PSR, was performed, based on more realistic evaluation of the timing and available resources. The scope, for both plants, includes PSA level 1+, including fire and internal flooding for power, shutdown and low power states, and later a level 2 PSA, involving development of eight major studies, for which it was assumed an average of 24 month for performance of each study. Completion of the whole program is planned for 2015.

The main PSA development activities for the Angra 1 plant performed to date within this program were:

- Extension of the existing level 1 study to level 1+; completed in December of 2006;
- Model improvements for the above PSA study, including pump seal LOCA, review of reliability of high pressure safety injection valves, evaluation of reliability of the control room air conditioning; completed in 2008;
- Revision 0 of the Angra 1 Fire PSA, performed jointly with EPRI, using the state-of-the-art methodology of EPRI TR-1011989 (NUREG/CR-6850), EPRI/NRC-RES “Fire PRA Methodology for Nuclear Power Facilities”; started in February 2007 and completed in August 2010.
- Support to the development of Severe Accident Management Guidelines (SAMG) for Angra 1, based on the Westinghouse Owners Group (WOG) SAMG methodology; completed in end of 2009 (see Article 19(4)).

For the Angra 2 plant, a preliminary evaluation of the 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.

The estimated Angra 2 core damage frequency (CDF) for internal events, obtained from this approach was 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 an at-power specific level 1+ PSA for Angra 2, considering internal events and flooding, was signed with an experienced external contractor in the end of 2004, to be developed in a 30-month period, up to mid 2007. This study was incorporated in the previously mentioned PSA development program. The main PSA development activities for the Angra 2 plant performed within this program were:

- Conclusion of revision 0 of the level 1+ PSA of Angra 2 by the external contractor, in mid 2008;
- Conclusion of revision 1 of this PSA, performed internally, in mid 2009, with implementation into the model of the identified required modifications;
- Development of application of the Angra 2 Risk Monitor, using the above PSA model, for Configuration Risk Management of on line maintenance of this Plant; in progress.
- Participation in the preparation of guidelines and Terms of Reference for the contracting of the development of a Severe Accident evaluation model and SAMG for Angra 2, to be done with the support of the European Union, taking advantage of a recently signed Cooperation Protocol between Brazil and the European Union, in which the EU provides funding for safety improvement projects. This project is to be initiated in beginning of 2011 with a planned 3-years execution period;
- Support to the development of the Maintenance Rule for the Angra 2 Plant.

In early 2010 the development of the Maintenance Rule for the Angra 2 plant was completed. This work was developed internally, led by the Maintenance department, with involvement of the Plant Engineering, Operations and PSA areas. Work for its implementation is in progress.

Some of the main insights resulting from the Angra 2 level 1+ PSA were:

- The existing procedure of Feed and Bleed from the Secondary side for the beyond design event of total loss of feedwater is too complicated resulting in a too large probability of human error and failure of the procedure;
- Connecting the bus bars of the 4 redundancies of the two existing Emergency Diesel 1 (large Diesels) and 2 (small Diesels) power supply nets, in such a way that in case of failure of a Diesel 2 of one or more redundancies, the bus bars of these redundancies are fed by the corresponding Diesel 1 bus bar redundancies, is an effective risk reduction measure. This feature already exists in the German plants of the Angra 2 family but was not implemented in Angra 2.
- Provision of double secured power supply for some critical secondary side valves, required for DBA and BDBA accident control will contribute effectively to risk reduction.

The resulting CDF obtained for the Angra 2 plant is of the order of $2x10^{-5}$ per reactor.year, which, when compared to the CDF of its German sister plants, is almost an order of magnitude higher.

A part of this difference can be explained by lack of some of the safety features listed above. However the major part arises from differences in assumptions when following American PSA guidelines as used for Angra 2, or German guidelines. To attempt to clarify this discrepancy an independent review is being contracted with the German Institute for Reactor Safety - GRS.

Another important insight arising from the ELETRONUCLEAR PSA development program is that to have a usable PSA model in accordance to up-to-dated methodology takes considerably longer than expected, even without any unforeseen problems. The issuing of the revision 0 of the Angra 2 PSA level 1+ and Angra 1 Fire PSA, both performed with well known and well experienced consultants, required 1 to 2 years more than the original planning.

All technical documents submitted to CNEN by the licensee go through a process of safety assessment by CGRC. The result of this process is documented on technical reports, which contain the review findings. These findings may accept the document, require further information, identify non-compliance with regulations or require further action by the licensee.

In the period 2007-2009, the four divisions of CGRC produced 213 technical reports related to the three Angra plants. Out of this total, 92 were related to Angra 1, 49 to Angra 2, 65 to Angra 3 and 7 to the common site of these plants.

Over the years, the CGRC assessment of Angra 1 PSA study yielded over 150 requirements. Most of the pending issues are expected to be resolved by the new revision of the Angra 1 PSA.

The CGRC assessment of the level 1+ PSA of Angra 2 produced ten technical reports.

Article 14 (2) Verification of safety

On the utility side, the main elements for continued verification of safety are:

- Verification of strict adherence to the safety limits, limiting conditions of operation, repair times, system operability criteria and surveillance requirements established in the Technical Specifications (see Article 19(2));
- Verification of strict adherence to the ISI program;
- Verification through PSA tools of the allowable risk for the on line maintenance plant configurations (see Article 14(1));
- Verification of the adherence to the predictive and preventive maintenance program;
- Development and follow up of a comprehensive set of performance and safety indicators (see Article 6).
- Verification how safety problems from external operational experience affect the safety of the Brazilian Plants (see Article 19(7)).

On the regulatory side, to verify the safety of the operating plants CGRC makes use of two levels of surveillance. The first is a continuous inspection of activities carried out by the division of Resident Inspection. These on site inspectors have procedures to verify the execution of several activities such as periodic tests, maintenance actions, control room activities, evaluation of operational events, etc. and to report any deviations. The second is the yearly preparation of a Inspection and Audit Program to be implemented along the year by the headquarters divisions of CGRC. This inspection program may be complemented along the year as necessary. All inspections and audits are documented on Inspection Reports.

