



SIXTH NATIONAL REPORT OF BRAZIL

***FOR THE
NUCLEAR SAFETY CONVENTION***



August 2013

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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 Depository 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.

Brazil has presented periodically its National Report prepared by a group composed of representatives of the various Brazilian organizations with responsibilities related to nuclear safety. Due to the implications of the Fukushima nuclear accident in 2011, an Extraordinary National Report was presented in 2012.

This Sixth National Report is an update of the Fifth National Report in relation to the Convention on Nuclear Safety articles and also an update of the Extraordinary Report with respect to the action taken related to lesson learned from the Fukushima accident. It includes relevant information for the period of 2010/2012.

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.

Following the recommendation of the Fifth Review Meeting and the Extraordinary Meeting, the information is provided according to the Guidelines Regarding National Reports (INFCIRC/572.Rev3) and the corresponding Summary Reports, which established a different structure for the Report and request additional information. 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 Brasil tem apresentado periodicamente os Relatórios Nacionais preparados por um grupo composto por representantes das várias organizações brasileiras com responsabilidades relacionadas com a segurança nuclear. Além disso, um Relatório Extraordinário foi apresentado em 2012 contendo uma avaliação das implicações do acidente da Central Nuclear de Fukushima e a descrição das ações tomadas em decorrência das lições aprendidas com o acidente.

Este Sexto Relatório Nacional do Brasil atualiza a informação contida no Quinto Relatório Nacional em relação aos artigos da convenção sobre Segurança Nuclear e também atualiza a informação do Relatório Extraordinário com relação à implementação das ações tomadas em decorrência do acidente. O Relatório apresenta as informações relativas ao período de 2010 a 2012.

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 Quinta Reunião de Revisão e da Reunião Extraordinária, as informações são apresentadas segundo o Guia para Elaboração dos Relatórios Nacionais (INFCIRC/572.Rev3) e os respectivos Relatórios Sumários que modificam um pouco a estrutura usada nos relatórios anteriores e requerem informações adicionais.

No sumário executivo no princípio do Relatório, são feitas 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, implantando 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 plants¹. 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 based on 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, it 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 power 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 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.

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

Currently, Brazil has two nuclear power plants in operation (Angra 1, 640 MWe gross/610 MWe net, 2-loop PWR and Angra 2, 1345 MWe gross /1275MWe net, 4-loop PWR), and one under construction (Angra 3, 1351 MWe gross/1275 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, and is due to start operating by 2017. 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.

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 U₃O₈ in situ, recoverable at low costs.

Brazil has an ongoing project to build a Multipurpose Research Reactor (RMB). With a maximum power of 30 megawatts and powered by uranium silicite enriched up to 20%, it has a neutron flux of over 2×10^{14} neutrons per square centimetre per second. Upon completion of its conceptual project, the reactor site was chosen and environmental impact assessments were already conducted. The basic engineering projects are under way, benefiting of the cooperation with Argentina.

Related to the nuclear fuel cycle, Uranium mining activities developed in the mine of Caetité have had an annual output of 400 tons of yellow cake, which is enough to meet the needs of both Angra 1 and Angra 2. Reconversion, pellet production and fuel fabrication for both plants is performed 100% in Brazil by INB. The enrichment facility in operation, Resende, has an installed capacity that accounts for 6% of the fuel used in the two power plants. Whereas full capacity in the enrichment process at national level has not yet been achieved, the goal of the Nuclear Industries of Brazil (INB) continues to be achieving self-sufficiency, as is already the case in the subsequent phases of the nuclear fuel cycle.

As was the case in other countries, the Fukushima accident highlighted the need to reassess not only domestic nuclear safety standards, but also the overall level of participation of nuclear power in the Brazilian energy mix. Since then, renewed domestic discussions have been taking place on the previous long-term planning studies on energy policy that outlined the convenience of building four new nuclear power plants in Brazil.

The National Energy Plan 2030 (Plano Nacional de Energia – PNE 2030), issued by the Ministry of Mines and Energy of Brazil through one of its organizations, the Energy Research Enterprise (Empresa de Pesquisa Energética – EPE), presents

three alternatives for the resumption of the Brazilian Nuclear Plan that includes a scenario of two new power plants with 1300 MW and four others of 300 MW average power. ELETRONUCLEAR jointly with EPE is in the final stage of development of the selection of suitable sites for the deployment of new nuclear power plants in the Northeast, Southeast and South. Considering the completion phase of studies for site selection, defining technology and beginning construction of the new nuclear power plants, the most likely date for starting their operation would be beyond 2021, in accordance with the decennial governmental plan, PDE 2021 (Plano Decenal de Energia), published by the EPE in March 2013.

A.3. Commitment to 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 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 Sixth 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 new information related to the period 2010-2012. But the Sixth National Report of Brazil has been prepared as a self-standing document, with some

repetition of the information provided in the previous Reports so that the reviewers do not have to consult frequently the previous documents. An additional Part D was prepared summarizing the current status of the Action Plan related to the implementation of lessons learned from the Fukushima accident.

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 three annexes providing more detailed information on the nuclear installations, on the implementation status of the Fukushima Action Plan 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 has 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. The plant was originally designed in the 1970's, however all the changes introduced in Angra 2 due to internal and external operational experience as well as regulatory requirements have also been incorporated into the Angra 3 design. Furthermore, an evaluation and incorporation in the Angra 3 design of the safety relevant differences of the recent versions of the pertinent standards and regulations was required for the issuing of the Construction License in 2009. One substantial remaining challenge to both the Operator and Regulator is associated to the implementation and the licensing of the new digital control and protection systems and the computerized control room to be installed for the first time in Brazil, which 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 following:

1. Independence of the regulatory body: this topic has been dealt with by a proposal to reorganize the nuclear activities in Brazil. 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.
2. Assessment of safety culture: it has been carried out periodically by ELETRONUCLEAR, since it was the first company to apply a safety culture self-assessment in 1999, with the assistance of the IAEA. Further safety culture assessment was included in the 2011 OSART mission in Angra 2 NPP by IAEA decision, despite the company request of performing a separate SCART mission.
3. Periodical Safety Review (PSR): in this respect, Angra 1 PSR was evaluated and the corresponding Action Plan is essentially completed as described in Article 14(1). The PSR for Angra 2 was completed in November, 2012, covering the first 10 years of plant operation.
4. 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).

With respect to the first item of this list, a Technical Meeting on Recent Licensing of New Nuclear Power Plants was organized by the CNEN, together with the Brazilian Association for the Development of Nuclear Activities (ABDAN) in Rio de Janeiro, from 7 to 9 November 2012.

The objective of the Meeting was to present, discuss and compare the regulatory infrastructure, licensing procedures and methodologies currently been used to license and supervise new nuclear power plants. Specialists from organization that are currently licensing nuclear power plants, were invited from Argentina, China, France, Finland, India, Republic of Korea, United States of America, and the International Atomic Energy Agency.

Some of the several conclusions of the meeting were:

1. Different nuclear regulatory structures exist in different countries, reflecting different legal systems and practices.
2. IAEA Safety Requirements form a good basis for establishing the Regulatory Body and specifying its responsibilities and activities. These are generally covered by all participant countries, using different structures.
3. The question of the effective independence of the Regulatory Body was discussed at length, but it was recognized as a subject of difficult external evaluation.
4. The finance of the regulatory body also presents a broad range of practices, but it was stressed that adequate financing is essential; and licensing fees should not conflict with the effective independence of the Regulatory Body.
5. All Regulatory Bodies receive pressure from licensees to complete their review on time and avoid over-regulating, but they have to maintain their commitment to safety in a transparent manner as viewed by all stakeholders.

The suggestions made for Brazil ate the conclusion of the meeting were:

1. Brazil should proceed with the proposal of transforming DRS in a fully independent Regulatory Body without any ties with promotion activities. The decision on to where the new National Nuclear Safety Agency reports should not impair its capability to take independent licensing decisions.
2. Brazil should ensure that the new National Nuclear Safety Agency retains the necessary experienced human resources now available to DRS, and has the capability to obtain technical support in some additional areas. The newly recruited staff will have to undergo extensive systematic training on regulatory matters, including on the job training.
3. Capacity building in the whole nuclear area and for all organization is essential to the whole nuclear power program. It should be developed as a national program involving all parties involved, including industry, national laboratories and universities.
4. International Cooperation is paramount not only for capacity building, but also for sharing valuable experience both in operation area as well as in design and construction.

5. The IAEA IRRS mission is a useful tool to evaluate the regulatory body as well to identify gaps and deficiencies which may be later addressed to by an action plan.

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

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

- The situation of Angra 2 authorization for permanent operation: on June 15th 2011, CNEN issued the Authorization for Permanent Operation with conditions to be fulfilled during operating life.
- 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 have already been implemented for many years.
- Licencing of Digital Instrumentation and Control of Angra 3: CNEN has been signed in 2009/2010 an agreement with European Union to provide technical cooperation to improve the capacity within CNEN to carry out review and assessment of the safety of digital I&C systems as part of the licensing process of Angra 3 NPP, in construction, and modernization of Angra 1 and Angra 2, in operation. CNEN has also been participating on international workshops for IAEA standard revisions and workshop with NRC on activities for DI&C of US-EPR certification and with Canadian licensing planning for future reactors(see also Article 18(2)).
- The situation of INB under CNEN: this issue had some progress in terms of proposals related to the creation of an independent regulatory agency and the reorganization of the nuclear activities. However a concrete solution is yetto been implemented.
- Licensing of new sites for new plants: this issue is pending since no application for new sites is anticipated in the near future. Buta new regulation for site selection has been approved by CNEN (See Article 17).

B.5. Status of implementation of Fukushima Action Plan

As soon as it was identified the magnitude of the accident occurred in March, 11th 2011 at the Fukushima Daiichi Nuclear Power Station in Japan, the Board of Directors of Eletronuclear decided in March, 16th 2011 to constitute a Technical Committee, coordinated by the Presidency, counting on senior staff members of all

company's Directorates, with responsibility of following the accident evolution and measures taken to control it, to follow the recommendations from international organisms related to nuclear, environmental, industrial, and radiological safety as a consequence of the accident, and also to help the Executive Board on nuclear safety related matters resulting from the event.

On April, 19th 2011, Eletronuclear responded to the World Association of Nuclear Operators Significant Operating Experience Report (WANO SOER 2011-2) issued in March 2011, including the results of the recommended verifications regarding Angra 1 and Angra 2 NPPs capability to face beyond design basis accidents, with emphasis on station black out, flooding and fire hazards.

On May 13, 2011, CNEN issued document nr. 082/11-CGRC/CNEN formally requiring Eletronuclear to develop a preliminary safety assessment report, including a specific set of technical aspects taking in account the Fukushima accident. These included:

1. Identifying major design differences between Fukushima and Angra Units;
2. Identifying possible external initiating events (extreme) and the internal potential cause a common mode failure;
3. Control of concentrations of hydrogen in the containment;
4. Ensuring electricity supply emergency power;
5. Fulfillment of the requirements of station blackout;
6. Service water system, cooling chain;
7. Procedures for severe accidents;
8. Access to buildings and controlled area of the reactor after an severe accident
9. Development of Probabilistic Safety Analysis Level 1, 1 and 2;
10. Performance of "stress tests"
11. Emergency planning

The Eletronuclear Response Plan to Fukushima, or simply the Plan, was approved by the Executive Board of the company in November 2011 and shortly thereafter, submitted to CNEN, then revised in January 2013. It has 58 initiatives divided into three areas of evaluation: protection against risk events, cooling capacity, and limitation of radiological consequences. Some of these actions were already in progress, since Eletronuclear had started to develop studies to improve the safety of the plants and emergency plan even before the event in Japan.

The action plan includes studies and projects to be accomplished by 2016, with an estimated investment of about US\$ 150 million. Eletronuclear has already invested US\$ 15 million and by the end of 2013 will invest an additional US\$ 10 million.

Mobile devices are in the process of acquisition and, by the end of 2013, will be installed at the nuclear plant. This category includes the emergency Diesel generators, motor-pumps, and compressors.

The performance of the Stress Tests for Angra 1 and Angra 2 is also included as initiatives of the Eletronuclear Response Plan, and the time schedule for their completion takes into account two steps. The first step consists in developing the required evaluations, considering only engineering judgment, and the second step comprises the performance of detailed calculations using computer codes. The first step was concluded only for Angra 2 by December 31st, 2011. The second step was completed until March 31st, 2012. The results were evaluated by CNEN and presented to the Iberoamerican Forum of Nuclear and Radiological Regulatory Bodies (FORO).

Eletronuclear has also carried out a strong exchange of technical information participating and/or collaborating with many different Brazilian organizations (government, regulator, technical support organizations, vendors, service providers and other stakeholders) involved in maintaining and enhancing nuclear safety, and efforts made to achieve and maintain or strengthen a high level of nuclear safety in these organizations. In addition Eletronuclear participated and in certain instances led discussions through the media and directly with the several organizations, including governmental and public in general through seminars and open meetings. Besides, international organizations, such as GDF Suez, AREVA, Westinghouse, Rosatom and others were invited to discuss with Eletronuclear professionals aspects related to the Fukushima event and improvements needed.

Monitoring of ongoing initiatives in other nuclear power plants, together with other international organizations, indicates the perfect alignment of actions undertaken by Eletronuclear in response to the accident at Fukushima Daiichi to what has been practiced by the nuclear industry worldwide.

For this Sixth National Report, the areas of assessment were converted into topics indicated by the Convention guidance documents for the Extraordinary Meeting of 2012 and their current status of implementation is presented in an additional part D of the report and further detailed in Annex II.

B.6. Conclusions

At the time of the fifth 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 2010 – 2012, 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 Sixth 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.
- Improved the conditions for on site and off site management of emergency situations in alignment of actions undertaken in response to the accident at Fukushima by the international nuclear industry.

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

C. Reporting article by article

Article 6 Existing nuclear installations

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/1275 MWe net, 4-loop PWR). A third plant (Angra 3, 1351 MWe gross/1275 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 plant 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

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 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, affected 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
2010	4.263.040,75	69.334.717,90	77,26
2011	4.654.487,03	73.989.204,93	89,58
2012	5.395.561,26	79.384.766,19	97,26

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 5.428 tubes each instead of 4.674 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.

Another significant modification was the replacement of the RPV head done in the Plant outage in early 2013, based on industry results indicating that some of its materials, mainly Inconel 600, were susceptible to primary water stress corrosion cracking. This substitution was done preventively as no RPV head weld leakage was ever detected.

In addition to the Steam Generator RPV head replacements, 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 concluded 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;
- Reduction of snubbers;
- Obsolescence related activities, such as modernization of I&C and modernization of fire detection system;
- 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:

- 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;
- Replacement of the Loose Parts Monitoring system by an improved version;
- Substitution of the Inconel 600 core guide tube support pins;
- Application of weld overlay technique to the pressurizer Inconel 600 welds.
- Installation of a digital main feedwater control system (Ovation® Digital I&C Platform) in 2013.
- Replacement of the full Reactor Protection system electronic circuit cards due to ageing

On the analysis side, the Angra 1 level 1+, internal events, PSA suffered its 3rd overall revision, taking into account actual plant data, developments in human reliability analysis and in models.

The Plant Fire PSA study, jointly developed with the US Electric Power Research Institute (EPRI) using the state-of-the-art methodology of NUREG/CR –

6850 was completed and is being applied in the revision of the Angra 1 Fire Hazard Analysis. 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 set of Severe Accident Management Guidelines (SAMG) developed with Westinghouse are in the process of verification and validation as well as training of the involved personnel.

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 execution of the scope of Action Plans has been completed with the exception of a few long term programs. More details are presented in Article 14(1).

Human performance follow-up and improvement committees established during the previous review period continue to provide initial and refreshing training on the use of human error prevention tools as well to monitor trends in personnel performance.

The assessment of the Human Factor Engineering aspects of the Angra 1 Control Room performed under a Cooperation Agreement with the European Commission has been successfully completed.

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. The Angra 1 specific full scope simulator acquired through international bid is presently being developed. More details are presented in Article 11(2) and Article 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) and satisfactory development of the program of safety related improvements identified in this PSR.

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 defined the necessary environmental studies to be carried out and submitted to IBAMA in order to justify the issuance of an environmental operating license. The report “Environmental Control Plan” (Plano de Controle Ambiental – PCA) was submitted to IBAMA in March 2009. For more details concerning this process, see Article 17(2).

Angra 2

In June 1975, a Cooperation Agreement for the peaceful uses of nuclear energy was signed between Brazil and the Federal Republic of Germany. Under that agreement Brazil accomplished the procurement of two nuclear power plants, Angra 2 and 3, from the German company, KWU - Kraftwerk Union A.G., 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. Angra 2 NPP has been operating at full power since mid November 2000 and began the commercial operation on February 1st, 2001.

Due to legal constraints imposed by the Brazilian Public Ministry related to the environmental licensing (see Article 7(2), Angra 2 was operating based on an Authorization for Initial Operation (AOI) issued by CNEN that was extended for periods of 8 months. On June 15th 2011, CNEN issued the Authorization for Permanent Operation with conditions to be fulfilled during operating life. One of these conditions is the performance of a Periodical Safety Review (PSR) each 10 years. The first PSR was started in July 2011 and concluded in November 2012 with the issuance of the Global Report of Periodic Safety Review for CNEN approval.