In the period 2007-2009, CGRC performed 75 inspections and audits. Out of this total, 39 were at Angra 1, 14 at Angra 2, 3 at Angra 3 and 9 on the common site. Also during the period there was no violation of any limiting condition for operation (LCO), neither of any Completion Time.

Article 15 Radiological protection

Radiological protection requirements and dose limits are established in Brazil in the regulation for radiological protection CNEN–NN–3.01–Radiological Protection Basic Directives [17], 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. 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 Radiological Protection 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 Radiological Protection Program of Angra 1 and Angra 2, included in the Final Safety Analysis Reports, sets forth the philosophy and basic policy for radiological 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.

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 all averaged annual accumulated individual doses below 1 mSv and no one with radiation dose above 14 mSv in the 2007-2009, despite the large amount of additional activities performed in 2008 and 2009 for the replacement of the Angra 1 steam generators. The dose distribution for the 2007 – 2009 period is summarized in the Table 4, shown below.

Table 4 - 2007-2009 DOSE DISTRIBUTION FOR ANGRA 1 AND ANGRA 2

Year	2007 (Film Badge)		2008 (Film Badge)		2009 (TLD)	
	Number of Persons		Number of Persons		Number of Persons	
Dose Range (mSv)	**A1**	**A2**	**A1**	**A2**	**A1**	**A2**
0.0 <-- 0.2	1113	1339	1314	1468	1923	2462
0.2 <-- 1.0	383	271	404	220	763	399
1.0 <-- 2.5	228	77	204	77	434	30
2.5 <-- 5.0	129	9	94	20	157	0
5.0 <-- 7.5	51	1	22	1	12	0
7.5 <-- 10	20	0	0	0	12	0
10 <-- 15	18	0	0	0	1	0
15 <-- 20	0	0	0	0	0	0
20 <-- 50	0	0	0	0	0	0
50 <---	0	0	0	0	0	0
Total of Persons	1942	1697	2038	1786	3302	2891
Highest Dose (mSv)	13.60	5.00	7.10	5.00	11.40	2.30
Median Dose (mSv)	0.15	0.05	0.11	0.04	0.14	0.03
Average Dose (mSv)	1.00	0.28	0.60	0.28	0.66	0.19
Collective Dose (person.mSv)	1662	250	925	283	1772	204

The annual collective dose of the last 3 years reflects the mobilization for Angra 1 steam generator replacement. For the coming years, efforts are in place to reduce the collective doses for Angra 1, aiming to values below the industry average, by improving the ALARA planning of the activities, including source term reduction, additional shielding, and better use of human performance tools.

A plant ALARA Commission for each Plant, composed of different groups (Operation, Maintenance, Chemistry, System Engineering and Radiological 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.

Additionally, the ELETRONUCLEAR Radiological Protection organization achieved the accreditation for two of its laboratories, the Thermoluminescent Dosimetry Laboratory and the Secondary Standard Dosimetry Laboratory for Radiation Instruments Calibration. A third laboratory, the In Vivo Dosimetry Laboratory, is in accreditation process, integrated within an IAEA program for accreditation, and the process for the In Vitro Internal Dosimetry Laboratory is in progress for implementation.

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 CNEN NN –1.14[10], an Effluents Releasing and Wastes Report is issued every semester, documenting the liquid, gaseous and aerosol effluents: batch number, radionuclides present and their concentration, waste quantity and type sent to radioactive waste facilities and the meteorological data in the period.

Also in this report, the effective equivalent dose for the critical individual is presented. In the period of 2007-2009, this dose reached the average value of 1.4E-03 mSv/year, which is much lower than the 1 mSv/year value and the dose constraint value of 0.30 mSv/year, established in regulation CNEN-NN-3.01 [17].

The environmental institute IBAMA monitors the impact of the plants on the environment through a system of inspection in which the State Institute for the Environment (INEA) and the Prefecture of Angra dos Reis also participate.

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) 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, for the period 2007-2009.

Table 5. Environmental Monitoring Program Results for 2007-2009

	Year		
	2007	**2008**	**2009**
	Measured values in mSv/30 days (E-2)		
I – Impact Area	7,00	7.40	6.71
C – Control Area	5.75	6.40	5.80

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

As it can be seen from the above Table 5, there is essentially no variation of the measured values in the survey periods. The average values for the Impact and Control areas measurements are statistically equivalent, indicating the absence of radiological impact from the power plants.

Article 16 Emergency preparedness

Article 16 (1) Emergency plans and programs

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.

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.

Modifications in the meteorological data acquisition and processing system as agreed with CNEN, are scheduled for implementation in the next four years. These modifications consist on the relocation of two existing towers and installation of a new one, the installation of the Danish ARGOS (Accident Reporting and Guiding Operational System) radiological plume evaluation code system and an upgrade in the meteorological data acquisition and transmission to CNEN.

The On-site Emergency Plan involves several levels of activation, from Unusual Event, Site Alert, Site Area Emergency up to General Emergency.

The initial notification for activation of the On-site Emergency Plan is done by the Shift Supervisor from the Control Room, which notifies the Plant Manager, as Emergency Group coordinator, which alerts the coordinators of the other Emergency Groups, the Site Superintendent and the Authorities (CNEN 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.

The On-site Emergency plan is revised every two years. A specific revision will occur before the first core load of Angra 3, which construction has formally started in June 2010 (first pouring of concrete at reactor building base plate).