Angra 2 operational record for the period 2001/2012, 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	10.488.288,90	77.036.812,30	90,11
2009	10.153.593,49	87.190.405,79	92,24
2010	10.280.766,54	97.471.172,56	88,09
2011	10.989.764,07	108.460.936,63	99,09
2012	10.645.229,04	119.106.165,67	92,06

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 the following years.

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 reactor 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 has a status 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 2007/2012, the main activities at the plant were dedicated to implementation of measures for improvement of performance of major non-safety equipment/components.

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;
- Improving the calculation of the thermal power through reconciliation data.

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 recommendation derived from the Angra 2 level 1+ PSA, is still in the design detailing phase;
- 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;
- Replacement of the existing Reactor Control system by digital Control System.
- Enlarging the Bleed capacity of the reactor coolant system Bleed & Feed equipment.
- Replacement of the hydrostatic seals of the reactor cooling pumps by hydrodynamics seals.
- Replacement of faulty butterfly valves of the Component Cooling system by valves of new design.

On the analysis side, the Angra 2 internal events, level 1+ PSA study is undergoing its second revision with the support of an external contractor. A contract for development of an expanded PSA scope comprising Shutdown, Internal Fire, External events and Level 2 has been signed with the Plant Supplier. More details are given in Article 14(1).

The development of Severe Accident Management Guidelines (SAMG) for Angra 2 is well advanced, being done through the Cooperation Agreement with the European Commission.

Also in the period covered by 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 implemented.

In the Operational Experience area the systematic for collection, trending and reporting of minor events and near-events has been developed and implemented for both plants. The established external operational experience committees evaluate significant event reports from WANO, INPO and VGB as well as Plant Supplier Information Notes making recommendations for plant implementation when pertinent.

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.

The major hardware and software upgrade of Angra 2 full scope simulator initiated 3 years ago, which included the substitution of the old hardware and former operational system as well as the models of the most relevant systems has been completed successfully after a long Verification & Validation period.

A multidisciplinary company team from design and support engineering, safety analysis, operations, maintenance, radiation protection and quality assurance, led by a Board appointed committee have conducted the first Angra 2 Periodic Safety Review when the plant reached its tenth year of operation.

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 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 current 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. 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.

On May 25th, 2010 CNEN issued the Construction License with a list of 56 Conditions to be fulfilled before the Authorization for Initial Operation

These conditions are in eight areas, as follows:

- [1] Six (6) general conditions
- [2] One (1) condition related to civil construction area
- [3] Eight (8) conditions related to mechanical area
- [4] Three (3) conditions related to electrical area;
- [5] Six (6) conditions related to I&C area
- [6] Four (4) conditions related to safety analysis area
- [7] One (1) condition related to human factors engineering
- [8] One (1) condition related to physical protection

Some highlights of these conditions are:

- Submittal of the test procedures including the acceptance criteria and commissioning programs, before the start of each test.
- 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.

Until December 2012 ELETRONUCLEAR answered 36 CNEN's conditions. CNEN released the construction of the following structures: reactor building annulus, reactor auxiliary bldg, switchgear bldg, feedwater bldg and the erection of steel containment. Detailed engineering reports related to other safety related buildings were issued by ELETRONUCLEAR and are under evaluation at CNEN.

The preparation of Final Safety Analysis Report, including a new chapter 19 (Severe Accidents and Probabilistic Safety Analysis), is under way at ELETRONUCLEAR, in order to be submitted to CNEN two years before the Authorization for Initial Operation.

The training of plant operators has already started.

With respect to Angra 3 environmental license, IBAMA proposed in 1999 the Terms of Reference for the preparation of the development of the EIA/RIMA. The EIA/RIMA Reports for Angra 3 were prepared under the responsibility of ELETRONUCLEAR and submitted to IBAMA in May 2005.

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 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.

Concerning the status of construction of the plant first concrete for the reactor base plate was poured following CNEN issuing of the Construction License, on the 1st of June 2010. So far (mid of 2013) around 50% of the civil construction work has been completed. The reactor building is presently built up to the elevation of 19 m. The spherical steel containment bottom part has been floated for positioning and securing in place and the containment has been erected up to its 5th zone. The turbine building is close to completion with its crane already installed. The installation of the tanks that are civil construction dependent is being done. At the moment the borated water storage tanks have been mounted in the reactor building annulus, as well as several tanks in the reactor auxiliary building.

The bidding process for the electro-mechanical erection contract is completed and the consortia that will perform the work are expected to be on site until the end of 2013.

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.

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 66 months duration, from reactor base plate first concrete to the end of the power tests and start of commercial operation. It is expected that Angra 3 will be connected to the grid in 2017.

Recent safety improvements at Angra 3

The reference plant of Angra 3 NPP is Angra 2 NPP, as built, but also incorporating into the design the up-to-date requirements of rules and standards, in force at the time of the application to the Construction License in 2003, as well as the modifications made in structures and systems so as to increase the protection and the capability of the plant to withstand beyond design basis accident scenarios. Moreover, as regards the differences from Angra 2 that are important to withstand

these scenarios, Angra 3 is being built at an elevation that is one meter higher than the one of Angra 2.

A tornado hazard study was prepared for Angra 3 design taking into consideration a probability of occurrence of 10^{-7} /year, as required by the American guideline of the NRC, RG 1.76, "Design Basis Tornado and Tornado Missiles for Nuclear Power Plants" (2007). The hazard assessment indicated a maximum tornado wind speed of 209 km/h for the site. However, considering the maximum occurrences in the region, equivalent to the EF3 category, ELETRONUCLEAR conservatively adopted 242 km/h as the design speed for tornadoes (average between the limits of the EF3 category), also similarly to the design tornado established for the Region III in the United States. The corresponding tornado missiles have been also adopted in the design.

The seismic event SSB (combination of Burst Pressure Wave – BPW with SSE effects) is being applied for the design of all safety related structures, systems and components (class I and IIA civil structures; class 1 or 2A systems and components). The design concept, which is based on the KWU PWR 1300 MW Standard Model, includes an increased staggered defense-in-depth configuration, which does not only provide highly redundant safety systems to cope with design basis accidents, but in addition it provides a further line of defense consisting of dedicated ultimate safety features. By use of these ultimate safety features, some specific events can be coped with, like loss of main control room (including absence of operators for up to 10 hours) and station blackout. In addition, these features provide a robustness reserve even for beyond design basis external events.

The low probability external events SSB and Tornado were raised to "classical" design basis accidents against the previous consideration as "design extension" events in Angra 2. This concept represents an upgrade when compared to the one adopted for the reference plant (Angra 2), where some safety related SSC's were designed only for SSE and not for SSB (e.g., Switchgear Building – UBA, Large Diesel Generator (D1) Building - UBP). This upgraded concept is conservatively adopted, and can be considered as an additional safety margin in the defense-in-depth line.

As referred in the previous paragraph all Unit 2 safety design features are being maintained in the safety design concept for Unit 3 (as for instance: decoupling between Emergency Feed Building - ULB and Switchgear Building - UBA; internal flooding protection, design criteria of up to 10 hours for SSB and up to 2 hours for SSE).

The emergency power supply of Angra 3 consists of two sets of Diesel generators:

- Emergency Power Supply D1 (4 x 50% large Diesel Generators) which supplies the power for all safety related systems in case of Loss of Off-site Power (LOOP).

- Emergency Power Supply D2 (4 x 50% small Diesel Generators) which supplies the power in case of LOOP and loss of D1 emergency Diesel Generators for the minimum required set of safety related systems (reactor protection system, emergency control room, emergency feedwater system, emergency residual heat removal chain and the main steam blowdown stations). The D2 emergency Diesel generators could be called “SBO Diesels”, in order to reflect on international requirements.

Even considering the above mentioned situation, an additional power supply installation for Angra 3, consisting of a Diesel Generating Set, similar to the DG of one redundancy of the Emergency Diesel building - UBP, shall be included in the plant design, due to the following points:

- The applied edition June/1999 of Standard KTA 3701, introduced in item 3 (2) d) a new requirement regarding an independent power supply installation, additionally to the two offsite connections;
- Requirement for energy supply 72 hours after an external event where the external energy supply (525 kV and 138 kV) fails (KTA 3701, App.C, item C 2.4);

Therefore, ELETRONUCLEAR decided to include the UBN structure with one DG Set including all necessary supporting systems. This DG Set is air cooled and is designed with the same safety requirements of the UBP building (resistant to SSB, tornado and TNT explosion).

This additional diesel generator can also replace one of the 4 diesel generators of the Emergency Power Supply D1 in case of maintenance.

The initiatives of ELETRONUCLEAR's Fukushima Response Plan focus on the plants in operation, Angra 1 and Angra 2. The results of the studies related to site conditions will define interventions in the site infrastructure as well as in the plants, including design changes to be incorporated in Angra 3 during the construction phase. Part of the initiatives related to design improvements in Angra 2, mainly in relation to beyond design basis accidents, is already considered in Angra 3 design. Other design modifications in Angra 2, resulting from specific issues addressed in connection with the Fukushima accident, such as the possibility of connection of mobile equipment, will be afterwards incorporated in Angra 3 design.

The following recent improvements are being implemented in Angra 3:

- Hydrogen Reducing System, which reduces the Hydrogen content in the containment continuously by means of PAR's (Passive Autocatalytic Recombiners) during normal operation, design basis accidents (DBA) as well as after beyond design basis accident (BDBA).
- Nuclear Sampling System for the Containment Sump and Atmosphere, which is designed for the purpose of obtaining high quality samples of the containment atmosphere even after a BDBA. In addition also the containment sump can be sampled after BDBA.

- Containment Filtered Venting System, which vents the containment atmosphere through special filters to prevent loss of containment integrity in case of BDBA like core melt causing high pressure inside the containment.
- The Primary Side Bleed & Feed, to remove core heat in case of BDBA, has its capacity increased and the bleed valves are powered by dedicated batteries to be available in case of Station Black-out (SBO).
- The Secondary Bleed & Feed, to remove primary side heat in case of BDBA, has the bleed valves powered also by batteries to be available in case of SBO (including the loss of the D2 emergency Diesel generators called “SBO-Diesels”).

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) requires that any installation which may cause significant environmental impact shall be subjected to environmental impact studies that must 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, and Supplementary Law 140 of 2011.12.08. 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 III) 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, Tecnologia e Inovação (Ministry of Science, Technology and Innovation - MCTI).

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 III. Item A.III.3 for a list of relevant CNEN regulations).

The licensing regulation CNEN NE 1.04[3] 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

A) Nuclear Licensing Process

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 [4], 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 [5]. 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 [6]. 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.

B) Environmental Licensing of Angra 1, 2 and 3.

The main guidelines for the implementation of the environmental licensing are expressed in the Law 6938 of 1981, Supplementary Law 140 of 2011, CONAMA Resolutions 001/86 and 237/97, and Normative Instruction n^o 184/2008 of IBAMA.

These guidelines discipline the environmental licensing for projects with potentially adverse effects on the environment, following three main steps:

- Preliminary License – Granted at the preliminary planning stage, approving the general concept of the installation and place, evaluating its environmental feasibility, and establishing the basic requirements and conditions for the next implementation phases, relative to mitigation of the eventual environmental impacts. In general a Prior License is required for projects that need evaluation of environmental impacts.
- Installation License – Authorizes the construction of the installation in accordance with the approved specifications, programs and projects - including measures that are considered essential to protect the environment and human populations. 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 and after the verification of the effective fulfillment of the previous license conditions, and the effective implementation of measures to protect the environment and human populations during operation.

Among the requirements for issuing a Prior License, three technical reports are presented by the project's proponent to provide IBAMA with a comprehensive set of information to support the decision-making process: an Environmental Impact Study (EIA), an Environmental Impact Report (RIMA), and a quantitative Risk Assessment (EAR) for the external public and environment.

Public participation in the environmental licensing process is ensured by legislation through public hearings prior the issuing of the Prior License (CONAMA Resolution 09/87). One of the requirements is transparency in the process, through the dissemination in official newspapers and local press of any hearing scheduled, license application made and decisions of the environmental agency.

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 took control of 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 Operation License. The report “Environmental Control Plan - PCA” was submitted to IBAMA in March 2009.

At that time, although Angra 2 was already under construction, CONAMA determined that IBAMA should require from ELETRONUCLEAR, which succeeded FURNAS in 1997 as the owner of the plant, 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’s 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 the impact of Angra 2, 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 these conditions, IBAMA issued a report (Parecer Técnico N^o 015/2006 – COEND/CGENE/DILIC/IBAMA) concluding that, under the technical point of view, all of the conditions compiled in the TCAC were met.

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.

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. ELETRONUCLEAR expects that an order of 4-5% of the total cost of the Angra 3 project will be spent to comply with the above referred conditions.

In September 2011, IBAMA informed that a Joint Operating License would be issued for the nuclear installations in operation at the CNAAA site – Angra 1, Angra 2 and the Radwaste Management Centre (including initial storage facilities). In parallel, the Installation License for Angra 3 is being reviewed in order to adjust it to the actions of the Joint Operating License of the CNAAA.

In order to issue this licence, IBAMA requested Eletronuclear to fulfill a new set of Conditions established in five Technical Assessments Reports, which were answered by Eletronuclear. These five reports are related to:

1. Parecer Técnico n. 14/2012 – COEND/CGENE/DILIC/IBAMA: Analysis of the Angra 1 “Environmental Control Plan - PCA” and related documents, focused in the installation and operations issues related to environmental control engineering e monitoring.
2. Parecer Técnico n. 15/2012 – COEND/CGENE/DILIC/IBAMA: Analysis focused in the installation and operations issues related to environmental control engineering e monitoring of the Radwaste Management Centre (including initial storage facilities).

3. Parecer Técnico n. 24/2012 – COEND/CGENE/DILIC/IBAMA: Analysis focused in the installation and operations issues related to environmental control engineering e monitoring of Angra 2.
4. Parecer Técnico n. 4924/2013 – COEND/CGENE/DILIC/IBAMA: Analysis focused in the environmental management, control and monitoring systems due to the construction of Angra 3. Reviewing of the Installation License conditions due to the actions of the Joint Operating Licence, once some conditions where related to CNAAA operation.
5. Parecer Técnico n. 5340/2013 – COEND/CGENE/DILIC/IBAMA: Integrated Analysis of all Environmental Programs related to social actions, emergency plans, non-radiologic risk analyses, environmental monitoring and environmental impact mitigation due to the installations in operation in the CNAAA.

It is expected that the Joint Operating License for the CNAAA and the reviewed Installation Licence for Angra 3 will be promulgated in the second semester of 2013, after the decision of the president of IBAMA supported by those 5 technical reports.

About the Complementary Unit for the Storage of Irradiated Fuel – UFC, which will be constructed in CNAAA, IBAMA emitted the Terms of Reference for the Environmental Study, prior to the licensing process, in February of 2013.

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.

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 of 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 collects 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.

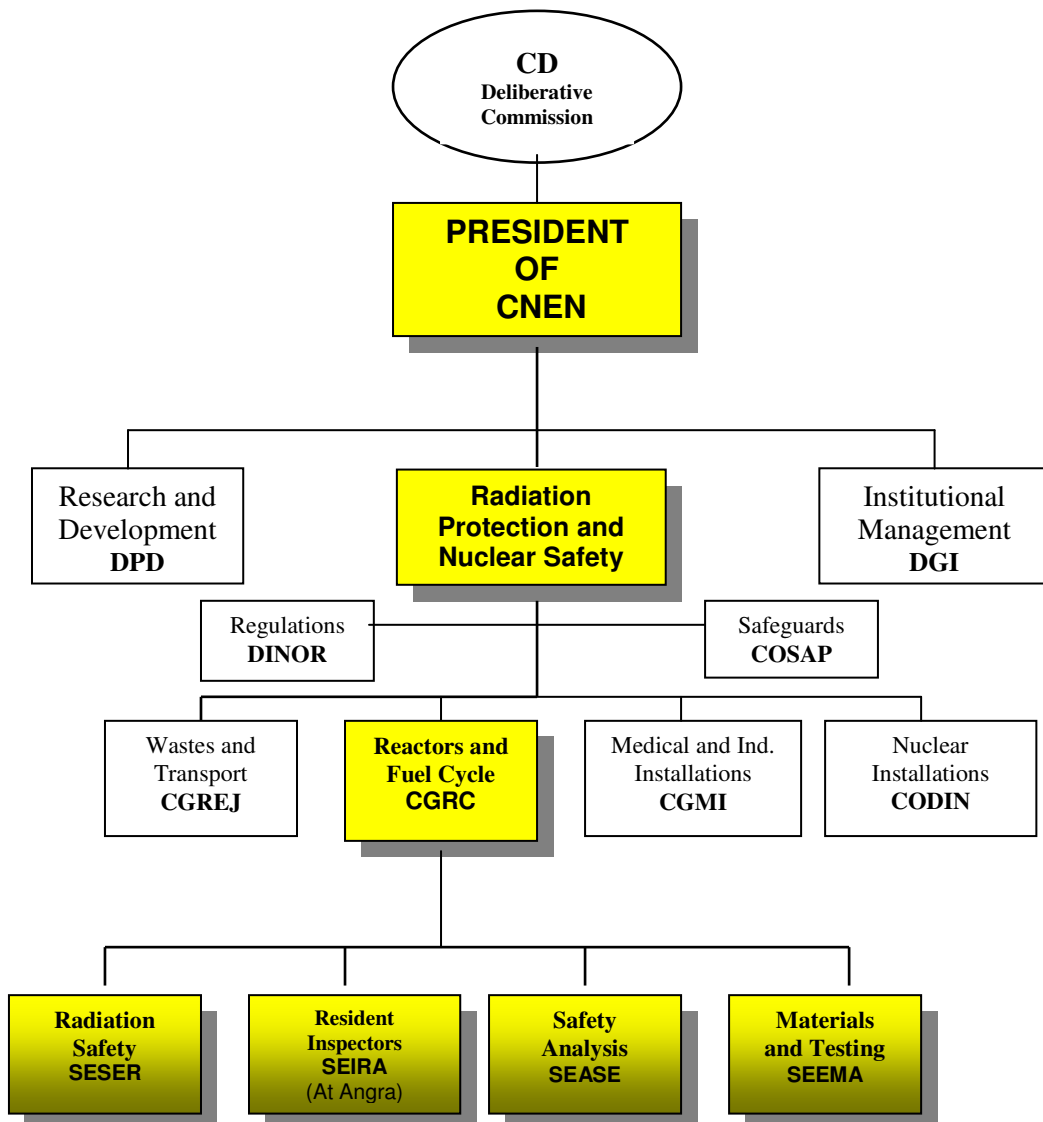


Fig. 1 – CNEN Structure (simplified)

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. DRS staff is 237 people. CGRC itself comprises 51 people, 43 of which are technical.