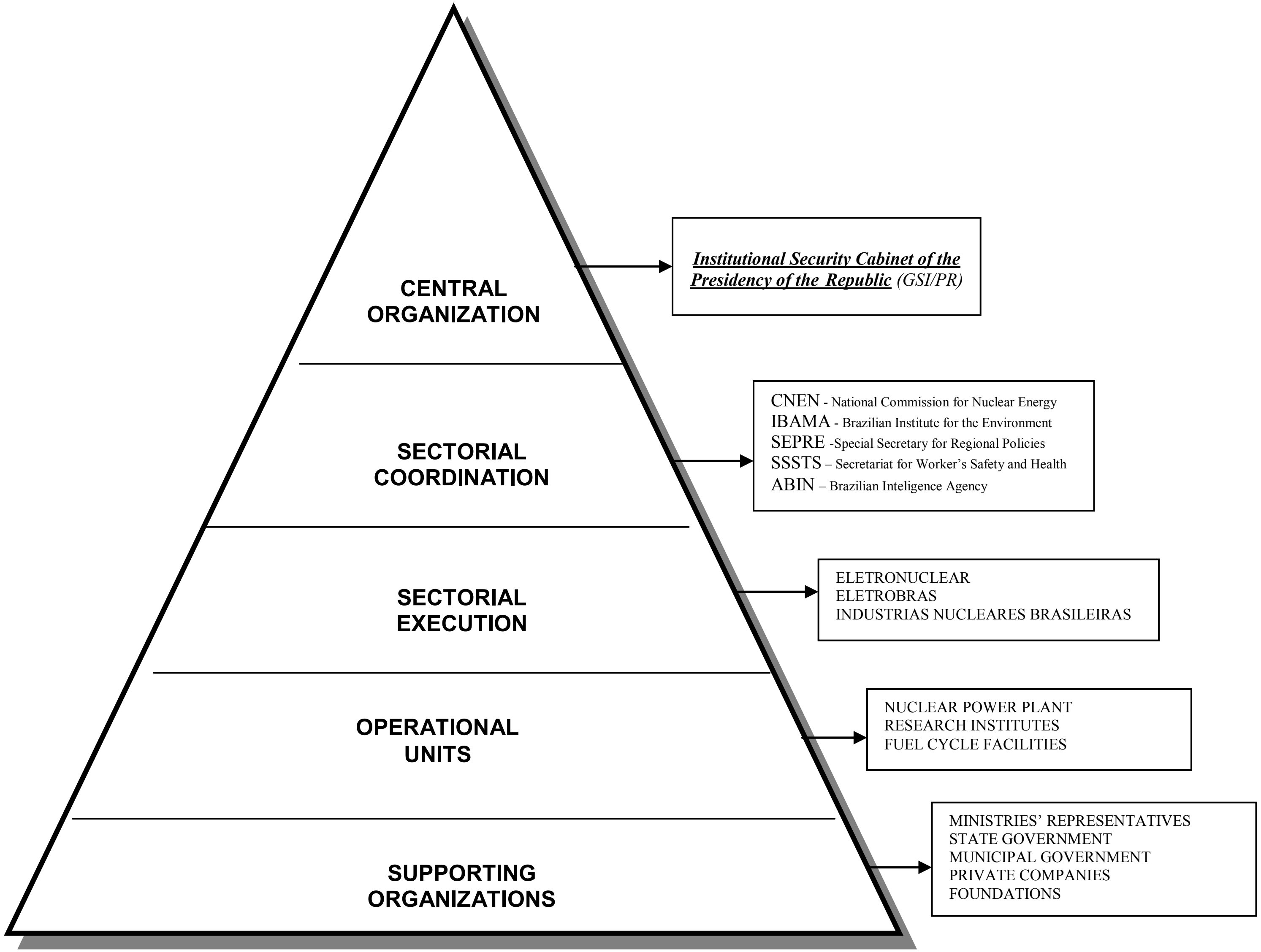
Off Site Emergency Preparedness

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. 4).

Within SIPRON, the Central Organization issued a set of General Norms for Emergency Response Preparedness [18], 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 II).

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. 4. 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 unusual event through 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 Ministry of Science and Technology (MCT) and since 2009 in the Institutional Security Cabinet of the Presidency of the Republic (GSI/PR)

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 [18],[19] (See also A.2.5 of Annex II) and in the new revision of Rio de Janeiro State Plan for External Emergency, approved by the state governor by Decree 40.908 of August 17-2007.

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. Full-scale exercises were performed in 2007 and 2009 (with the presence of 12 international observers from eight countries and 15 domestic observers), and a partial exercise is scheduled for September 2010. 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 GSI/PR.

With respect to emergency planning, a manual containing quality assurance guidelines for emergency response planning has been issued and implemented since 2003.

In order to comply with the Angra 2 TCAC requirements relative to emergency planning 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. The resulting recommendations were incorporated into a long term action plan, already implemented. 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 included an agreement between ELETRONUCLEAR and the National Transports Infrastructure Department (DNIT) to improve the BR-101 federal highway passing through the Angra site, at a cost of about 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.

As for the On–site Emergency Plan, the Off-site Emergency plan will be revised before the first core load of Angra 3 nuclear power plant, presently under construction.

Article 16 (2) Information of the public and neighboring states

Regarding information to the public, SIPRON norm NG-05 [20] 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 defence, 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. A daily silent sirens test is also done. The information about these tests is included in the calendar that is distributed every year to the whole population within the EPZ-5. These 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.

Article 17 Siting

Article 17 (1) Evaluation of site related factors

The Brazilian siting regulation, CNEN 09/6[8] and CNEN NE 1.04, Licensing of Nuclear Installations [7], require a site approval before the issuance of a construction authorization. The Angra site was approved for 3 nuclear power units. As established in these regulations, a site approval is issued after Regulator review and acceptance of, at least, the following information:

- General and safety characteristics of the proposed plant design;
- Population distribution, existing and planned roads, use of the area surrounding the site and distances to population centers;
- Physical characteristics of the site, including seismology, geology, hydrology and meteorology;
- Preliminary evaluation of potential effects on the environment resulting from plant construction and operation (normal and accident conditions);
- Preliminary site environmental pre-operational monitoring plan

Site related factors, in particular, those that affect nuclear safety, have been reviewed at specific times, that is, before issuance of the construction licenses for each one of the 3 nuclear power plants, during plant Periodic Safety Reviews or whenever new knowledge about external events that might affect the Angra site arose, indicating the need for such reviews.

The evaluation of all site related factors affecting the safety of the nuclear installations was initially performed for the design of the Angra 1 nuclear power plant in the 1970s. The American Weston Geophysical Corporation was involved in the geological and geophysical investigations of the region and site, together with Brazilian organizations. These investigations were reviewed during the 1980s for the design of Angra 2, the second plant to be built in this same site. The seismic catalogue and the geological faults were updated in 1998 by involving seismologists of the Institute of Astronomy and Geophysics of the University of São Paulo, considering the state of the art at that time. At that time, the installation of a seismometer was planned for the site, in order to study regional seismological aspects as micro-seismic events, analyze the propagation and attenuation of seismic waves and the crustal regional structure. This seismographic installation has been operating since the beginning of 2002.

As a preparation for the restart of Angra 3 construction, a Probabilistic Seismic Hazard Analysis (PSHA) was performed by specialists from Pontificia Universidade Católica – PUC, RJ (1999-2000), considering the previously mentioned seismic catalogue. The original horizontal Peak Ground Acceleration (PGA) of 0,1 g for Safe Shutdown Earthquake, which was deterministically adopted for the site, was confirmed by the PSHA.

In the context of the Angra 1 Periodic Safety Review (PSR), performed in 2004-2005, all external events assumed for the design of the plant structures have been reviewed. The seismic catalogue was updated considering seismic events up to December 2003. The seismic hazard analysis was updated in 2005.

The result of the PSR, as already reported in the previous Brazilian National Report, was that the original assumptions concerning seismic design response spectra, maximum floods and storms as well as off site explosions, were found to be still valid. A research on tornado events in the region (not considered in the original design basis) was also started at that time and presented a negligible probability of occurrence for the site**.**

A recent comprehensive review of site conditions was carried out, contemplating the newest version of the applicable regulations, in preparation for the restart of construction of Angra 3. Natural external events such as explosion, aircraft crash, meteorological and severe weather conditions, external flooding and earthquakes, as well as human made external events, were re-evaluated by experts from different research institutes in Brazil, considering the state of the art. The results of this review are presented in Article 17(3).

The site related design criteria for the first two plants, Angra 1 and Angra 2, built in the Angra site are listed below:
Angra 1 was designed to resist the following external events:

- Two Earthquake levels are considered in the plant design: OBE (Operating Basis Earthquake) and SSE (Safe Shutdown Earthquake; this is also named as DBE – Design Basis Earthquake for this plant design).
- TNT explosion (20 tons) from a truck on the road close to the site, considered according to NRC RG 1.91 (1975).

Angra 2 was designed to resist the following external events:

- Two Earthquake levels are considered in the plant design: DBE (Design Basis Earthquake) and SSE (Safe Shutdown Earthquake).
- SSB load case, from the combined effects of a Safe Shutdown Earthquake (SSE) and a Burst Pressure Wave (BPW) is also considered for the main class 1 structures (structures that are required for plant shutdown and residual heat removal in case of SSE).
- TNT explosion (23 tons), considered according to NRC RG 1.91 (1978).

Both Units 1 and 2 were designed for the following external events:

- SSE level earthquake corresponding to 0,1g horizontal peak ground acceleration on the rock surface supporting the plants foundations.
- External flooding: considering a 10000 years return period flood and that the water will accumulate on the site to a maximum height of 60 cm;
- A conservatively adopted wind speed of 45 m/s and ASCE Standards used for design.

Due to the very low probability of occurrence the following external events were not considered in the design of Units 1 and 2 at Angra site:

- Tornadoes, waterspouts and hurricanes;
- Tsunamis;
- Aircraft crash

The demographic distribution in areas that affect the emergency preparedness plan continue to be evaluated. 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, and its update performed in 2007.

Article 17 (2) Impact of the installation on individuals, society and environment

The basic criterion concerning the impact of introducing a new industrial installation in a given site is that it should have minimum adverse effects on individuals, society and the environment.

For a nuclear power plant, the major impact is associated to the potential of radioactive releases, in normal operation or accidental conditions. Minimization of this risk is ensured by a design that adequately incorporates all levels of the "defense in depth" concept as demonstrated by deterministic safety analyses and complemented by probabilistic safety analyses.

The nuclear licensing of a new plant consists in the verification of compliance to the above criteria before issuing construction and operation licenses. These same criteria are monitored during plant operation and in particular, when performing a plant PSR, for authorization of continuation of plant operation.

Control and mitigation of Beyond Design Events are covered by symptom oriented Emergency Operating Procedures and in case of Severe Accidents, by Severe Accident Management Guidelines.

A well structured Emergency Plan is the last level of defense in depth for protection of the population.

The level of compliance of the Brazilian nuclear power plants to the above criteria is described in the text of the different Articles of this report.

The environmental licensing for authorization of construction and operation of a new plant contemplates, besides de radiation risk covered by the nuclear licensing, all other potential adverse effects arising from plant construction and operation activities on the population and environment in the area of influence of the plant.

For the Angra 1 plant, with construction started 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 license by FEEMA, as described in Article 7.

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" require an environmental license. This involves the development of an Environmental Impact Study (EIA) and the preparation of an Environmental Impact Report (RIMA) before site approval. Since the Angra site had already a nuclear power unit, Angra 1, in operation, the environmental licensing of Angra 2 included the preparation of an EIA/RIMA only for the operation license. These documents were reviewed by IBAMA in cooperation with CNEN and, from their evaluation, a Basic Environmental Project (PBA) was established and implemented by ELETRONUCLEAR.