In the period, CGRC staff registered a loss of five professionals, mostly due to retirement. By the end of 2012, the staff qualification shows 25 holding a Ph.D. degree or equivalent, 16 holding a M.Sc. in nuclear science or engineering, and 9 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 2010-2012, CNEN conducted 20 inspections in Angra 1, 26 in Angra 2, 4 in 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 [6].

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.

In 2012 CNEN initiated a project, supported by the European Community, and entitled: "Training and Tutoring for experts of the NRAs and their TSOs for developing or strengthening their regulatory and technical capabilities". Within this cooperation project three members of the CNEN technical staff attended to two courses: (1) on criticality and thermo-hydraulics in ENEA, Italy, and (2) on NPP's Safety, in the IRSN, France, both in 2012.

A tutoring module 5, still within the same EU project, namely, "Regulatory review and oversight of NPP during operation", in Ljubljana, Slovenia, has been attended by two members of CNEN Technical staff in November 2012. Moreover, in

December 2012, a course on Fire Protection, in GRS, Cologne/German was attended by one member of CNEN technical staff.

Concerning training courses sponsored by the IAEA, one member of the CNEN staff attended to the "Training Course on Preparation, Review and Assessment of Safety Documents for Research Reactors", in Chicago, from 03/12/2012 to 07/12/2012.

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 are close to retirement age.

Article 8 (2) Status of the regulatory body

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

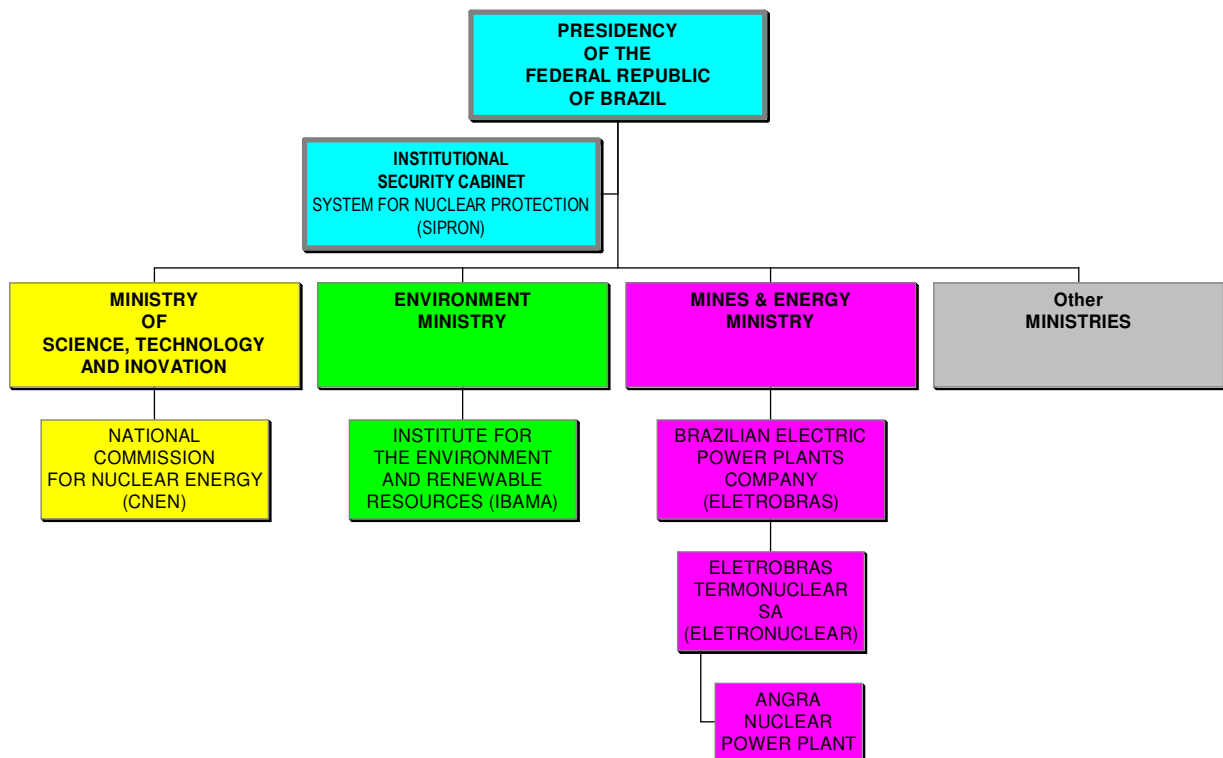


Fig. 2 – Brazilian organizations involved in nuclear power plant safety

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, Technology and Innovation (MCTI), 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, a recent proposal has been made to create a independent nuclear regulatory agency as mentioned in A.3.

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 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.

IBAMA

IBAMA was created on February 22nd 1989, by Law 7735. Under the Ministry for Environment (MMA), IBAMA has the responsibility to implement and enforce the National Environmental Policy (PNMA), established by Law 6938 of 1981. The objectives of the PNMA are to preserve, improve and recover environmental quality, ensuring the conditions for social and economic development and for the protection of human dignity. The PNMA established the National System for the Environment (SISNAMA), which is composed by the National Council for the Environment (CONAMA) and executive agencies at the federal, state and municipal levels.

Environmental licensing is a legal obligation prior to the installation of any project or activity that exploits natural resources and has a potential to pollute or degrade the environment. The CONAMA Resolution No. 237/1997 and, after, Supplementary Law 140 of 2011.12.08 established that IBAMA is the responsible for licensing of the environmental component of activities and projects related to prospecting, mining, producing, processing, transporting, storing and disposing of radioactive materials at any stage or using nuclear energy in any of its forms and applications. Therefore, among the Brazilian environmental agencies, IBAMA is responsible for environmental licensing of Nuclear and Radioactive Installations.

The nuclear licensing and the environmental licensing processes are independent, parallel, and complementary acts. IBAMA is responsible for the environmental licensing of any installation with potentially significant socio-environmental impact and environmental risk, including the nuclear installations. In the environmental licensing process, possible direct and indirect impacts of a project imposed to the external environment and communities are assessed. These includes, but are not restricted to, the: physical aspects (geology, hydrogeology, climate, water availability), atmospheric emissions (radioactive and conventional), and chemical generation and control of liquid and gas effluents; interactions with biotic system (marine and terrestrial fauna and flora) and possible incorporations (bioaccumulation, toxicity); socioeconomic and health implications to the human populations in the vicinity of the project.

The structure of IBAMA is presented in Figure 3 The main organizational unit involved with environmental control of nuclear power plants it's the Directorship of Environmental Licensing (DILIC) and the Directorship of Environmental Control (DIPRO).

The Directorship of Environmental Protection acts in the response of an eventual Nuclear Accident in the CNAEA, as it represents IBAMA in CCCEN.

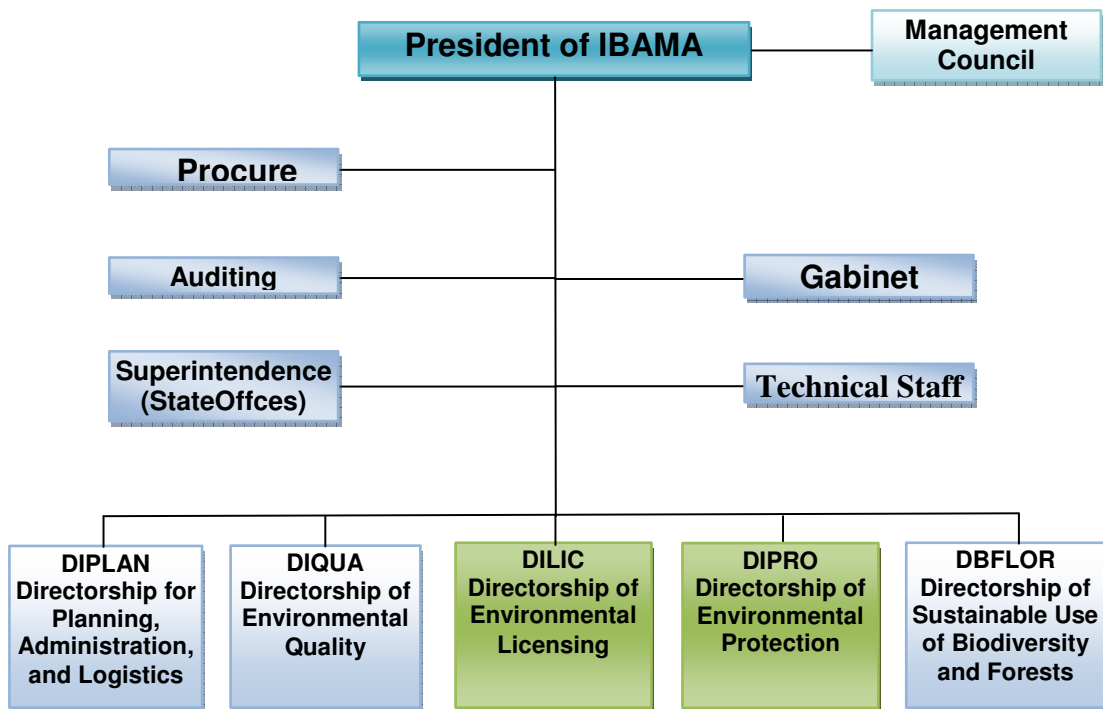


Fig. 3 IBAMA Structure

The environmental licensing for nuclear installation it's carried out by the Coordination of Electrical Power, Nuclear Energy and Pipelines (COEND), the Coordination of Mining and Civil Infrastructure Projects (COMOC) and the Coordination of Ports, Airports and Waterways (COPAH). The structure of DILIC is presented in Fig.4.

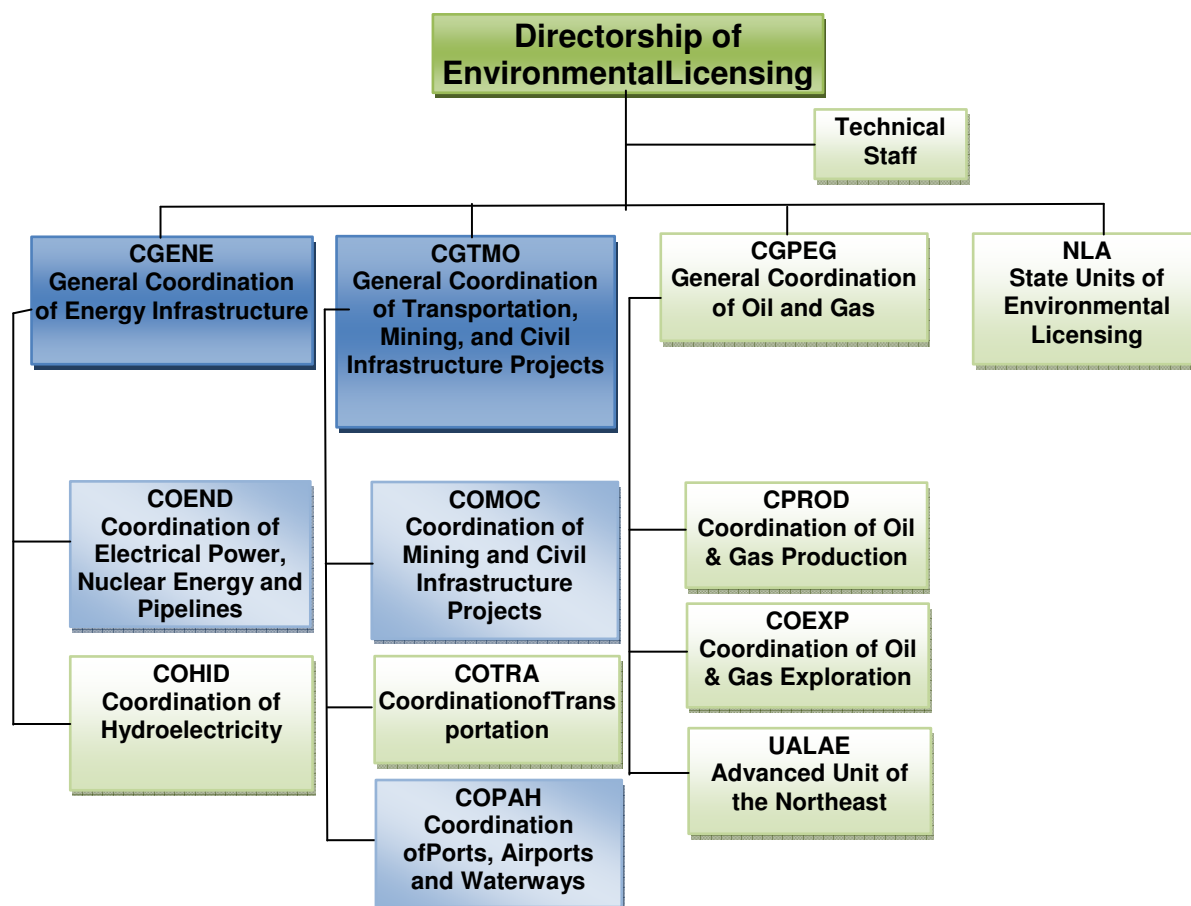


Fig. 4 DILIC Structure

COEND performs the environmental licensing of the Nuclear Power Plants, the Nuclear Fuel Manufacturing Plant, the Nuclear Research Centers, the Radioactive Materials Deposits, the Transportation of Radioactive Materials, and, after enactment of Supplementary Law 140/2011, the COEND is responsible for the environmental licensing activity for radioactive facilities, while COMOC performs the environmental licensing of Uranium Mines and COPAH performs the environmental licensing of the nuclear submarine shipyard.

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 [7] 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.”

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-NN-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[8] and quality assurance policy statements[9] in December 1996, which is based on the concept of Safety Culture.

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 [9] 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.

At ELETRONUCLEAR

ELETRONUCLEAR is a company resulting from the merging, 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 already had policies aiming at giving priority to nuclear safety. The current organization structure of ELETRONUCLEAR is presented in Figure 5, which is essentially the same as presented in the previous National Report.

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. 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”.

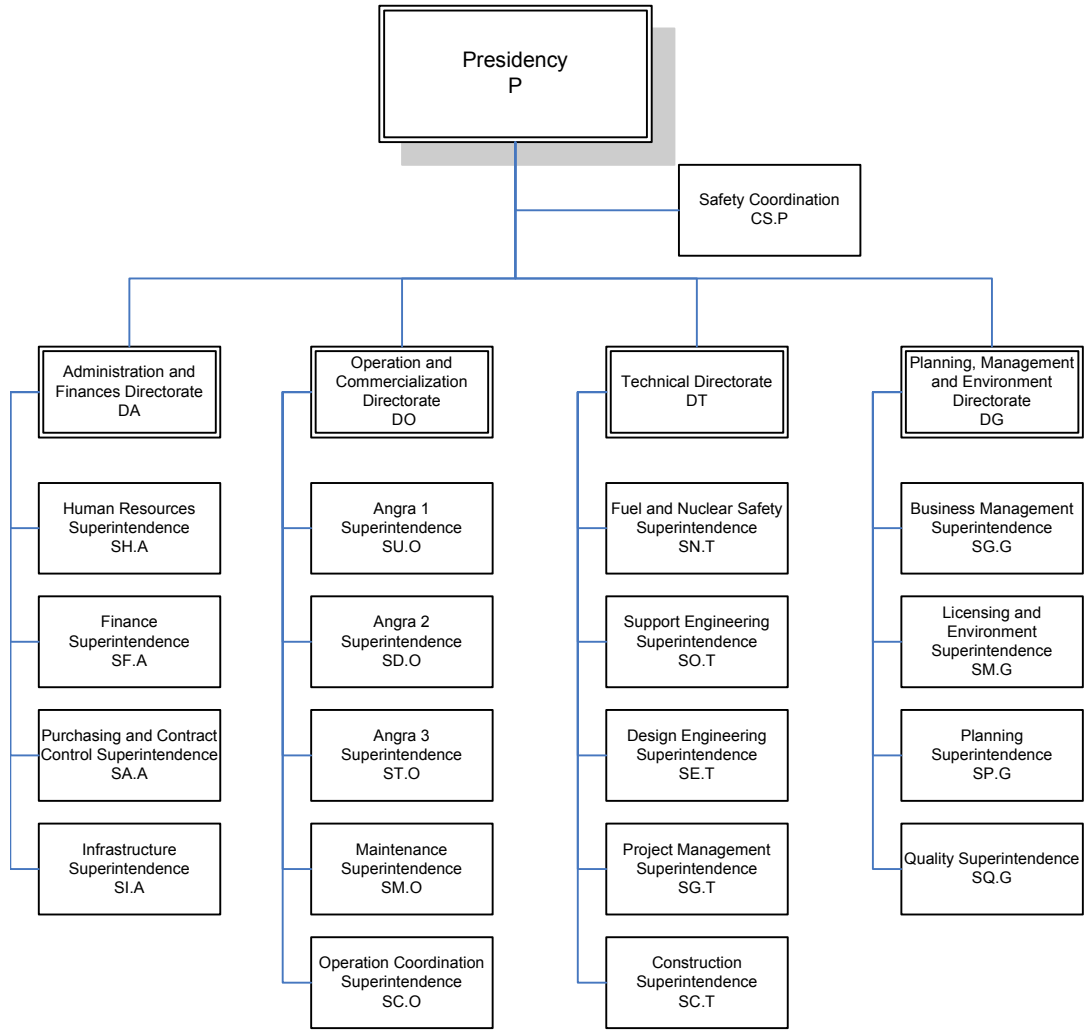


Fig. 5 ELETROBRAS TERMONUCLEAR S.A – ELETRONUCLEAR Organization Chart

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.