The RIMA constitutes the main document for interaction with the public, and was thoroughly 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.

The environmental licensing of Angra 3 involved preparation of a new EIA/RIMA specific for this plant, submitted to IBAMA in 2005. The environmental Installation License (equivalent to the nuclear Construction License) was issued in 2009.

Article 17 (3) Re-evaluation of site related factors

A re-evaluation of site parameters as well as of the external events considered in the design of the existing Nuclear Power Plants, Angra 1 and Angra 2, performed in the context of the Angra 1 Periodic Safety Review (PSR), conducted until 2005, had confirmed the validity of the original assumptions.

As documented in the Angra 3 Preliminary Safety Analysis Report (PSAR) recent re-evaluations of the design criteria for external events, were performed for the new Angra 3 plant. This re-evaluation resulted in some external event design criteria differences when compared to the ones applied to Angra 1 and 2, basically due to new requirements in the present revision of the regulations applied for Angra 3.

These differences, as discussed below, do not have a substantial impact on the original site external events design criteria and are considered additional improvements agreed between CNEN and ELETRONUCLEAR to be applied for a new plant.

- All class 1 structures, systems and components shall be designed to resist a SSB load case, from the combined effects of a Safe Shutdown Earthquake (SSE) and a Burst Pressure Wave (BPW). The original horizontal Peak Ground Acceleration (PGA) of 0.1 g for SSE, which was deterministically adopted for the site, was confirmed by a Probabilistic Seismic Hazard Analysis (PSHA).

- All class 1 structures shall also be designed to resist tornado effects and an explosion from a TNT-loaded truck on the road in the vicinities. The tornado hazard analysis showed that a design for a medium EF3 (Enhanced Fujita scale) is a conservative assumption for the site.

- The maximum wind velocity was revised, taking into account the available data from CNAAA meteorological towers, Unit 3 location in the site and a 100-year-return period. Therefore, a maximum basic wind speed of 41.0 m/s was adopted and the Brazilian Standard for wind loads on civil structures shall be used to determine the characteristic wind speeds and the pressure coefficients. This revision does not represent a significant change of the site parameters adopted for Units 1 and 2, where a wind speed of 45 m/s was conservatively adopted, but other standards, such as ASCE, were used for design.

- Regarding water level (flood), precipitation and sea level were re-evaluated without significant consequences on plant design. The drainage system in the vicinity of Unit 3 is designed considering rainfalls with recurrence period of 10,000 years. Unit 3 ground-level is 1 (one) meter higher than Units 1 and 2. The access to safety buildings are placed 45 cm above ground level (+6.15 m), assuring that no flood will affect the plant operation.

Article 17 (4) Consultation with other Contracting Parties likely to be affected by the installation

Due to the special geographical situation Angra site, no other Contracting Party is expected to be affected by the construction and operation of the nuclear power plant. Therefore, no consultation with neighboring countries is included in the licensing process.

Article 18 Design and construction

Article 18 (1) Implementation of defence in depth

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[7] 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. Safety principles such as passive safety or the fail safe function, automation, physical and functional separation, redundancy and diversity was also incorporated in the design.

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.

Article 18 (2) Incorporation of proven technologies

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. 3) under the Technical Directorate. With the recent approval of restart of construction for the Angra 3, this unit had to be restructured and enlarged to be able to perform its scope of activities.

Due to the long delay of Angra 3 construction, new design features can be incorporated in the design, especially in the area of instrumentation and control, taken into account the current development of the technology. However, only proven technology already used in other reference plant is planned to be incorporated.

The proposed use of digital technology for the plant instrumentation will pose a challenge, not only to the licensee, but to CNEN as a reviewer as well.

Article 18 (3) Design for reliable, stable and manageable operation

As mentioned in Article 12, human factor was not a major issue at the time of design of Angra 1, and several reevaluation and backfittiings were carried out in this area along the plant life. For Angra 2, more automation was already incorporated in the design, taken into account the state of the art of the technology. For Angra 3, it is expected that even more advances will be taken into account.

From the regulatory point of view, more attention will be taken with respect to these aspects, and the requirement for a Human Factor Engineering evaluation will be repeated for Angra 3.

Article 19 Operation

Article 19 (1) 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 Article 7(2)(ii), legal disputes related to the environmental licensing are under way. Due to this dispute, 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 2007-2009, CNEN conducted 39 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 2007-2009, CNEN conducted 14 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 9 inspection covered areas of the organization common to both units, such as Meteorology Systems, Emergency Planning, Physical Protection, Waste storage and Training.

Article 19 (2) Operational limits and conditions

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.

The Angra 1 Technical Specifications are under review to change its format to the Westinghouse design - Standard Technical Specifications and to translate to the Portuguese language. A proposed version has been submitted to CGRC and the analysis yielded 53 requirements. The licensee has responded to some of these requirements and they are presently under analysis.

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.

For Angra 2, the operability criteria of the systems, as required in the Limiting Conditions for 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.

Article 19 (3) Procedures for operation, maintenance, inspection and testing

Safety requirements during operation are established by regulation CNEN-NE-1.26 [11]. Additional CNEN regulations establish more detailed requirements for maintenance [21] and in service inspection [22].

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.

Article 19 (4) Procedures for responding to operational occurrences and accidents

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 (severe accidents). 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 Article 12), 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.

Severe Accident Management Guidelines have been developed for the Angra 1 plant in the 2008 – 2009 period, through a contract with Westinghouse, using the Westinghouse Owner Group (WOG) concept. This concept was applied to essentially all Westinghouse PWR in the USA and abroad and was developed to address elements of USNRC Severe Accident Management Program (SECY-89-012).

The WOG SAMG provides structured guidance for: (1) Diagnosing plant conditions (2) Prioritizing response, (3) Evaluating alternatives and (4) Verifying implementation of actions, being a process for choosing appropriate actions, based on actual plant conditions.