The CAON is supported, in its plants safety oversight task, by a CAON subcommittee, composed with members from Operations, Design and Support Engineering, Maintenance, Safety Analysis, Training and Quality Assurance. This committee reviews the operational experience reports, the Plants Safety committees meeting minutes as well as the Plants modifications documentation and takes any identified safety related issue to the CAON for scrutiny. This subcommittee also provides the CAON with an yearly evaluation of the Plants safety status.

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. 5).

In 2011, ELETRONUCLEAR began a joint work with IAEA in the Project RLA9060 – Enhancing Operational Safety in Nuclear Installations. This project that has its additional scope funded by European Union – Enhancement of Safety Culture, involves not only Brazil, but also Mexico and Argentine. From this work, 8 Peer Visits involving 26 Participants (among which 16 Brazilians) identified 53 Good Practices (49 for Brazil) that are under development and adjustment to be applied in a routine basis. Besides, a web platform (LASCN – Latin American Safety Culture Network) is being created by the project to sustain experience and information sharing between counterparts. As a consequence, ELETRONUCLEAR is developing a Corrective Action Program which aims at having a single program that captures all inputs from deficiencies and allows a link to the associated actions. For the company, this is a first step in the direction of implementing a Nuclear Oversight process, inspired in one of those good practices observed as well as improving its communication process based on benchmarking with partners of this project.

Article 11 Financial and human resources

Article 11 (1) Financial resources

ELETRONUCLEAR is a state-owned company of closed capital controlled by ELETROBRAS, an open capital company which holds the control of all the federal public companies of electrical energy in Brazil.

Until the year 2012, the company had as its revenue source the sale of electrical energy to its related counterpart FURNAS, generated by its plants Angra 1 and Angra 2, through a contract of electrical energy supply.

From January 1st 2012 onwards, as established by article 11 of law number 12.111 from December 9th 2009, the payment of the electrical energy generation revenue of ELETRONUCLEAR will be prorated among all the concessionaires, licensees or authorized companies of public distribution service in the National Interconnected System – SIN in the Portuguese acronym. By means of the Normative Resolution n° 530, issued on December 21st 2012, ANEEL establishes the methodology for the calculation of the annual part-quotas related to the energy of Angra 1 and Angra 2 generation centers and to the conditions for the commercialization of this energy according to article 11 of law n° 12.111/209. These part-quotas represent the energy percentage originated by the plants to be allocated to each distributing company calculated by the ratio between the billed market of the consumers and the sum of the billed markets of the captive consumers of all distributing companies of the National Interconnected System (SIN).

The company has been keeping adequate resources for the operation and maintenance of the plants of Angra 1 and Angra 2, as can be seen from the examples presented in Table 3, where a detailed comparison of the executed budgets for the years 2010 and 2012 is presented:

Table 3. Comparison of ELETRONUCLEAR Budget for the Years of 2010 and 2012.
Values in million R\$ (approximate million US\$).

Items	YEARS	
	2010	2012
Primary Costs		
Angra1 & 2 Personnel (salaries + benefits)	357 (210)	430 (215)
Angra1 & 2 Fuel	271 (159)	310 (155)
Other services, subcontractors and materials	439 (258)	501(250)
Investments		
Angra 1 & 2 Upgradings (including engineering)	172 (101)	131 (65)
Angra 3 Site Maintenance and Construction	343 (201)	664 (332)

NOTE: Ratio US\$/R\$: in 2010 = 1,00/1,70; in 2012 = 1,00/2,00.

The apparently elevated increase of the budget of 2012 in relation to 2010, when using values in Reais/R\$, is due to the strong depreciation of the Brazilian currency in comparison to the American currency (US\$).

When comparing the 2010 and 2012 budgets in Real (R\$), a meaningful increase in investments and primary costs are noted, mainly due to acceleration of the construction of Angra 3. Regarding Angra 1 and Angra 2, until 2010 great investments had been realized, that included the exchange of the two Steam Generators of Angra 1.

With reference to the budgetary expenditure of the exercise 2012, destined to the modernization of Angra 1 and Angra 2, one can verify a reduction of the 23% when compared with the exercise of 2010. Despite this investments reduction, during the period of 2010 to 2012, the following implementations had been realized:

- Substitution of the Reactor Pressure Vessel Head in Angra 1
- Acquisition of the Simulator to training operators of Angra 1
- Project Modifications in Angra 1 and Angra 2
- Modernization of the Instrumentation and Control in Angra 1
- Substitution of several Equipments and Components in Angra 1 and Angra 2.

The company keeps in a Brazilian Federal Public Bank an exclusive investment fund whose use is restricted to the future financing of the decommissioning activities of the plants of Angra 1 and Angra 2, under the ownership of its holding (ELETROBRAS), as determined by the CNPE – National Board of Energy Politics.

The annual sums destined for this fund are formed from monthly contributions and have coverage in the rates structure during the same period of depreciation of the plants (3.3%/per year). The decommissioning costs were reevaluated and the results lead to estimated values of 307 million dollars for Angra 1 and 426 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 2.583 employees on its permanent staff and a few long-term contractors, which supply additional personnel.

Of the total of ELETRONUCLEAR employees, 1.035 (40 %) have a university degree, 1.001 (38.8%) are technicians and the remainder 547 (21.1%) are administrative personnel. The personnel turnover of the company in the review period, resulted on the ingress of 432 new employees and 154 leaving the company in the last three years, most of them to other companies related to the oil industry.

As reported in the previous National report a project for determination of the existing technical know-how at ELETRONUCLEAR as well as existing and foreseeable future know-how gaps, was developed in the 2001-2005 period, in cooperation with the EPRI and the IAEA, with the purpose of minimizing the consequences of experienced personnel losses caused by retirement of the ageing work force.

The above-referred Knowledge Management development has been accomplished and applied. The results remain available for routine use by the different technical organization units of the company.

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 Corporate University that will serve the several affiliated utilities.

Eletronuclear has also recently reached an agreement with the Brazilian Coordination for Improvement of High Level Education Personnel (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – CAPES) to provide 60 scholarships to graduate programs in public or private institutions that have courses in the nuclear area. The agreement signed between the two institutions seeks to stimulate and support the training of human resources in the nuclear sector.

Completing 5 years in 2012, the current ELETRONUCLEAR Human Performance Program has been systematizing actions in order to promote the improvement of employees working at CNAEA so as to reduce human errors and error-related events. This program includes not only the company's permanent staff but also contractors.

The Human Performance Program has a significant contribution of the Psychologists from the ELETRONUCLEAR permanent staff (they also participate in the plants human performance committees) and the work done always considers the plant's needs. The most recent results are:

- Basic trainings applied to all new employees including disciplines as error theory, errors precursors, and error prevention tools.
- Application of the Human Performance Module inside the Outage Training to 1349 contractors from Angra 1 and 884 from Angra 2 NPPs before their respective refueling outages.
- Behavioral and stress management trainings were also performed to 25 Reactor Operators and 18 Senior Reactor Operators from the Angra 3 NPP new operators staff.
- Application of the Supervisors Development Program to the Operation Directorate, involving 44 employees between 2011 and 2012.
- Participation in simulators training to follow-up behavioral aspects (team work, leadership, communication, decision-making processes, etc.) for the operators staff.
- Since 2011, the psychologist staff of Eletronuclear was effectively included in the root-cause analysis group working at the plants Angra 1 and Angra 2 analyzing all kind of events, even those at first are not related to human errors. In 2012, 50 events occurred in Angra 1 and 60 in Angra 2 were analyzed. These numbers represent an increase of 182% in the total number of events analyzed by the psychologists group since 2011.

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.

The construction of two new blocks (~700 m²) for classroom and mechanical, electrical and I&C maintenance labs training to support identified needs of better practical maintenance training and additional classroom space for the Angra 3 personnel was completed in end of 2010.

As reported in the previous Brazilian National Reports, Angra 1 operators have done their simulator training abroad, in simulators of similar plants.

This situation is about to change, since, 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.

The preparatory activities as well the international bid for the supply of a replica full scope simulator for the Angra 1 Plant were concluded in February 2012, with the contract signature with the bid winner, the Spanish simulator supplier Tecnom.

The simulator development is on schedule with completion of site acceptance tests planned for mid 2014. Considering the additional activities of training of instructors in the operation of the simulator and preparation and running of the simulator training material the ready-for-training date for this simulator is scheduled for January 2015.

In the meantime simulator training of Angra 1 operators will continue to be held abroad.

An Angra 2 full scope simulator is available on site for operator training since beginning of 1985. This simulator was originally used to provide external training services 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 has undergone periodical partial upgrading of the hardware (basically the computers) at 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 contract for a major software and hardware upgrade was signed in mid 2009. The work involved substitution of the computers and of the old operational system, provision of a new instructors station with modern features, review of the models programming language and provision of new models for the core, primary system and containment. This upgrade took longer than expected and was finally completed by end of 2012 after a long verification and validation period.

The acquisition of the Angra 3 simulator, which will feature the same digital instrumentation that will be installed in the Plant, as well as a separate module that allows simulation of severe accident behavior, is still in discussion with the Angra 3 plant technology supplier AREVA.

In the meantime the future Angra 3 operators are being trained in the Angra 2 simulator, taking advantage of the similarity between the Angra 2 and 3 plants. These operators will be licensed for Angra 2 so that they will be able to acquire practical control room experience in Angra 2 before going to Angra 3.

A final simulator training period will be applied when the new Angra 3 simulator is available to allow these operators to familiarize themselves with the Angra 3 computerized control room, which is the most important difference between the two plants.

In the period under review (2010 to 2012), the initial and re-qualification training programs performed for the Angra 1 power plant operators, allowed 51 operator licenses to be renewed and 17 new licenses to be granted.

For Angra 2, in the same period, 10 new operators completed successfully their training program and received their licenses and 49 operators completed the training requirements for license renewal.

The first group of 20 Angra 3 operators have completed their initial training using the Angra 2 simulator and passed the written, oral and simulator examinations to obtain their licenses for Angra 2.

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 respective FSAR. Implementation and updating of these requirements is 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 [5] and NE-1.06 [10].

According to regulation CNEN NN 1.01[5], 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 [11].

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 266 new employees are in classroom or in practical training at the plants. 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.

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[5] and their medical qualification[10]. 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 2010 – 2012, CNEN has issued a total of 68 licenses for Angra 1, 17 new operator licenses (8 RO and 9 SRO) and 51 renewals (24 RO and 27

SRO), and a total of 59 licenses for Angra 2, 10 new licenses (5 RO and 5 SRO) and 49 renewals (13 RO and 36 SRO).

The standard CNEN-NN-1.01– Licensing of Nuclear Reactor Operators also establishes the criteria for inactive or active licenses. By December 2012, there were 8 inactive SRO licenses for Angra1, and 5 for Angra 2.

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

It is worth mentioning that the last exam to issue licenses for Angra 1 operators was carried out for the first time in the Spanish Tecnatom Simulator, with the presence of CNEN examiners.

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 plant supplier country, 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 retraining 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.

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. The hardware and software of this Integrated Computer System is upgraded in 3 to 4 years intervals, for better equipment performance and increase of features, such as number of monitored parameters, frequency of data acquisition, among others.

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.

In response to a CNEN requirement of establishing a Human Factor Engineering program for Angra 1 following the American licensing guidelines of NUREG 0711, Human Factor Engineering (HFE) Program Review Model, and incorporating this program in a new FSAR chapter (chapter 18), as established in NUREG 0800 Standard Review Plan, an evaluation of the Angra 1 HFE, with a duration of 2 years was developed along 2011 and 2012. The expertise for developing this program has been provided through a Cooperation Protocol between Brazil and the European Commission.

This work was completed providing an overall review of the Angra 1 HFE aspects, in particular of the Main Control Room. No major discrepancy was found. Some upgrade recommendations have been issued for displays in the main control room. An important major finding of this work was the identification of a lack of a systematic approach to identify and evaluate HFE aspects in plant modifications. A proposal for such approach was made and incorporated in the plant modifications procedures.

As required, an FSAR chapter 18 was prepared and has been recently sent to CNEN.

The family of German PWRs, to which Angra 2 belongs, was designed giving great importance to HFE safety and operational aspects. The most important feature is known as the “30 min rule”, by which the plant I&C is designed to meet the requirement of automatic accident control for the first 30 minutes, to allow sufficient time to the operators to plan their subsequent manual actions for accident control.

Regarding operational aspects, repetitive and routine operations have been automated to relieve operators of boring tasks and so reducing the possibility of human errors. The long operational experience of these plants, as well as the first 12 years of operation of Angra 2, confirm the effectiveness of their EFH.

As already informed in the previous National Report, for Angra 2, CNEN requirements concerning HFE evaluation were basically the same reported above for Angra 1. That is, the preparation of a chapter 18, in accordance to NUREG 0800 following NUREG 0711. Although Angra 2 was designed following basically German standards, it was agreed in the licensing process to adopt the above NUREGs for itemization and format, with the contents and criteria from the actual plant design documentation. The developed chapter 18 was approved with a series of conditions, most of them fulfilled before criticality and some for later compliance.

These last requirements have been incorporated in a HFE verification program using the Angra 2 full scope simulator and analytical evaluations 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 human reliability analysis developed for the Angra 2 level 1+ PSA and operator behaviour in case of beyond design events including severe accidents. Work is being done on both fronts; the actions involved however are of long duration, such as developing a Level 2 PSA and the respective human reliability analysis.

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 (SPDS) 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 main finding in the field of HFE in the recently completed Angra 2 PSR was, as for Angra 1, the lack of a systematic approach for treating these aspects in the plant modifications process.

The Periodic Safety Review of Angra 1 also yielded some action 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 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[5] 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[7]. 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, (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[5], incorporates this operational experience.

Regarding Angra 3, the FSAR chapter 18 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.

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[12], 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[7]. 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 unit.

For Angra 3, ELETRONUCLEAR prepared a quality assurance program applicable to the mounting and assembly phases in accordance with the Standard CNEN-NN-1.16[12]. After the commissioning phase, this program will include the requirements of the Standard CNEN NN-1.26[7], as already established for the first two units.

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 closely monitored the quality assurance activities of Angra plant, trying to focus more on results than on the formalities. Special audits were 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.

This system is already implemented by Eletronuclear, so called Pendency Management System (Sistema de Gerenciamento de Pendências - SGP) and can be accessed on the corporate Intranet and is subject to auditing by Quality Assurance. As an improvement suggested by the IAEA Project RLA 9060, a larger Corrective Action Plan is being considered, using the current software or an improved one.

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 NE1.04[3] in Brazil.

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). Similar procedures are being followed for Angra 3 licensing.

Licensing regulation CNEN NE 1.26, Operational Safety of Nuclear power Plants [7], requires that a Periodical Safety Review (PSR) be performed for each operating nuclear power plant at 10-year intervals.

Concerning the use of PSA in the licensing process, CNEN issued a Guideline in 1993 that have been followed since then. These guidelines are based on CNEN Standard - NN 1.04, which allows the adoption of internationally recognized guidelines, such as those of the US NRC and the IAEA, in case there is no formal Brazilian regulations for certain issues. Later, in 1997, CNEN Standard NE 1.26[7] was issued, requiring the capability of risk management, which implies the PSA study elaboration, to be used as a complementary tool to the deterministic analysis.

Moreover, additional PSA requirements were included in the License Conditions of Angra 1 and Angra 2 Authorizations for Permanent Operation. PSA requirements were also included in the Licensing Conditions of the Construction License for Angra 3.

Angra 1

Periodical Safety Review (PSR)

The first Brazilian PSR was performed for Angra 1 in 2004. 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 CNEN standard NE 1.26[7] and the guidelines of the IAEA safety guide NS-G-2.10 - Periodic Safety Review of Nuclear Power Plants, and making use of international experience from similar plants in Spain (Almaraz) and Slovenia (Krsko), with initial guidance from an external experienced expert. About 30 man-year were spent in an 18 month period. 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[7], 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”. For 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 44 opportunities for improvement, action plans were established and implemented, except for a few long term ones: completion of the development of the envisaged levels 1 and 2 scope of PSA studies; development of the program for evaluation of the isotopic content, as well as the fulfillment of the material condition of the radioactive waste packages already generated, for final deposition; and completion of the implementation of the Systematic Approach to Training for all the Angra 1 Plant disciplines.

As indicated in Article 6, 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) and satisfactory development of the program of safety related improvements identified in this PSR.

Considering that the Angra 1 Plant has already a long operating time, having reached 30 years of commercial operation in beginning of 2013, its second PSR, covering the period 2004 – 2012, has as main focus an in-depth evaluation of the plant ageing and obsolescence management programs. This PSR has been started in May, 2013 and is due by mid 2014. Its results are also intended to be used to support a request for life extension.

Deterministic Analysis

In this review period an extensive scope of new deterministic safety assessments have been performed for the Angra 1 NPP. The whole Safety Analysis chapter of the Angra 1 FSAR, covering the plant transients and accidents, has been 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 developed by Westinghouse, Korea Nuclear Fuel and Indústrias Nucleares do Brasil). All this major design changes required additional safety analyses. The evaluation process carried out by CNEN was finalized in 2009. The new fuel is planned to be introduced in the core during the 2015 refueling outage.

Probabilistic Safety Assessment (PSA)

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 on 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 has been evaluated by CNEN, with the assistance of IPEN staff, and several new requirements were issued to ELETRONUCLEAR in the period 2003-2009.

This PSA is presently in its revision 3, issued in 2012, with the purpose of periodic update, as well as to fulfill the referred CNEN requirements. The periodic update contemplates new plant data and changes in plant hardware and procedures, such as modifications associated with the steam generators replacement. Advances in modeling, such as 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, new modeling of ECCS valves and main control room cooling were also incorporated. A reevaluation of the PSA human reliability analysis was performed, using state of the art EPRI HRA Calculator.

Several important findings, leading to upgrading of plant hardware and operational procedures, arose from this new PSA study. The implementation of new 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} /reactor.year.

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 screening and, when pertinent, evaluation of the impact on the overall plant risk, of all proposed plant modifications.

As a further application, the Angra 1 level 1 PSA has been used to support the implementation 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, based on CNEN requirements related to the Angra 1 PSR was performed, based on more realistic evaluation of the available resources. The scope includes PSA level 1+, including

fire and internal flooding at power, shutdown and low power states, as well as level 2 PSA, involving development of eight major studies, for which it was assumed an average of 24 month for performance of each study. This scope was later extended to include External Events PSA. Completion of the whole program is planned for 2015- 2016.

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 mentioned 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;
- Preparation of the 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.
- Issuing of the Angra 1 level 1+, internal events PSA 3rd overall revision; in 2012;
- Issuing of revision 1 of the Angra 1 Plant Fire PSA study, at the beginning of 2013, incorporating refinement of rooms modeling, which is being applied in the revision of the Angra 1 Fire Hazard Analysis, to evaluate the associated risk reduction of each of the proposed modifications to improve the plant fire protection;

Severe Accident Assessment

A contract with Westinghouse was signed to develop Severe Accident Management Guidelines (SAMG) for Angra 1, based on the Westinghouse Owners Group (WOG) SAMG methodology. The revision 0 of these SAMG has been completed in end of 2009 and is presently in the process of verification, validation and training (see Article 19(4), for more details).

Angra 2

The licensing process for Angra 2 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. CNEN judged that to use two different approaches for licensing would be too time and resources consuming. Accordingly, CNEN 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 limiting conditions for operation, and other relevant matters have been addressed. As far as applicable, the FSAR has been revised to incorporate the modifications derived from these requirements. On the basis of this revision ELETRONUCLEAR was granted the Authorization for Initial Operation in 2001.

Periodical Safety Review (PSR)

As reported in previous National Reports, due to problems independent of plant performance involving the Public Ministry, Angra 2 had been operating on an Initial Operation Authorization, renewed yearly. In June of 2011, after approximately 10 years of operation, Angra 2 Permanent Operation Authorization was issued. One of the conditionings of this Authorization, reinforcing the requirements of the CNEN standard NE 1.26, was the performance of the first Angra 2 PSR, to be issued until the end of 2012. The final Angra 2 PSR report, including the plant global safety assessment, was submitted to CNEN on November of 2012.

The assessments were performed by a multidisciplinary company team from design and support engineering, safety analysis, operations, maintenance, radiation protection and quality assurance, led by a Board appointed committee. About 10 man.year were necessary to complete this work. Having available the experience acquired with the performance of the Angra 1 PSR, being Angra 2 a fairly new plant with a modern documentation system and having available the plant design knowledge (ELETRONUCLEAR was the plant architect engineer), led to a substantially lower effort than the required for the first Angra 1 PSR, which was a turn-key plant, delivered in the early eighties.

The PSR work followed the guidelines of the IAEA guide NS-G-012. A check was done against the draft of the new revision of this Guide, DS 426. The 13 Safety Factors (FS) of the NS-G-012 guide have been assessed, plus an additional one, Severe Accident Management, included as a consequence of the lessons learned from the Fukushima accident. This work resulted in 33 individual assessment reports and one final PSR report containing the summary of the assessments and the plant global evaluation.

Strengths and weaknesses of each FS have been identified. The weaknesses have been subdivided in Deficiencies and Improvement Opportunities. The Deficiencies have been classified from 1 to 5 in accordance to their decreasing importance to safety. The impact to safety of each individual Deficiency, as well as of the whole set of Deficiencies, on the operation of the plant over the elapsed assessment period as well as on the subsequent operation of the plant have been evaluated.

No class 1 deficiencies (high safety importance) have been identified. The final conclusion of the first Angra 2 PSR was that the plant operated safely along its first 10 operation years and that no relevant safety problem was identified that could impact the subsequent operation of this plant.

Action plans have been developed and submitted to CNEN for elimination of the 14 Deficiencies identified, which were basically: lack of procedure (checking of fire penetrations) or poor compliance with some existing safety related

documentation procedures; need to encompass the several ageing management activities in a systematic ageing management program in accordance to the latest IAEA guidelines; development of immobilization processes for contaminated lubricating oil and residual mud from systems clean up; and long permanence time of quality assurance corrective action requests.

Actions plans for the 65 identified Improvement Opportunities are under development.

The PSR for Angra 2 is under evaluation by CNEN. Two issues related to the PRS, the Human Factors Engineering Program and the Severe Accident Management Program were submitted to CNEN only in 2003, and are initial evaluation.

Deterministic Safety Assessment

The safety assessment, with the purpose of demonstration of the adequacy and safety of the plant design bases, includes 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 was the Angra 2 large break LOCA analysis, which was performed following the “best estimate” methodology approach using a “best estimate code” of the RELAP5 MOD2 family, coupled with uncertainty evaluation. This analysis was evaluated by CNEN with the assistance of two international consultants: the German institute GRS (Gesellschaft für Anlagen und Reaktorsicherheit) and the University of Pisa. The verification and acceptance of these analyses was performed through independent calculations performed by the CNEN with the support of the University of Pisa.

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% power increase of Angra 2, together with a fuel design change (HTP - high thermal performance fuel with M5 cladding). Reanalysis of the LB-LOCA with uncertainty quantification was also part of this assessment.

Probabilistic Safety Assessment (PSA)

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 performed taking the German Risk Study, 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 mid 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.

The at-power specific level 1+ PSA for Angra 2, considering internal events and flooding, was developed in the 2005 – 2008 period by an external contractor. Revisions of this study have been incorporated in the previously mentioned PSA development program. To date revision 1 has been issued and revision 2 is being prepared, with support of an external contractor. CNEN requested also to increase the set of Level 1 PSA studies for Angra 2 to include Low Power and Shutdown, Internal Fire, External Events as well as Level 2.

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 an 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;
- Revision 2 of this PSA; underway with completion planned for end of 2013.
- Conclusion of the development of application of the Angra 2 Risk Monitor, using the above PSA model, for Configuration Risk Management of on line maintenance of the plant. The Angra 2 Risk Monitor is being routinely used by the operation and the maintenance planning group.
- Support to the development of the Reliability Centered Maintenance program for the Angra 2. The development of this program is presently completed and implemented.
- Contract of the plant supplier, AREVA, for the development of the referred scope of PSA studies requested by CNEN; foreseen to be completed by mid 2015.

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 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 had not been 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 present CDF value obtained for the Angra 2 plant is 1.15×10^{-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.

Similarly to Angra 1, this PSA has been used routinely for maintenance planning in order to ensure a safe plant configuration during maintenances, to

evaluate the risk impact of plant modifications, to support the Reliability Centered Maintenance program and to support justifications to exceptions to the Technical Specifications, as for instance extended emergency Diesel unavailability times during the 10 years revision of this equipment.

Another important insight arising from the 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 planed.

Severe Accident assessment

The development of Severe Accident Management Guidelines (SAMG) for Angra 2 started in April 2011 is well advanced, being supported through a Cooperation Agreement with the European Commission. For more details see Article 19.(4).

CNEN Safety Evaluations

All technical documents submitted to CNEN by the licensee go through a process of safety assessment by the General Coordination for Nuclear Reactors (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.

During the period 2010-2012, the four divisions of CGRC produced 177 Technical Position reports (PTs) related to the three Angra units. Out of this total, 90 were related to Angra 1, 53 to Angra 2, 21 to Angra 3 and 13 to the common site of these units.

Over the years, the CGRC assessment of Angra 1 PSA Level 1+ study yielded several requirements that were reduced, by 2012, to 54 pending items still to be responded by ELETRONUCLEAR. Most of the pending issues are expected to be resolved and included in the new revision of the Angra 1 PSA Level 1+.

Relating Angra 2 PSA Level 1+, during the period from 2010-2012, only one Technical Position was issued by CNEN, requiring a thorough revision of the study submitted by the ELETRONUCLEAR. The CGRC new assessment of the PSA Level 1+ of Angra 2 will be performed on the first revision of the study, which is still expected to be issued by ELETRONUCLEAR.

Angra 3

Concerning safety evaluation related to the Angra 3 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 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 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 current 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. For a few cases, the design had to be adapted to incorporate either new or more stringent requirements.

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.

On May 25th, 2010 CNEN issued the Construction License with a list of 56 Conditions to be fulfilled before the Authorization for Initial Operation

These conditions are in eight areas as follows:

- [9] Six (6) general conditions
- [10] One (1) condition related to civil construction area
- [11] Eight (8) conditions related to mechanical area
- [12] Three (3) conditions related to electrical area;
- [13] Six (6) conditions related to I&C area
- [14] Four (4) conditions related to safety analysis area
- [15] One (1) condition related to human factors engineering
- [16] One (1) condition related to physical protection

Some highlights of these conditions 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.

Until December 2012 ELETRONUCLEAR answered 36 of CNEN conditions. CNEN released the construction of the following structures: reactor building annulus, reactor auxiliary bldg, switchgear building, feedwater building and the erection of steel containment. Detailed engineering reports related to other safety related buildings were issued by ELETRONUCLEAR and are under evaluation at CNEN.

The preparation of Final Safety Analysis Report, including a new chapter 19 (Severe Accidents and Probabilistic Safety Analysis), is under way at ELETRONUCLEAR, in order to be submitted to CNEN two years before the Authorization for Initial Operation.

Article 14 (2) Verification of safety

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

- Existence of a structured permanent safety oversight process;
- 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, follow up and periodic evaluation of a comprehensive set of performance and safety indicators (see Article 6).
- Verification of how safety problems from internal and external operational experience affect the safety of the Brazilian plants (see Article 19(7)).
- Obtain periodic feedback of external comprehensive peer reviews (WANO, IAEA)

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 an 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 2010- 2012, CGRC performed 59 inspections and audits. Out of this total, 20 were at Angra 1, 26 at Angra 2, 4 at Angra 3 and 9 on the common site. During the same period there was one report of Angra 1 Technical Specification violation, dated October 2010, due to exceeding the limit date for a test performance.

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 [13], 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 0.32 mSv and no one with radiation dose above 8 mSv in the 2010-2012. The dose distribution for the 2010-2012 period is summarized in the Table 4, shown below.

Table 4 - 2010-2012 DOSE DISTRIBUTION FOR ANGRA 1 AND ANGRA 2

Year	2010 (TLD)		2011 (TLD)		2012 (TLD)	
	Number of Persons		Number of Persons		Number of Persons	
	A1	A2	A1	A2	A1	A2
0.0 <-- 0.2	1519	1773	1714	1297	1534	2176
0.2 <-- 1.0	336	270	306	16	20	191
1.0 <-- 2.5	156	57	150	0	0	11
2.5 <-- 5.0	66	7	51	0	0	0
5.0 <-- 7.5	5	0	13	0	0	0
7.5 <-- 10	0	0	0	0	0	0
10 <-- 15	0	0	0	0	0	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	2082	2107	2234	1313	1554	2378
Highest Dose (mSv)	7.31	3.66	6.82	0.87	0.88	1.67
Median Dose (mSv)	0.00	0.00	0.00	0.00	0.00	0.00
Average Dose (mSv)	0.32	0.11	0.28	0.01	0.01	0.04
Collective Dose (person.mSv)	664	225	636	7	7	94

For the incoming years, efforts are in place to reduce the collective doses for Angra 1 and Angra 2, 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 the 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 has 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.

The reference levels for effluent discharge are in accordance with the reference level for dose constraint established 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[6], an Effluents Releasing and Wastes Report is issued for each unit 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 dose for the critical individual is presented. In the period of 2010-2012, the highest dose reached 3.53×10^{-3} mSv in 2010 and the average value for both plants is 1.37×10^{-3} 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 [13].

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.

Based on CNEN requirements, a Radiological Environmental Monitoring Program 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 and in Fig. 6 for the life of the site.

Table 5 – Environmental Monitoring Program Results for 2010-2012

	YEAR		
	2010	2011	2012
	Measured values in mSv/30 days (10^{-2})		
I – Impact Area	7,84	8,05	7,91
C – Control Area	6,89	7,29	7,27

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

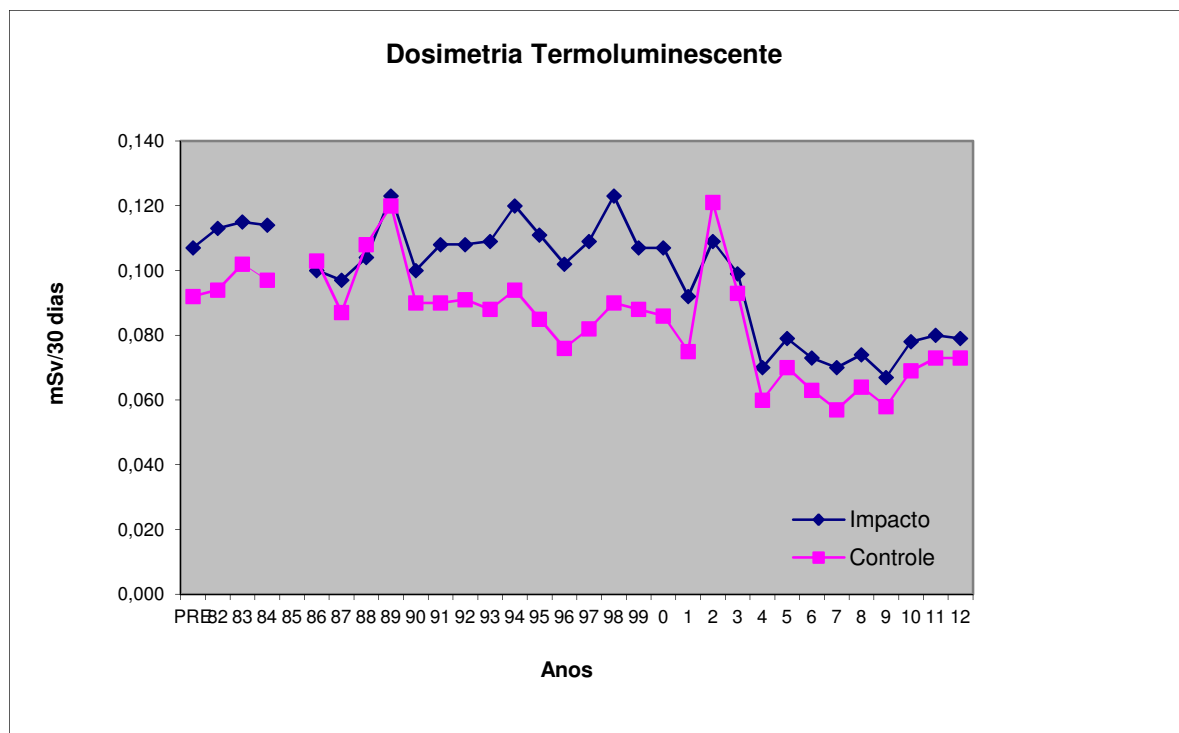


Fig. 6. Site life time environmental impact

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.