No detailed knowledge of Severe Accident phenomena for the specific plant is required and the SAMG measures rely basically on existing equipment.

The resulting documentation consists of guidelines for the control room operators for the initial transition from the EOP to SAMG; guidelines and computational aids to be used by the Technical Support Center staff that takes over operator orientation for control and mitigation of the event when using SAMG; SAMG background material and training material.

Development of a program to provide SAMG for the Angra 2, was pursued along 2009, taking advantage of a recently signed Cooperation Protocol between Brazil and the European Union, in which the EU provides funding for safety improvement projects.

Deviating from the SAMG approach used for Angra 1 the scope of this project involves the development of an Angra 2 specific Severe Accident Evaluation Model, to perform the analyses that will provide the bases for the preparation of the SAMG. A 3-years execution period, beginning in January 2011 is foreseen for this project, which will have a substantial ELETRONUCLEAR participation.

Article 19 (5) 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.

Article 19 (6) Reporting of incidents significant to safety

Reporting requirements to CNEN during operations are established in regulation CNEN-NE-1.14 [10].

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.

In addition, with the purpose of dissemination of operational experience that may be of value for other nuclear power plants, the ELETRONUCLEAR reports on the order of 5 significant events per plant/year to WANO and INPO.

The International Nuclear Events Scale (INES) is used to classify the safety significance of the events in the event reports.

Only INES events of level 0 have been reported to CNEN in the period by Angra 1 and 2.

- Angra1 reported 6 events in 2007, 8 in 2008 and 9 in 2009.
- Angra 2 reported 7 events in 2007, 4 in 2008 and 5 in 2009.

Event reports of lesser safety significance, as well as operational deviations that do not classify as reportable in accordance to regulation CNEN NE – 1.14, are available for CNEN audit and review.

Article 19 (7) Operational experience feedback

The operational experience feedback process in Brazil comprises two complementary systems: one performed by ELETRONUCLEAR, 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. Of the order of 100 to 130 reports per Plant/year including significant events and operational deviations are produced per year. The main contents of these reports are the identification, classification and description of the event, the identification of the direct and root causes, the causal factors, the consequences to safety and the recommended corrective actions.

Of these reports, on the average 4-7 per year/Plant are formally reportable to CNEN (see statistics for 2007-2009 in Article 19(6)above) following the requirements of CNEN-NE-1.14 [10].

The internal safety committee at each plant (CROU) review these reports before release and the most significant ones, basically the ones that are reported to CNEN, have to be evaluated also by the CAON, the committee that evaluates the safety of operation. A subcommittee of the CAON has the task of analyzing all produced reports and feedback to the CAON any specific or general deficiencies of individual reports or in the reporting procedure.

As indicated in Article 19(6), ELETRONUCLEAR is committed to report of the order of 5 significant events /year/plant to the World Association of Nuclear Operators – WANO as well as to the Institute of Nuclear Operators – INPO. When pertinent, these reports are also supplied to VGB, the German Association of Plant Operators.

Beginning in 2007, the plants have started to collect minor events and near misses. In the first year there were collected about 700 minor events. In the following years this number has increased to about 2000 minor events/plant/year. The collected events are classified in families and trended.

Insights from evaluation of these trends are used to establish corrective actions, as for example the implementation of an extensive human performance improvement program, referred to in Article 12, Human Factors.

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.

Following recommendations from an IAEA PROSPER mission in 2007 (see Table 6), the task of collecting, analyzing and disseminating External Operating Experience (EOE) within Eletronuclear, formerly done by the Engineering Support area, has been reorganized, with the goal of promoting more participation of the Plants in the process, improving the effectiveness of the process.

EOE Committees were established at each unit with participants from the plants Support Engineering and Nuclear Safety divisions. These committees evaluate the collected EOE, the main sources being WANO and INPO Significant Event Reports, IAEA Incident Reporting System, VGB, EPRI, and reactor designer pertinent information. Furthermore, they issue and follow up recommendations implementation.

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.

Of particular importance are the invited Peer Review missions performed by WANO or the IAEA, as they aim to identify departure from industry best practices concerning safety and reliability in plant operation. ELETRONUCLEAR adhered to these review programs from their inception, and since 2004 has established policy of performing of a complete internal (self assessment) 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 2007 - 2009.

Another important mechanism of transfer of experience is the participation in review or technical support missions to other nuclear power plants. ELETRONUCLEAR has had, since a long time, a strong participation in this type of missions.

Table 7 presents a list of international technical missions with participation of Angra personnel to other plants during the 2007 – 2009 period.

Table 6 - International Technical and review Missions to Angra Site in 2007- 2009.