This is confirmed by the graph shown in Figure 4, which shows a compilation of Impact and Control measurements from the preoperational phase of the first NPP to be installed on site up to end of 2012, with two Plants in operation. The lack of data for 1985 in the Fig.4 was due to the destruction of the remote Environmental Monitoring Laboratory due to a landslide. The apparent variations in 1998 and 2001 are due to changes in monitoring places or changes in measuring instrumentation.

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 Angra1 nuclear power plant. 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 meter 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 sent to a computerized system in the Technical Support Center / Control Room of Units 1 and 2, through which the follow up and calculation of the spreading of the radioactive cloud is performed.

The former four meteorological towers are being modified with relocation of two of them and installation of new three towers. In addition, an automatic meteorological data transfer to CNEN for emergency management is planned. This new data acquisition system is under implementation but not yet operational. The Decision Support System Argos (Accident Reporting and Guidance Operational System), with a capability of making prognosis up to 72h ahead of the event, for atmospheric releases, by means of the Numerical Weather Prediction, produced in Brazil by CPTEC/INPE, has been implemented and is fully operational at CNEN headquarters. Argos was originally developed by the Danish government, but now it is managed by an International Consortium that encompasses about 14 countries.

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, ensure 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 Brazilian Nuclear Protection System (SIPRON). In November 21st 2012 the Brazilian President has sanctioned the law 12.731 that revokes the law that has created the system on October 7th 1980 and institutes the new structure of SIPRON.

The Brazilian Nuclear Protection System is now organized as follows:

- a) A central organization – that is the Institutional Security Cabinet of the Presidency of the Federative Republic of Brazil;
- b) Three nuclear emergency response centers, and
- c) Four collegiate bodies.

Both the nuclear response centers and the collegiate bodies includes organizations at the federal, state and city levels involved with nuclear emergency preparedness and nuclear security activities as well as those involved with public safety and civil defense.

Within SIPRON, the Central Organization issued a set of General Norms for Emergency Response Preparedness [14], 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 III.5 of Annex III).

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 in collaboration 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.

It is important to state that even before the events in Fukushima, Eletronuclear was already working on projects for the construction of four wharves (although only two were later prioritized) for sea transportation of personnel, equipment and materials and incorporation into the Emergency Plan as alternatives to road access. Furthermore, as part of the periodic exercises program, the Brazilian Nuclear Authority held, in October 2012, a Nuclear Emergency Response Partial Exercise aimed at testing the effectiveness of the Nuclear Power Plant External Emergency Plan's communications network. In the course of such exercise, the functioning of several institutions within the Brazilian framework of nuclear emergency, preparedness and response was assessed.

In September 2013, a broader, General Exercise is expected to take place, as every odd years, involving nearly 1500 people from several institutions participating in the national emergency response framework.

At the off-site level, a National Center for Management of Nuclear Emergency (CNAGEN) operates in Brasilia at the Institutional Security Cabinet of the Presidency of the Republic.

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 [15],[16] (See also III.5 of Annex III) and in the new revision of Rio de Janeiro State Plan for External Emergency, approved by the state governor by Decree 41.147, of 24 January, 2008.

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.

IBAMA, through the Directorship of Environmental Protection - DIPRO, supports CCCEN in environmental issues during eventual nuclear accidents at Angra site with technical resources and equipments. IBAMA was accepted as a member of CCCEN in 2013. Since then, DIPRO is preparing its Complementary Emergency Plan (PEC).

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, 2009 and 2011, the last one with the presence of international observers from fifteen

countries. A partial exercise was performed in 2012 and another full-scale exercise is scheduled for September 2013.

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. During the 2011 full-scale exercise, it was simulated the potassium iodine tablets distribution to a community in the ZPE – 5 (west side). The Brazilian Health Ministry (MS) has issued in September 2012 the Pharmaceutical Assistance Protocol in case of Radiological- Nuclear Accidents which establishes the distribution politics of Potassium Iodine tablets for the population. The amount of 200.000 tablets was purchased by the MS and is under responsibility of Angra dos Reis Municipality. All exercises are prepared, conducted and evaluated under the coordination of the GSI/PR.

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 [16] 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 training courses for community leaders and public school teachers, guided tours for students from public schools to the Nuclear Plant (2,500 in 2012), educational lectures in community associations and 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, 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 Pontifícia 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 continues 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, such as demographic pressure due to the migratory population mainly in the period of the NPP construction, or, the effects in the biota due to thermal variation promoted by the discharges of the tertiary system.

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 demanded a new EIA/RIMA specific for this plant. After holding public hearings and technical analysis, IBAMA issued the Prior License n. 279/2008. Then, Eletronuclear presented the Basic Environmental Plan (PBA), the document required to support the issuance of the Installation License. After analyzing this document, IBAMA issued the Installation License n. 591/09 (equivalent to the nuclear Construction License) for the Angra 3 project in the 5th of March 2009, containing 51 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.

As mentioned before in Article 7, IBAMA is working on unifying the process of licensing the whole site (Central Nuclear Almirante Álvaro Alberto), and judged appropriate to review of the Installation License of Angra 3.

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, have 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.
- In March 2012, CNEN agreed to consider the concept of tornadoes proposed for Angra 3 in the Eletronuclear technical report SE.T/3/BP/011006 Rev.1. The conclusions from the discussions with the CNEN for Angra 3 will serve as a basis for evaluating the measures necessary for Angra 1 and Angra 2.
- Local Emergency Plan (Plano de Emergência Local – PEL), the site emergency plan under the responsibility of Eletronuclear, is revised each two years and the next revision is scheduled to be issued in July, 2013. An extraordinary revision will be issued before the core load of Angra 3.

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 defense 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.

The last significant modification in the Angra 1 was the reactor pressure vessel head replacement in 2013. The original head was made by Babcock & Wilcox and the penetration weld was fabricated with alloy 600 which is susceptible primary water stress corrosion crack. Although the original head have more than 12 years effective full power that ranks as high susceptibility, no indication was founded during the inspections. Together with the head replacement, all control rod drive mechanism and thermal insulation also been replacement.

The new head was made by Mitsubishi Heavy Industry and the new welds were made with alloy 690 which is not susceptible to the primary water stress corrosion crack. The head replacement will ensure the safety and reliability of Angra 1 the long term, contributing to extending the life of the plant. The old head and the old CRDM were stored in the mausoleum with the steam generator replaced.

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.

CNEN has signed in 2009/2010 an agreement with European Union to provide technical cooperation to improve the capacity within CNEN to carry out review and assessment of the safety of digital I&C systems as part of the licensing process of Angra 3 NPP, in construction, and modernization of Angra 1 and Angra 2, in operation. Experiences and practices from European Reactors have been presented and discussed through workshops (4 workshops) and visit to nuclear power with upgraded DI&C (Paks NPP), licensing experiences, etc. Evaluations of concepts, criteria and general requirements of DI&C of Angra-3 described in the PSAR were carried out from 2007 to 2010, as part of License Construction issued by CNEN.

Guidance for assessment of quality and reliability of software and programmable electronics based on IEC standards was developed by GRS-ISTec, revision 1, July 2012. An internal guideline of CNEN, consolidating the licensing experience of I&C systems since 1981, based on the NUREG-800 approach, is under revision, balancing the experiences from US and European for digital I&C

technology which is being used by new design (like EPR, AP1000), to be designed in the Angra-3 instrumentation. These experiences will be used in next phases of the safety evaluations of FSAR and commissioning activities, in compliance of initial operation licensing requirements.

CNEN has also been participating on international workshops for IAEA standard revisions, workshops with NRC on activities for DI&C of US-EPR certification, and with Canadian licensing planning for future reactors.

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 backfittings 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 [7].

Operation is monitored by CNEN through an established system of periodical reports [6], 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 2010-2012, CNEN conducted 20 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, Event Analysis, Monitoring of the Radioactive Effluents Release, Waste Treatment System, Fire Protection and Operators Training.

During the period 2010-2012, CNEN conducted 25 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. A 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 [7]. Additional CNEN regulations establish more detailed requirements for maintenance [18] and in service inspection [19].

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 of 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 and guidelines, logic trees and computational aids to be used by the Technical Support Center staff that takes over operator orientation for management of severe accident conditions. The complete SAMG documentation also includes a set of background material with the bases for the guideline actions and of SAMG training material to be used for initial and periodic retraining.

A second contract was signed with Westinghouse to support ELTRONUCLEAR in the process of verification and validation of the Angra 1 SAMG, integration of these SAMG into the Emergency Planning (EP) documentation as well as training of the involved personnel. The integration of the SAMG with the Emergency planning documentation will be tested through performance of an EP exercise with activation of the Plants Emergency Centers. This work is under way with completion foreseen for mid 2014.

To be coherent with the approach being adopted in the development of the SAMG for the Angra 2 plant as well as to follow IAEA and international practices, additional equipment to help manage a severe accident, such as passive H2 recombiners and filtered containment venting are being procured and purchased for installation in Angra 1. Accordingly, after clear definition of this additional equipment these SAMG will have to be revised to account for it.

Preparatory work for the development of a project to provide SAMG for the Angra 2 was pursued along 2009 - 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.

The project was initiated in March, 2011, and involves the development of Angra 2 specific SAMG, including transfer of know how. The project is envisaged to last 3 years, ending in mid 2014. AREVA was the selected contractor.

So far an Angra 2 severe accident calculation model using the MELCOR code has been developed and validated, the calculations for a comprehensive set of plant damage states have been performed, and the results are being analyzed. Furthermore the evaluation of the Angra 2 existing mechanical, electrical and I&C equipment with possible use in severe accident conditions has also been completed.

The next step consists in the development of simplified computational aids in form of curves or tables to allow quick identification of core or containment conditions in a severe scenario. From these results, Angra 2 specific severe accident management strategies will be derived.

The following additional equipment specific for severe accident management is already being considered in the development of the Angra 2 SAMG: passive H2 recombiners, filtered containment venting and containment sampling system.

In 2010 CNEN initiated a project (BR/RA/01), supported by the European Union, and entitled: "Nuclear Safety Cooperation with the Regulatory Authorities of Brazil (CNEN)". Within this project, CNEN is getting support from the EU to develop

an internal capacity to carry out the assessments of matters related to severe accident management. The ongoing tasks are mostly on the development of regulatory requirements for severe accident management, as well as the assessment of the severe accident management guidelines recently submitted to CNEN by the ETN. This project has been started in June 2011 and should take 2 years, ending in October 2013.

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. 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-NN-1.14 [6].

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 from 2010 - 2012, related to Angra 1 and 2.

- Angra1 reported 3 events of safety significance in 2010, 7 in 2011 and 2 in 2012.
- Angra 2 reported 2 events of safety significance in 2010, 2 in 2011 and 1 in 2012.

Event reports of lesser safety significance, as well as operational deviations that do not classify as reportable in accordance to regulation CNEN NN – 1.14[6], 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 130 to 150 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, between 1 and 7 per year/plant were formally reported to CNEN (see statistics for 2010-2013 in Article 19(6) above) following the requirements of CNEN-NN-1.14 [6].

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, 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.

The invited Peer Review missions performed by WANO or the IAEA, are of particular importance, since they aim to identify departure from industry best practices concerning safety and reliability in plant operation. ELETRONUCLEAR adhered to these review programs since 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 2010 – 2012 review period.

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 2010 – 2012 period.

Table 6 - International Technical and Review Missions to Angra Site between 2010- 2012.

No	Date	Organization	Location	Type of mission
2	June 14-18, 2010	WANO PC	A2	WANO Peer Review – 2 nd Follow up
3	October 25 – 29, 2010	WANO PC	A1	WANO Peer Review – Follow up
4	December 13 – 17, 2010	WANO AC	A1/A2	Technical Support Mission – Equipment Reliability
5	February 21– 25, 2011	INPO	A1/A2	Angra Supervisor Training Course
6	March 14 – 17, 2011	IAEA	A1/A2	RLA/9/060 Enhancing of Safety Culture
7	March 28- April 14, 2011	IAEA	A2	OSART
8	June 27 – July 01, 2011	INPO	A1/A2	Technical Mission to evaluate design modification process and its priorities
9	November 07 – 10, 2011	INPO	A1/A2	Control Room Operators Work Development Seminar
10	November 07 – 10, 2011	WANO PC	A3	Peer Review (Construction Phase)
11	December 01 – 09, 2011	INPO	A3	Assistance Visit – Training Gap Assessment
12	April 18 – 20, 2012	WANO-PC	A1/A2/A3	Nuclear Oversight
13	July 30 – August 2, 2012	INPO	A1/A2	Next Level Leadership Seminar
14	August 20 – Sept 06, 2012	IAEA	A1	OSART
15	December 03 – 07, 2012	IAEA	A2	OSART Followup

A1/A2/A3: Angra 1 / Angra 2/Angra3 NPP
 EPRI: Electric Power Research Institute
 IAEA: International Atomic Energy Agency (Vienna, 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 between 2010- 2012.

No	Date	Leading Organization	Type of mission
1	April, 02 – 25, 2010	WANO PC	PeerReview – Training – Sta Maria de Garoña NPP, Spain
2	May 29 – June 06, 2010	WANO PC	Technical Support Team – Radiation Protection – Cofrentes NPP, Spain
3	June 12 – 20, 2010	IAEA	Prosper Mission – Operational Experience - Sizewell A NPP, England
4	June 26 – July 04, 2010	WANO PC	Latin American Radiological Protection Symposium – Vandellós NPP, Spain
5	June 26 – July 04, 2010	WANO PC	Latin American Radiological Protection Symposium – Vandellós NPP, Spain
6	June 26 – July 04, 2010	WANO PC	Latin American Radiological Protection Symposium – Vandellós NPP, Spain
7	January 21 – February 11, 2011	WANO PC	Peer Review – Organization and Administration – Paluel NPP, France
8	April 01 – 10, 2011	WANO PC	Technical Support Team – Maintenance – Dalian NPP, China
9	May 06 – 29, 2011	WANO PC	Peer Review – Engineering – Hinkley Point B, England
10	May 14 – 22, 2011	WANO PC	Technical Support Team – Maintenance – Tihange, Belgium
11	May 28 – June 09, 2011	IAEA	IAEATEchnical Mission – License Renewal and Life Extension – Paks NPP, Hungary
12	June 17 – 26, 2011	WANO PC	Peer Review Follow Up – Maintenance – Cattenom NPP, France
13	September 09 – 17, 2011	WANO PC	Technical Support Team – Engineering – Tihange NPP, Belgium
14	September 10 – October 02, 2011	WANO PC	Peer Review – Fire Protection – Brokdorf NPP, Germany
15	October 01 – 23, 2011	WANO PC	Peer Review – Training and Qualification – Oskarshamn NPP, Sweden
16	November 19 – December 11, 2011	WANO PC	Peer Review – Chemistry – Forsmark NPP, Sweden
17	March 05 – 09, 2012	WANO PC	Technical Support Mission – Operation Organization – Taishan NPP, China
18	April 02 – 20, 2012	WANO PC	Peer Review – Training and Qualification – Chinon NPP, France
19	April 09 – 27, 2012	WANO PC	Peer Review – Exit Representative – Penly NPP, France
20	May 03 – 25, 2012	WANO PC	Peer Review – Operations – LaSalle NPP, USA
21	May 21 – 25, 2012	WANO PC	Technical Support Mission – Housekeeping Programme – Cattenom NPP, France
22	September 10 – 28, 2012	WANO PC	Peer Review – Organization and Administration – Waste Vitrification Plant – Sellafield – England
23	September 17 – October 05, 2012	WANO PC	Peer Review – Maintenance – Borselle NPP – Holland
24	October 01 – 05, 2012	WANO PC	Technical Support Mission – Human Performance – Blayais NPP, France
25	October 08 – 26, 2012	WANO PC	Peer Review – Maintenance – Cruas NPP, France
26	October 08 – 26, 2012	WANO PC	Peer Review – Fire Protection – Cruas NPP, France
27	October 15 – November 02, 2012	WANO PC	Peer Review – Operations – Dungeness NPP, England
28	November 05 – 22, 2012	IAEA	OSART Mission – Operations – Temelin NPP, Czech Republic
29	November 12 – 30, 2012	WANO PC	Peer Review – Chemistry – Neckarwestheim NPP, Germany
30	November 19 – December 07, 2012	WANO PC	Peer Review – Fire Protection – Fessenheim NPP, France
31	December 03 – 21, 2012	WANO PC	Peer Review – Fire Protection – Atucha 1 NPP, Argentina
32	December 03 – 21, 2012	WANO PC	Peer Review – Maintenance – Atucha 1 NPP, Argentina

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 m³ liners. Compressed solid waste may be conditioned in 200-liter drums and not compressed waste, 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.

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 [19] 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.

The current 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	2969	Storage Facility 1/ Storage Facility 2 / Storage Facility3
Primary Resins	730	Storage Facility 1 / Storage Facility 2 / Storage Facility 3
Filters	516	Storage Facility 1 / Storage Facility 2 / Storage Facility 3
Non-Compressible	952	Storage Facility 1 / Storage Facility 2 / Storage Facility 3
*Compressible	712	Storage Facility 1 / Storage Facility 2 / Storage Facility 3
Secondary Resins	567	Storage Facility 1
TOTAL	6446	

* In 2006 Eletronuclear supercompacted 2027 waste drums. 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	10	In Plant Storage (UKA building)
Concentrate	179	In Plant Storage (UKA building)
Primary Resins	72	In Plant Storage (UKA building)
*Compressible	183	In Plant Storage (UKA building)
TOTAL	444	

* In 2006 Eletronuclear supercompacted 2027 waste drums. 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 (%)
814	65,0	469	45,7

Conclusions on Article 19

Activities by CNEN and ELETRONUCLEAR 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 plant 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.