No.	Date	Organization	Location	Type of mission
1	07.02.2007	WANO	Main office/A1/A2	WANO-PC Exit Meeting-Peer Review-Angra 2
2	30.07.2007	WANO	Main office	WANO-PC Corporate Peer Review Exit Meeting
3	09.07 – 12.07.2007	WANO	A1/A2	Operation Decision Making Seminar
4	01.08 – 02.08.2007	WANO	A1	Preliminary Visit WANO-PC Peer Review
5	13.08 – 14.08.2007	WANO	A1	Preliminary Visit WANO-PC Peer Review
6	04.09 – 05.09.2007	WANO	A1/A2	Event Investigation Training Root Cause Analysis
7	23.10 – 31.10.2007	IAEA	A1	PROSPER (Peer Review of the Operational Safety Performance Experience Review)
8	26.11 – 14.12.2007	WANO	A1	WANO Peer Review
9	16.06 – 18.06.2008	WANO	A1	WANO Peer Review-Exit Meeting
10	30.06 – 04.07.2008	WANO PC	A1	WANO Assist Visit – Outage Management
11	07.07 – 11.07.2008	WANO PC	A2	WANO Peer Review – Follow up
12	22.09 – 26.09.2008	WANO AC	A1/A2	Human Performance Assist Visit
13	06.10 – 10.10.2008	WANO PC	A1/A2	Leadership Seminar
14	03.11 – 06.11.2008	IAEA RLA/9/060	A1/A2	Workshop on Maintenance Safety Optimization. IAEA Program “Enhancing Operational Safety in Nuclear Installations”.
15	24.06.2009	WANO	Main Office	Visit of Mr. Luc Mampaey (WANO Managing Director), Mr Laurent Stricker (WANO Chairman) , Mr Rémy Laffin (Assistant to Mr Stricker) and Mr. Ignacio Araluce (WANO PC Director)
16	July 03-10.2009	WANO PC	Main office/A1/A2	WANO PC Corporate Review Follow up
17	August 31 – September 04.2009	IAEA RLA/9/060	A1/A2	Workshop on Dedication Process, Qualification of Equipment. IAEA Program “Enhancing Operational Safety in Nuclear Installations”.
18	September 24 and 25.2009	IAEA	A1/A2	Development of a TECDOC : Role of the Periodic Safety Review , Configuration Management , updating Final Safety Analysis Report and Design Basis Documents in Plant Safety.
19	November 09-13	IAEA	A1	PROSPER Mission - Follow-up
20	November 16-19	WANO PC	A1/A2	Assistance Visit for Task Observation
21	November 23-27	WANO PC	A2/A3	Assistance Visit Digital Control Room and Simulator

A1/A2: Angra 1 / Angra 2 NPP
EPRI: Electric Power Research Institute
IAEA: International Atomic Energy Agency (Viena, Austria)
INPO: Institute of Nuclear Power Operations (Atlanta, USA)
OSART: Operational Safety Analysis Review Team
PROSPER: Peer Review of the Operational Safety Performance Experience Review
TECDOC : IAEA Technical Document
TRILLO: Nuclear Power Plant (Spain)
TSM: Technical Support Mission
WANO: Word Association of Nuclear Operators (PC – Paris Center, France)

Table 7 - Technical Missions of ELETRONUCLEAR Personnel to other plants in 2007 – 2009.

No.	Date	Leading Organization	Type of mission
1	2007 (20.01 - 11.02)	WANO	Peer Review - Technical Support – Cruas NPP - France
2	2007 (12.03 - 30.03)	WANO	Peer Review – Engineering Support – Krsko NPP, Eslovênia
3	2007 (13.04 - 06.05)	WANO	OSART – Training and Qualification – Yonggwang NPP, South Korea
4	2007 (03.04 - 25.05)	IAEA	OSART - Emergency Planning – Tihange NPP, Belgium
5	2007 (31.08 - 29.09)	WANO	Peer Review - Technical Support - Grohnde NPP, Germany
6	2007 (01.09 - 22.09)	WANO	Peer Review - Operations – Embalse NPP - Argentina
7	2007 (14.09 - 07.10)	WANO	Peer Review - Fire Protection –Trillo NPP- Spain
8	2007 (07.10 - 26.10)	WANO	Peer Review - Maintenance – Neckarwestheim NPP, Germany
9	2007 (26.10 - 18.11)	WANO	Peer Review - Maintenance – Heysham NPP- England
10	2008 (01.02 - 10.02)	WANO	Technical Support Mission – Industrial Safety – Almaraz NPP , Spain
11	2008 (29.02 - 23.03)	WANO	Peer Review - Operational Experience - Belleville NPP, France
12	2008 (02.05 - 25.05)	WANO	Peer Review - Operations – Sellafield Reprocessing Plant, England
13	2008 (13.06 - 22.06)	WANO	Peer Review Follow Up - Hartlepool NPP- England
14	2008 (31.08 - 19.09)	WANO	Peer Review – Fire Protection - Borssele NPP- Holland
15	2009 (17.04 - 26.04)	WANO AC / INPO	Peer Review - Operator Training – Tecnatom – Spain
16	2009 (12.10 – 30.10)	WANO PC	Peer Review – Fire Protection – Phillipsburg NPP- Germany
17	2009 (11.11 – 05.12)	IAEA	SCART Mission – Safety Culture – Laguna Verde NPP, Mexico
18	2009 (23.11 – 11.12)	WANO PC	Peer Review – Training – Heysham 2 NPP, England
19	2009(27.11 - 20.12)	WANO PC	Peer Review – Maintenance – Isar NPP - Germany
20	2009(01.12 – 19.12)	WANO PC	Peer Review – Technical Support – Rajasthan NPP- India

IAEA: International Atomic Energy Agency
INPO: Institute of Nuclear Operations, USA
SCART: Safety Culture Assessment Review Team
WANO: World Association of Nuclear Operators (AC: Atlanta Center, PC: Paris Center)

From the regulatory point of view, in 2007, CNEN/CGRC audited the licensee internal and external operational experience assessment system to evaluate its adequacy and found no non-compliance.

All Significant Events Reported by the licensee goes through a preliminary evaluation by the resident inspectors to check for any inconsistencies and for the adequacy of the applicable recommendations. A final analysis of the event is carried out by the headquarters divisions.

CNEN is a member of the IAEA-IRS technical cooperation program exchanging experience with other participant countries. Also CNEN has a bilateral technical cooperation agreement with German GRS to exchange experience in the areas of operational events, PSA and Aging programs. In the period there was a meeting per year with GRS personnel.

Article 19 (8) Management of spent fuel and radioactive waste on the site

Angra 1 nuclear power plant is equipped with systems for treatment and conditioning of liquid, gaseous and solid wastes. Concentrates from liquid waste 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 last five years comprise:

- Upgrade of the evaporator package for Angra 1.
- Supercompactation of 2027 drums of waste.
- 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. Additionally, there are also procedures established for clearance of radioactive waste.

According to the Brazilian legislation [23] 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 on-site initial storage facility located at the Angra site.