D. Status of Activities Related to Fukushima Accident

As soon as it was identified the magnitude of the accident occurred in March, 11th 2011 at the Fukushima Daiichi Nuclear Power Station in Japan, the Board of Directors of Eletronuclear decided in March, 16th 2011 to constitute a Technical Committee, coordinated by the Presidency, counting on senior staff members of all company's Directorates, with attributions to follow-up the accident evolution and measures taken to control it, to follow-up the recommendations from international organisms related to nuclear, environmental, industrial, radiological safety and security as a consequence of the accident, and also to help the Executive Board on nuclear safety related matters as a result of the event follow-up.

In April, 19th 2011, Eletronuclear responded to the World Association of Nuclear Operators Significant Operating Experience Report (WANO SOER 2011-2) issued in March 2011, including the results of the recommended verifications regarding Angra 1 and Angra 2 NPPs capability to face beyond design basis accidents, with emphasis on station black out, flooding and fire hazards.

On May 13, 2011, CNEN issued a document number 082/11-CGRC/CNEN formally requiring Eletronuclear to develop a preliminary safety assessment report, including a specific set of technical aspects taking in account the Fukushima accident. These included:

1. Identify the major design differences between Fukushima and Angra Units;
2. Identify possible external initiating events (extreme) and the internal potential cause a common mode failure;
3. Control of concentrations of hydrogen in the containment;
4. Ensuring electricity supply emergency power;
5. Fulfillment of the requirements of station blackout;
6. Service water system, cooling chain;
7. Procedures for severe accidents;
8. Access to buildings and controlled area of the reactor after an severe accident
9. Development of Probabilistic Safety Analysis Level 1+ and 2;
10. Performance of "stress tests"
11. Emergency planning

The Board of ELETRONUCLEAR approved on November 30, 2011, the Plan Eletronuclear Response to Fukushima, prepared by the Management Committee under the presidency of the company, comprising studies and projects related to the reevaluation of the safety of the nuclear power plants, in the light of lessons learned from the accident at the plants of Central Fukushima Daiichi in Japan.

The preparation of the Plan was based on the Preliminary Assessment Report of the Accident at the Fukushima Daiichi Central, developed by ELETRONUCLEAR and submitted to CNEN in August 2011, and the results preliminary evaluations developed by the nuclear industry worldwide.

An Extraordinary National Report of Brazil, following the Guidance for National Reports specially issued by the officers of the Convention on Nuclear Safety was prepared and presented to the Extraordinary Meeting in Vienna in August 2012. More details about actions immediately taken by both CNEN and Eletronuclear due to the event can be found there.

The Fukushima Response Plan, in its original version was submitted to CNEN immediately upon approval by the Executive Board of the company. The development of studies and projects were initiated immediately, and in January 2013 was issued the 2nd revision of the Plan, as shown in Annex II.

Studies and projects listed in the plan are aimed at nuclear plant in general (the site) and for units Angra 1 and Angra 2. The results for Angra 2 will be directly incorporated into the design of Angra 3, where applicable.

The Plan comprises three areas of evaluation: Event Risk Protection, Cooling Capacity and Limitation of Radiological Consequences (see Fig.8). These areas include studies and projects for the period 2011 to 2016, shown in Annex II, with an estimated investment of about US\$ 150 million. The main focus and objectives of these three areas can be seen in the figure below.

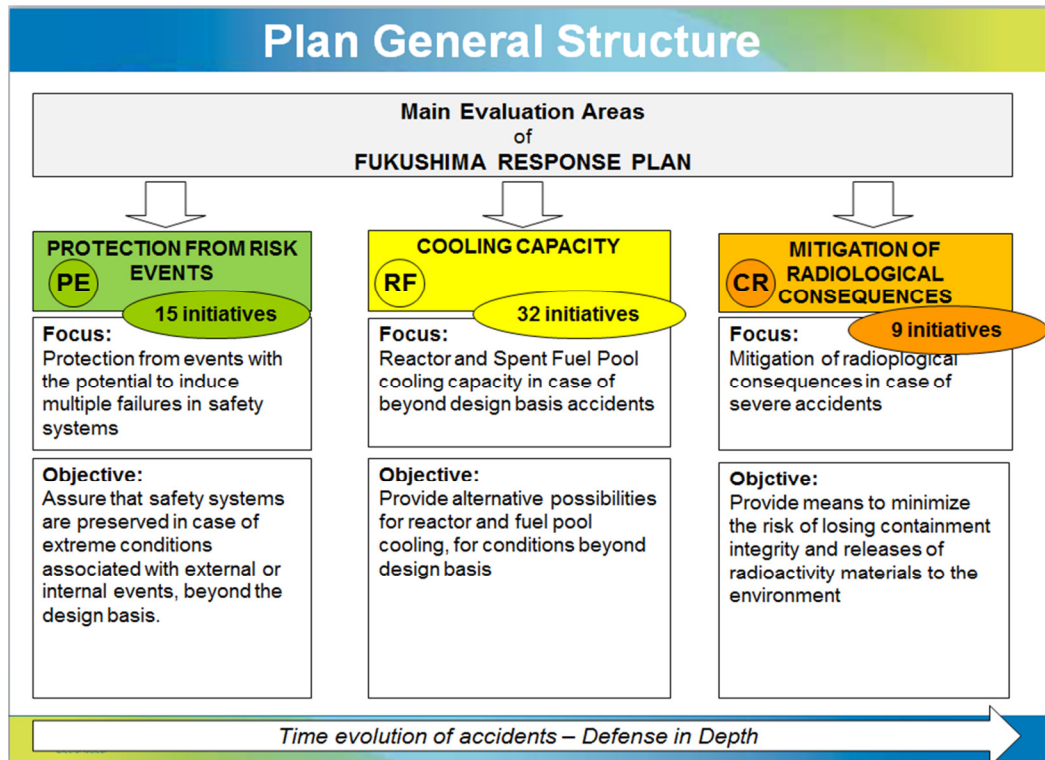


Fig. 8 ELETRONUCLEAR Fukushima Action Plan Structure

The development of the Plan in its first year was impacted in many of their initiatives by hiring difficulties, especially with regard to studies of external events, which mostly involve consultants or of renowned research institutions, with a problematic own viability.

Moreover, initiatives involving evaluation efforts to be developed by the company's own engineering teams had his execution impacted by competition with several other task forces, mainly those related to activities in support of the operation of Angra 1 and Angra 2, involving projects that were already under development, associated with commitments with regulatory authorities, such as the exchange of the Reactor Vessel Head in Angra 1 and completion of the Periodic Safety Review of Angra 2.

Despite these difficulties to first unleash the initiatives, efforts implemented in early 2012 enabled the preparation of the "Stress Test" Evaluation Report for the CNAEA plants - DT-006/12, already submitted to CNEN in April 2012, which was the base for the revision 1 of the Plan, with reorientation and inclusion of some new initiatives.

The results of the report itself and the development of some of the initiatives substantiate further reorientation of priorities in order to accelerate initiatives that could provide important gains in safety margins in the short and medium term.

In the area of **Protection against Risk Events** reevaluation, there was a large concentration of efforts in the areas related to the reevaluation of torrential rains scenarios associated with situations of landslides.

These studies are in final review of their results, and it is expected for the

end of 2013 to complete the definition of possible interventions to increase the safety margins with respect to these threats.

The completion of the reassessment of the CNAAA pier protection adequacy, considering sea movements determined by severe weather conditions is expected for the end of 2013.

The conclusion of the studies that extend to Angra 1 and Angra 2 the consideration of tornadoes threats, already introduced in the Angra 3 licensing process is scheduled for the end of 2013.

The studies related to the revaluation of the seismic threat, with the expansion of the geological and seismic database and its probabilistic treatment will require a larger study, extending the analysis for subsequent years.

Internal events specific revaluations in Angra 1 were contracted. It is expected to complete the tasks related to Fire Hazard in 2013, and those related to Internal Flooding in 2014.

In the area of **Reactor and Pools Cooling Capacity** revaluation, priorities were oriented according to the results of the "Stress Test" Evaluation Report, already referenced.

Therefore, the initiatives related to the implementation of the possibility of connecting mobile devices for emergency power supply, recharging batteries, steam generators feed and air supply for valve actuation were prioritized. All equipments have been specified and are in the process of contracting to be available by the end of 2013.

The development work of design changes to provide means of quick connections of the equipments has already been initiated, with the forecast project completion in September 2013. The installation by the end of the year 2013 will depend on the viability of the materials needed to implement those changes.

Projects related to the water supply for the plants were also prioritized, including the installation of new water supply lines to the Water Pre-Treatment Plant and implementation of a new water reservoir attending seismic requirements in quota able to provide means of feeding the steam generators in a totally passive way. Another project prioritized according to the results of the "Stress Test" Evaluation Report was to provide alternative means of cooling the Diesel groups in Angra 1, in case of loss of service water system. It is expected that all these projects will be implemented between 2014 and 2015.

Still considering means for cooling the reactor, it is planned for the next outage of Angra 2, in May 2013, the installation of primary system bleed-and-feed, attending conditions beyond the design basis.

The studies regarding alternative means of cooling the pools in Station Black Out scenarios were contracted to Westinghouse and AREVA, respectively, for Angra 1 and Angra 2, and should be finished by the end of 2013.

Projects concerning resources for manual interconnection of emergency buses internally in each unit are being developed in 2013 for installation in 2014.

Furthermore, the conceptual study for the establishment of a source of an additional emergency power supply was performed, including the possibility of manual interconnection of emergency buses of the two units. The project for a possible busbars interconnection in emergence between the two units should be prioritized over 2013.

Concerning procedures, the implementation process of the SAMGs of Angra 1 was initiated and development of SAMGs for Angra 2 is proceeding. Both processes scheduled for completion in the first half of 2014.

The preliminary study for the implementation of an Emergency Control Point should be issued in 2013 and the process of acquiring *In Vitro* Dosimetry equipment has already begun.

In the area of **Limitation of Radiological Consequences**, initiatives related to the implementation of systems and equipments for protection of the plants containments, had intensified. Contracting goods and services was concluded in the first quarter of this year. The installation of hydrogen catalytic recombinors in Angra 1 is scheduled for the outage of 2014, and in Angra 2 in the outage of 2015. The installation program is still depending on a more detailed assessment of the interference of assembly activities with the outage activities.

Regarding containment venting, technical discussions with Westinghouse on the installation in Angra 1 and trade negotiations with AREVA for Angra 2, are still ongoing, predicting technical definition and procurement of supplies still in 2013.

With regard to initiatives related to the improvement of the Emergency Plan, the projects of wharves in Frade and Praia Vermelha have been completed. Deployed the first of four alternative tracks for movement of personnel have also been finalized. It is expected that by the end of 2013 the project development of the two other wharves, Praia Brava and Mambucaba, and deployment of the remaining tracks will be completed.

In the following sections the status of each of the initiatives that comprise the Plan, at the end of March 2013, is presented.

D.1 Area of evaluation: Protection Event Risk

The first area of assessment is the evaluation of extreme scenarios of natural disasters, such as checking the facilities, as designed and constructed, would be affected in case of such events. In this area there are studies on earthquakes, effects of torrential rain, slope stability and movements of sea.

Waves – The power plant site is protected by a breakwater protection designed for the containment of waves up to 4 meters in elevation in relation to the highest tidal designed for the region. Currently, the Company is carrying out studies to account for the occurrence of adverse weather phenomena in the region of the Bay of Ilha Grande, which could have the result on wave elevation higher than 4 meters to be considered. Additionally, the company is acquiring a sea movement monitoring system to periodic update of data on tides, waves and currents. Importantly, the access to safety buildings of Angra 1 and Angra 2 are located at 5.60 meters above the sea level. Those from Angra 3 will be at 6.60 meters.

Tsunamis – The nuclear power plants were built in low seismic risk areas and they are not subject to tsunamis due to geological characteristics of Brazilian territory. Brazil is far away from the edges of tectonic plate where it is located and, unlike the case of Japan, the edge of our plate, which is under the ocean, withdraws from it is adjacent. This fact of the South Atlantic Ocean plates move away - unlike the North Pacific plates that collide - makes it physically impossible that, even in the case of a strong earthquake on site, a tsunami wave will be formed.

Rainfalls – Studies are being completed for reevaluation of the flooding quotes scenarios considering further adverse obstruction of channels and drainage networks, in which obstruction of the tunnel includes water discharge in Piraquara de Fora and their overflow to the site. In these studies the effects of rain with a probability of once every 10,000 years are considered. Based on the findings of these studies additional measures of protection against flooding will be defined which could involve increasing the rainwater channels drainage capacity and changes in the input thresholds of some of the buildings where safety equipments are installed.

Slopes – All slopes and containment works executed in the vicinity of the nuclear plant have continuous monitoring and are subject to periodic reviews. Eletronuclear is reassessing the protective measures against slopes sliding to define opportunities for improvement in the existing protection. Additionally, the limit situation of total break of the slopes surrounding the power site and its implications on the safety buildings are being assessed.

Tornadoes – In Angra 3 project the effect of tornadoes is already being considered. In Angra 1 and Angra 2, the impact of this phenomenon in the structures and equipments of the external area of the two units is still under study.

Earthquakes – The Angra site is located in a region of low seismicity. Besides, Eletronuclear is updating geological and seismological data in the region

and evaluating if there are improvements to be made. All studies of these areas are underway, being conducted mostly by universities and research centers in Brazil. The most important should be ready first by mid-2013. According to the findings of the studies, the company may implement additional measures to increase the existent safety margins.

Considering the characteristics of the site, the scope of the studies done to implement in the nuclear complex and the safety margins adopted in the project, it is expected that the studies should confirm the adequacy of facilities and of the protection measures adopted, limiting the implications of their results to localized interventions in certain structures to improve safety.

D.2 Area of evaluation: Cooling Capacity

In this second area, conditions are evaluated to ensure proper cooling of the reactor and the fuel pools in extreme conditions, which include the loss of electricity supply for safety systems and the loss of the cold source, the blockage of water intakes. This type of evaluation has been developed systematically to all nuclear plants, notably in Europe, under the so-called "Reviews of Resistance" or "Stress Tests".

It should be noted that, following the concept of defense in depth, the occurrence of these conditions is assumed despite all the security measures of the premises against the risk events that may cause the loss of electricity supply and the loss of the cold source, and margins of safety considered in the implementation of these measures.

Although Angra 1 and Angra 2 have the resources to cool the reactor and the pool for conditions beyond the design basis, studies and projects developed aimed at providing facilities for new alternatives for cooling the reactor and the pools fuel under these conditions, using systems and fixed equipment installed in power plants, and as portable Diesel generators, motor pumps and refrigeration units.

The studies consider different levels of failure of safety systems up to the extreme condition of unavailability of all fixed plant systems that rely on electricity supply or sea water for cooling.

With the completion of studies, began the technical specification of equipment, already in the process of acquisition, predicting its availability in the plants until the end of 2013.

In parallel, changes in plants that allow quick connection of mobile equipment are being prepared to meet postulated emergency conditions. Training of emergency crews to be prepared for the use of these resources is also underway.

D.3 Area of evaluation: Limitation of Radiological Consequences

The third area is the evaluation of measures designed to prevent or limit releases of radioactive materials into the environment in case of severe accidents, which are characterized by partial melting of the reactor core. The focus of the

studies and evaluation projects in this area is maintaining the integrity of the steel containment that isolates the primary circuit of the reactor and the environment.

The implementation of these measures are already being hired in companies responsible for projects Angra 1 and Angra 2, following the same solutions adopted in similar plants in the United States and Europe.

D.4 General Considerations

From the US\$ 150 million projected to the Plan, about US\$ 15 million are already spent and others US\$ 10 million committed to contracting processes.

In the two evaluation areas most directly related to the specific characteristics of each project, Cooling Capacity and Limitation of Radiological Consequences, Eletronuclear is developing studies and projects with the participation of the companies responsible for the original designs of Angra 1 and Angra 2, with the support of international institutions supporting operators of nuclear power plants, such as INPO – Institute of nuclear Power Plant Operators, EPRI – Research Institute of Electric Power and WANO – World Association of Operators of Plants nuclear.

The performance of the Stress Tests for Angra 1 and Angra 2 is also included as initiatives of the Eletronuclear Response Plan, and the time schedule for their completion takes into account two steps. The first step consists in the development of the required evaluations, considering only engineering judgment, and the second step comprises the performance of detailed calculations using computer codes. The first step was concluded only for Angra 2 by December 2011. The second step was completed in March 2012 and the results included in the Stress Test Report (Relatório de Avaliação de Resistência das Unidades da CNAAA para as Condições do Acidente de Fukushima – “Stress Test” – DT-006/12, de 29/03/2012), forwarded to CNEN in April 2012.

These results were evaluated by CNEN and presented to the Iberoamerican Forum of Nuclear and Radiological Regulatory Bodies (FORO) in a meeting held in Buenos Aires, in June 2012, when regulators from Argentina, Brazil, Spain and Mexico presented the National Report prepared by each country, as well as their cross related peer reviews, that were discussed and agreed by all participating countries.

As a consequence of the assessments performed, recommendations have been identified and are expected to be implemented on a three-step time frame: short, medium and long term, the latest reaching the year 2016. However, a follow-up technical meeting for the short and medium term recommendations will be held in 2014. And, finally, another meeting of the FORO, in 2016, will address the longer term recommendations.

Annex II provides a complete view of the ELETRONUCLEAR Action Plan in terms of the initiatives established for each of the assessment areas already mentioned, in its first review, issued in August 2012. Annex II presents also the status of the Plan at the June of 2013, the initiatives in each area of assessment,

as well as the schedule of the final implementation of actions to improve safety over the period 2013 to 2016.

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]Licensing of Nuclear Installations - CNEN-NE-1.04 - July 1984.
- [4]Siting of Nuclear Power Plants - Resolution CNEN 09/69.
- [5]Licensing of Nuclear Reactor Operator - CNEN-NN-1.01 - October 1979.
- [6]Operational Reporting for Nuclear Power Plants - CNEN-NN-1.14 - 2002.
- [7]Operational Safety in Nuclear Power Plants - CNEN-NE-1.26 - October 1997.
- [8]Safety Policy of CNEN – Directive n.295 of 23 December 1996.
- [9]Quality Assurance Policy of CNEN – Directive n.296 of 23 December 1996.
- [10]Health Requirements for Nuclear Reactor Operators - CNEN-NN.1.06 - 1980
- [11]Certification of Qualification of Radiation Protection Supervisors - CNEN-NN-3.03 - October 1997.
- [12]Quality Assurance for Safety in Nuclear Power Plants and Other installations - CNEN-NN-1.16 – September 1999.
- [13]Basic Radiation Protection Directives - CNEN-NE-3.01 – January 2006.
- [14]General Norm for Planning of Response to Emergency Situations – SIPRON – NG-02 - 1996
- [15]Directive for the Preparation of Emergency Plans related to the Unit 1 of Almirante Alvaro Alberto Nuclear Power Plant – SIPRON Directiva Angra – 1997.
- [16]General Norm for Establishing Public Information Campaigns about Emergency Situations – SIPRON - NG-05 – 1997.
- [17]Maintenance of Nuclear Power Plants - CNEN-NE-1.21 - August 1991.
- [18]In-service Inspection of Nuclear Power Plants - CNEN-NE-1.25 - September 1996.
- [19]Law 10.308 of 2001.11.20 – Rules for the site selection, construction, operation, licensing and control, financing, civil liability and guaranties related to the storage of radioactive wastes.

Annex I

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 building.	Dry cylindrical steel shell and external concrete
Fuel assemblies	121
Main supplier	Westinghouse El. Co.
Architect Engineer	Gibbs& Hill / Promon Engenharia
Civil Contractor	Construtora Norberto Odebrecht
MechanicalErection	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 building.	Dry spherical steel shell and external concrete
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	1351 MWe
Net electric power	1275 MWe
Type of reactor	PWR
Number of loops	4
Number of turbines	1 (1High Pressure/3Low pressure)
Containment building.	Dry spherical steel shell and external concrete
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	(2017)
First Criticality	(2017)
Grid connection	(2017)
Commercial operation	(2018)

ANNEX II

FUKUSHIMA ACTION PLAN STATUS
(Summary Status of June30th, 2013)


FUKUSHIMA RESPONSE PLAN - Initiatives for protection against hazard events - Status in June 2013

INITIATIVE CODE	THREAT	DEFINITION OF COUNTERMEASURES	TIME SCHEDULE FOR IMPLEMENTATION IN THE PLANT
PROTECTION AGAINST EXTERNAL EVENTS			
PE121 a 124	Landslides	The results of the reassessment of the slopes stabilization works are under evaluation.	Report with the recommendations for additional stabilization works and slope monitoring measures scheduled for August 2013 and implementation planned for the second semester of 2014.
PE141 a 143	Site flooding due to rainfalls	The results of the revaluation of flooding scenarios are being verified so as to define the flooding level forbdba conditions.	Definition of an increased flooding level forbdba conditions scheduled for August 2013. Design for increased protection to be developed over the first semester of 2014 and implementation over the second semester of 2014 and first semester of 2015.
PE131 a 133	Tidal waves	The ongoing revaluation of the jetty structure stability for design basis conditions is to be finished in August 2013. The revaluation of maximum wave heights for extreme weather conditions is under way, with results scheduled for September 2013.	The completion of the revaluation of jetty stability for extended design conditions is scheduled for end of 2013. Specification and contracting of jetty reinforcement measures is planned for the first semester of 2014, for performance in 2014 and 2015.
PE151 e 152	Tornadoes	Identification of components to be protected and the respective protection measures up to the end of 2013.	The design for implementing the protection measures is to be developed during the first semester of 2014 and the implementation is planned for 2014 and 2015.
PE111 a 113	Earthquakes	Evaluation of seismic design margins according to EPRI procedure to be started with a preliminary evaluation based on the results of similar plants.	Contracting of the preliminary evaluation scheduled for September 2013 and results for the first quarter of 2014. Detailed evaluation planned for 2015 and possible works in the plants in 2016.
PROTECTION AGAINST INTERNAL EVENTS			
PE211	Internal flooding in Angra 1 due to pipe breaks	The revaluation of internal flooding scenarios has already started and the identification of plant vulnerabilities is expected until April 2014.	Based on the results of the revaluation study, the design modifications will be defined and detailed in 2014, for implementation throughout 2015 and 2016.
PE221	Internal fire in Angra 1	The revision of the plant Fire Hazard started in 2011. The final report with prioritization of plant works scheduled for the end of 2013.	Based on the results of the revision of the Fire Hazard, the design changes will be defined in 2014 and the detailed design and implementation of the plant modifications will be performed throughout 2015 and 2016.
INITIATIVES RELATED TO THE EMERGENCY PLAN			
CR311	Public evacuation restrictions due to road interruption	Construction of four wharfs around the site.	The design is ready for the first two wharfs, with construction scheduled for 2014. The design of the two remaining wharfs is planned for 2014, with construction in 2015.
RF613	Hindrances to the proper management of radiological emergencies	Implementation of an off-site Radiological Control Center	The basic design for the new facility is ready. The detailed design is to be contracted until the end of 2013. Construction is planned for 2015 and 2016.
CR313	Infrastructure limitations for management of emergencies	Enlargement and upgrading of Emergency Centers	Contracting by the middle of 2014 and implementation throughout 2015 and 2016.


FUKUSHIMA RESPONSE PLAN - Angra 1 initiatives for coping with SBO and LUHS - Status in Jun 2013

INITIATIVE CODE	THREAT	DEFINITION OF COUNTERMEASURES	TIME SCHEDULE FOR IMPLEMENTATION IN THE PLANT
PLANT MODIFICATIONS FOR REACTOR AND FUEL POOL COOLING IN ANGRA 1			
RF413	Failure of both Emergency Diesel Systems due to loss of ultimate heat sink	Conceptual design for alternative cooling with mobile pump is ready.	Detailed design and purchasing of supplies up to the end of 2013. Implementation at site planned for the first semester of 2014.
RF411	Operational restrictions for utilization of Emergency Diesel Generators in emergency conditions	Basic design is ready for the possibility of manual interconnection of emergency busbars of one train to the Emergency Diesel Generator of the other train.	Detailed design scheduled for January and supplies to March 2014. Implementation planned for the next plant outage.
RF435	Loss of both Emergency Diesel Systems (SBO)	Supply of essential safety consumers by a mobile Diesel Generator of 1,800 kVA decided within the frame of the Stress Tests.	Purchase of Diesel Generator in July and delivery to site up to December 2013. Design modification for fast connection is in progress. Detailed design and delivery of connection materials (cables and feeders) scheduled for March 2014 and installation plan
RF412	Limitation of batteries' capacity	Recharging of batteries by a portable diesel generator of 250 kVA decided within the frame of the Stress Tests.	Purchase of Diesel Generator in July and delivery to site up to November 2013. Design modification for fast connection is in progress. Detailed design and delivery of connection materials (cables and feeders) scheduled for February 2014 and installation p
RF112	Loss of emergency core cooling systems due to SBO and/or LUHS	Connection of mobile pumps for feeding the Steam Generators and for refilling of the Auxiliary Water Storage Tank decided within the frame of the Stress Tests.	Purchase of mobile pumps in July and delivery to site up to December 2013. Design modification for fast connection is in progress. Detail design and delivery of connection materials (cables and feeders) scheduled for June 2014 and installation planned for
RF113	RCP leakage for long term operation in natural circulation under SBO conditions	The implementation of Westinghouse SHIELD sealing device was decided.	Purchase order scheduled for the second semester of 2013. Delivery to site in the middle of 2014 and installation planned for the plant outage in 2015.
RF312	Loss of Spent Fuel Pool cooling due to SBO conditions	Westinghouse proposal of installing a second heat exchanger for operation with the external mobile refrigerating unit is under evaluation.	Technical and commercial proposal scheduled for July 2013 and purchase in the beginning of 2014. Delivery to site up to the end of 2014 and installation planned for 2015.
PLANT MODIFICATIONS FOR REACTOR AND FUEL POOL COOLING APPLICABLE TO ANGRA 1 AND 2 UNITS			
RF431	Operational restrictions for utilization of Emergency Diesel Generators available at site	The conceptual design for interconnecting emergency busbars of both units is ready (possibility of an Emergency Diesel of one unit to supply consumers of the other unit).	Detailed design and connection materials scheduled for April 2014. Implementation planned to be concluded in 2015.
RF433	Loss of all on-site AC generation (SBO)	Preliminary feasibility studies for installing a small hydropower unit in the vicinity of the plant.	Detailed technical and environmental studies scheduled for the second semester of 2013.
RF131	Degradation of plant pretreated water supply system	Upgrading of Water Pretreatment Station and replacement of the piping.	Detailed design for replacing the piping from the pumping house up to Pretreatment Station until the end of 2013 and replacement of the piping until 2015. Detailed design for replacing the piping from the Pretreatment Station down to the plant until May 2
RF133 e 134	Loss of plant water supply due to failure of existing pretreated water supply system	The conceptual design for the new seismic reservoir and connection to the plants is completed.	Detailed design scheduled for the first quarter of 2014. Implementation planned for the end of 2014.
MITIGATION OF CONSEQUENCES OF SEVERE ACCIDENTS IN ANGRA 1			
CR111	H ₂ explosion inside containment following a severe accident	Installation of passive H ₂ catalytic recombiners.	Equipment was already purchased. Installation planned for 2015.
CR112	Containment overpressure	Installation of filtered containment venting system.	Technical specification scheduled for the end of 2013. Purchase in the middle of 2014, for installation in 2016.
RF512	Complexity of severe accidents management	Implementation of the Severe Accident Management Guidelines (SAMGs) already available for the plant.	Validation and personnel training in 2013. Implementation completion is planned for June 2014.


FUKUSHIMA RESPONSE PLAN - Angra 2 initiatives for coping with SBO and LUHS - Status in Jun 2013

INITIATIVE CODE	THREAT	DEFINITION OF COUNTERMEASURES	TIME SCHEDULE FOR IMPLEMENTATION IN THE PLANT
PLANT MODIFICATIONS FOR REACTOR AND FUEL POOL COOLING IN ANGRA 2			
RF421	Operational restrictions for utilization of Emergency Diesel Generators in emergency conditions	A design to allow supply of consumers of Emergency Diesel System 2 by the Emergency Diesel System 1 is already under way.	Detailed design and delivery of materials scheduled for February 2014. Installation planned for the next plant outage in 2014.
RF435	Loss of both Emergency Diesel Systems (SBO)	Supply of essential safety consumers by a mobile Diesel Generator of 1,000 kVA decided within the frame of the Stress Tests.	Purchase of Diesel Generator in July and delivery to site up to December 2013. Design modification for fast connection is in progress. Detailed design and delivery of connection materials (cables and feeders) scheduled for March 2014 and installation plan
RF422	Limitation of batteries' capacity	Recharging of batteries by a portable diesel generator of 250 kVA decided within the frame of the Stress Tests.	Purchase of Diesel Generator in July and delivery to site up to November 2013. Design modification for fast connection is in progress. Detailed design and delivery of connection materials (cables and feeders) scheduled for February 2014 and installation p
RF122	Loss of emergency core cooling systems due to SBO and/or LUHS	Connection of mobile pumps for feeding the Steam Generators and for refilling of the Auxiliary Water Storage Tank decided within the frame of the Stress Tests.	Purchase of mobile pumps in July and delivery to site up to December 2013. Design modification for fast connection is in progress. Detailed design and delivery of connection materials (cables and feeders) scheduled for June 2014 and installation planned f
RF221	Failure of reactor cooling through secondary side	Extension of Bleed-and-Feed for operation under SBO conditions.	Partial installation during the last plant outage, to be completed during the next plant outage in 2014.
RF322	Loss of Spent Fuel Pool cooling due to SBO conditions	Design modification to allow connection of the fire fighting system to the fuel pool cooling heat exchanger.	Conceptual design scheduled for the end of 2013. Purchasing of detailed design and supplies by the middle of 2014 and installation up to 2016.
PLANT MODIFICATIONS FOR REACTOR AND FUEL POOL COOLING APPLICABLE TO ANGRA 1 AND 2 UNITS			
RF431	Operational restrictions for utilization of Emergency Diesel Generators available at site	The conceptual design for interconnecting emergency busbars of both units is ready (possibility of an Emergency Diesel of one unit to supply consumers of the other unit).	Detailed design and connection materials scheduled for April 2014. Implementation planned to be concluded in 2015.
RF433	Loss of all on-site AC generation (SBO)	Preliminary feasibility studies for installing a small hydropower unit in the vicinity of the plant.	Detailed technical and environmental studies scheduled for the second semester of 2013.
RF131	Degradation of plant pretreated water supply system	Upgrading of Water Pretreatment Station and replacement of the piping.	Detailed design for replacing the piping from the pumping house up to Pretreatment Station until the end of 2013 and replacement of the piping until 2015. Detailed design for replacing the piping from the Pretreatment Station down to the plant until May 2
RF133 e 134	Loss of plant water supply due to failure of existing pretreated water supply system	The conceptual design for the new seismic reservoir and connection to the plants is completed.	Detailed design scheduled for the first quarter of 2014. Implementation planned for the end of 2014.
MITIGATION OF CONSEQUENCES OF SEVERE ACCIDENTS IN ANGRA 2			
CR121	H ₂ explosion inside containment following a severe accident	Installation of passive H ₂ catalytic recombiners.	Equipment was already purchased. Installation planned for 2015.
CR122	Containment overpressure	Installation of filtered containment venting system.	Technical specification scheduled for the end of 2013. Purchase in the middle of 2014, for installation in 2016.
RF522	Complexity of severe accidents management	Implementation of the Severe Accident Management Guidelines (SAMGs) already available for the plant.	SAMGs in preparation. Implementation, including validation and personnel training, up to the end of 2014.

Annex III

RELEVANT CONVENTIONS, LAWS AND REGULATIONS

III.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.

III.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

Law N° 12.731 of 21/11/2012 that reorganize the Brazilian Nuclear Protection System (SIPRON). 12.731 DE 21/11/2012

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 dated 1999.09.21 – 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.

Supplementary Law 140 dated 2011.12.08 - Set standards relating to sections III, VI and VII of the sole paragraph of art. 23 of the Constitution, for the cooperation between the Union, the states, the Federal District and the municipalities in administrative proceedings arising from the exercise of common responsibility for the protection of outstanding natural landscapes, the protection of the environment, the control of pollution in any of its forms, and the preservation of forests, fauna and flora.

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 nucleoeletricas - (*Operation reports for nuclear power plants*).

NE 1.16 - Garantia de qualidade para a segurança de usinas nucleoeletricas 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 nucleoeletricas - (*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 nucleoeletricas - (*Maintenance of nuclear Power plants*).

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

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

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

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

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

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

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

NN 1.15 - Supervisão técnica independente em atividades de garantia da qualidade em usinas nucleoeletricas - (*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 nucleoeletricas -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 nucleoeletricas - (***Transport, receiving, storage and handling of fuel elements in nuclear power plants***).

NE 5.03 - Transporte, recebimento, armazenagem e manuseio de itens de usinas nucleoeletricas - (***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***).

III.4. CONAMA/IBAMA 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, especially 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).

IBAMA Normative Instruction n ° 184/08– (*Establishes within this Agency, the procedures for federal environmental permits*) - (17/07/2008).

III.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*). GSIPR N° 34 of 24 /08/ 2012.

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. nº8 – GSIPR of 24/03/ 2011.

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.nº 40 – CH/GSIPR, of 25/06/ 2012.

Comitê de Articulação nas Áreas de Segurança e Logística do Sistema de Proteção ao Programa Nuclear Brasileiro – CASLON(***Coordination Committee for the Safety and Support Areas of the System for Protection of the Brazilian Nuclear Program***) –Port. nº31 GSIPR, of 26 /03/ 2012.

This 6th National Report was prepared by a Working Group from the following organizations:

Comissão Nacional de Energia Nuclear (CNEN)

Eletrôbrás Termonuclear S. A (ELETRONUCLEAR)

*Central Organization for the Protection of the Brazilian Nuclear Program
(SIPRON)*

Instituto Brasileiro da Amazônia e Meio Ambiente (IBAMA)

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