This facility is composed of three units, called Storage Facility 1, Storage Facility 2 and Storage Facility 3. Additionally, there is a Steam Generators Storage Facility for storage of the two old Angra 1 steam generators, replaced in 2009. All the referred Storage Facilities are presently in operation.

In Angra 2, all the produced waste is stored in a compartment of the Reactor Auxiliary Building, inside the Plant, called in-plant storage facility.

An extensive drum super-compacting campaign was executed between 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 Storage Facility 1 by additional five years.

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.

The inventory of waste stored at Angra site is presented in the Tables 8 and 9 below:

Table 8 - Waste Stored at Angra Site – Angra 1 NPP

Type of Waste	No. of Packages	Location
Concentrate	2902	Storage Facility 1/ Storage Facility 2 / Storage Facility3
Primary Resins	706	Storage Facility 1 / Storage Facility 2 / Storage Facility 3
Filters	477	Storage Facility 1
Non-Compressible	926	Storage Facility 1 / Storage Facility 3
*Compressible	633	Storage Facility 1
Secondary Resins	527	Storage Facility 1
TOTAL	**6171**	

**Supercompacted waste drums from Angra 1.The crashed drums were placed inside special metallic boxes.*

Table 9 - Waste Stored at Angra Site – Angra 2 NPP

Type of Waste	No. of Packages	Location
Filters	6	In Plant Storage (UKA building)
Concentrate	179	In Plant Storage (UKA building)
Primary Resins	72	In Plant Storage (UKA building)
*Compressible	107	In Plant Storage (UKA building)
TOTAL	**364**	

** Supercompacted waste drums from Angra 2. The crashed drums were placed inside special metallic boxes.*

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.

The inventory of spent fuel and the occupation of the respective Spent Fuel Pools at Angra site are presented the Table 10 below:

Table 10 – Spent Fuel Storage at Angra Units

Angra 1 NPP		Angra 2 NPP	
Spent Fuel Stored	**Occupation (%)**	**Spent Fuel Stored**	**Occupation (%)**
690	61%	384	35%

Conclusions on Article 19

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

Expectations for near future are good. The replacement of Angra 1 steam generators past 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 in recent years.

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 facilities.

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.

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 – INFCIRC/572.Rev3 (28 September 2009).

[3]National Report of Brazil – Convention on Nuclear Safety – Rio de Janeiro – September 1998.

[4]Second National Report of Brazil – Convention on Nuclear Safety – Rio de Janeiro – September 2001.

[5]Third National Report of Brazil - Convention on Nuclear Safety – Rio de Janeiro – September 2004.

[6]Forth National Report of Brazil - Convention on Nuclear Safety – Rio de Janeiro – September 2007

[7]Licensing of Nuclear Installations - CNEN-NE-1.04 - July 1984.

[8]Siting of Nuclear Power Plants - Resolution CNEN 09/69.

[9]Licensing of Nuclear Reactor Operator - CNEN-NN-1.01 - October 1979.

[10]Operational Reporting for Nuclear Power Plants - CNEN-NN-1.14 - 2002.

[11]Operational Safety in Nuclear Power Plants - CNEN-NE-1.26 - October 1997.

[12]Safety Policy of CNEN – Directive n.295 of 23 December 1996.

[13]Quality Assurance Policy of CNEN – Directive n.296 of 23 December 1996.

[14]Health Requirements for Nuclear Reactor Operators - CNEN-NN.1.06 - 1980

[15]Certification of Qualification of Radiation Protection Supervisors - CNEN-NN-3.03 - October 1997.

[16]Quality Assurance for Safety in Nuclear Power Plants and Other installations - CNEN-NN-1.16 – September 1999.

[17]Basic Radiation Protection Directives - CNEN-NE-3.01 – January 2006.

[18]General Norm for Planning of Response to Emergency Situations – SIPRON – NG–02 - 1996

[19]Directive for the Preparation of Emergency Plans related to the Unit 1 of Almirante Alvaro Alberto Nuclear Power Plant – SIPRON Directiva Angra – 1997.

[20]General Norm for Establishing Public Information Campaigns about Emergency Situations – SIPRON - NG-05 – 1997.

[21]Maintenance of Nuclear Power Plants - CNEN-NE-1.21 - August 1991.

[22]In-service Inspection of Nuclear Power Plants - CNEN-NE-1.25 - September 1996.

[23]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.

Annexes

I.– EXISTING INSTALLATIONS
I.1. Angra 1

Thermal power	1876 MWth
Gross electric power	640 MWe
Net Electric power	610 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

I.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

I.3. Angra 3

Thermal Power	3765 MWth
Gross electric power	1312 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
Construction restart date	1 July 2010
Core load	(2015)
First Criticality	(2015)
Grid connection	(2015)
Commercial operation	(2016)

II. RELEVANT CONVENTIONS, LAWS AND REGULATIONS

II.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.

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.

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

II.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.

II.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°.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).***

II.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).

II.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.

Estrutura Regimental e o Quadro Demonstrativo dos Cargos em Comissão e das Gratificações de Exercício em Cargo de Confiança do Gabinete de Segurança Institucional da Presidência da República (Nº V do Art. 1º do Anexo I – Órgão Central do Sistema de Proteção ao Programa Nuclear Brasileiro – SIPRON) (***Structure of the Institutional Security Cabinet of the Presidency of the Republic – Annex I – Central Organization for the Protection of the Brazilian Nuclear Program – SIPRON***) Decree nº 6.931 of 11.07.2009.

This 5th National Report was prepared by a Working Group from the following organizations:
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Central Organization for the Protection of the Brazilian Nuclear Program (SIPRON)

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August 2010.

CNEN
Comissão Nacional de Energia Nuclear

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Ministério da
Ciência e Tecnologia

Ministério de
Minas e Energia

Ministério das
Relações Exteriores

Gabinete de
Segurança Institucional da
Presidência da República

FIFTH NATIONAL REPORT OF BRAZIL