NATIONAL REPORT

OF

BRAZIL

FOR THE

JOINT CONVENTION ON THE SAFETY OF SPENT FUEL MANAGEMENT AND ON THE SAFETY OF RADIOACTIVE WASTE MANAGEMENT

May 2006

FOREWORD

On 29 September 1997 the Join Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management was open for signature at the headquarters of the International Atomic Energy Agency in Vienna. Brazil signed the Convention on October 11^{th}, 1997 and ratified it by the Legislative Decree n. 1.019 of November 14^{th}, 2005. Brazil deposited the instrument of ratification with the Depositary on 17 February 2006.

The Convention objectives are to achieve and maintain a high level of nuclear safety worldwide in spent fuel and radioactive waste management. One of the obligations of the Parties to the Convention is the preparation of a periodical National Report describing the measures taken to implement each of the obligations of the Convention, including a description of the policies and practices related to spent fuel and radioactive waste management and an inventory of related material and facilities.

Since Brazil has not participated in the First Review Meeting, neither in the Preparatory Meeting for the Second Review Meeting, this first National Report was prepared for presentation in the Second Review Meeting, under the condition of "late ratifier".

The National Report of Brazil was prepared by a group composed of representatives of the various Brazilian organizations with responsibilities related to safety of spent fuel and radioactive waste, and is presented to the Parties of the Convention. The National Report contains a description of the Brazilian policy and programme related to the safety of nuclear energy, and an article-by-article description of the measures Brazil is taking to implement the Convention obligations, according to the format of document INCIRC/604.

SUMÁRIO

Em 29 de setembro de 1997 a Convenção Conjunta sobre Segurança no Gerenciamento de Combustível Nuclear Usado e sobre Segurança no Gerenciamento de Rejeitos Radioativos foi aberta para assinaturas na sede da Agência Internacional de Energia Atômica em Viena. O Brasil assinou a convenção em 11 de outubro de 1997 e ratificou-a através do decreto legislativo n. 1.019 de 14 de novembro de 2005, depositando o instrumento de ratificação no Depositário em 17 de fevereiro de 2006.

O objetivo da Convenção é alcançar e manter um alto nível de segurança no gerenciamento de combustível nuclear usado e de rejeitos radioativos em todo o mundo. Uma das obrigações das Partes da Convenção é a preparação a cada 3 anos de um Relatório Nacional descrevendo as medidas tomadas a fim de cumprir os objetivos da Convenção.

Como o Brasil não participou na Primeira Reunião de Revisão, nem na Reunião preparatória para a Segunda Reunião, este primeiro Relatório Nacional do Brasil foi elaborado para ser apresentado na Segunda Reunião de Revisão. O Relatório foi preparado por um grupo composto por representantes das várias organizações brasileiras com responsabilidades relacionadas com a segurança de combustíveis usados e rejeitos radioativos, e é apresentado às Partes da Convenção. O Relatório contém uma apresentação da política nuclear brasileira, o programa relacionado com a segurança nuclear e uma descrição das medidas tomadas pelo Brasil para implementar as obrigações de cada artigo da Convenção. O conteúdo do Relatório segue as Diretrizes estabelecidas pelas partes durante a reunião preparatória da Convenção contidas no documento INCIRC/604 de 1 de julho de 2002.

As considerações finais apresentadas na seção K levam à conclusão de que o Brasil alcançou e vem mantendo um alto nível de segurança na gerência de combustíveis usado e de rejeitos radioativos em todas as suas atividades, implementando e mantendo defesas efetivas contra o potencial risco radiológico a fim de proteger os indivíduos, a sociedade e o meio ambiente de possíveis efeitos da radiação ionizante, evitando acidentes nucleares com conseqüências radiológicas e mantendo-se preparado para agir efetivamente em uma situação de emergência.

Consequentemente, o Brasil alcançou os objetivos da Convenção Conjunta sobre Segurança no Gerenciamento de Combustível Nuclear Usado e sobre Segurança no Gerenciamento de Rejeitos Radioativos.

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NATIONAL REPORT OF BRAZIL FOR THE JOINT CONVENTION ON THE SAFETY OF SPENT FUEL MANAGEMENT AND ON THE SAFETY OF RADIOACTIVE WASTE MANAGEMENT

Section A - INTRODUCTION

A.1. THE BRAZILIAN NUCLEAR POLICY

The Brazilian Federal Constitution of 1988 states in articles 21 and 177 that the Union has the exclusive competence for managing and handling all nuclear energy activities, including the operation of nuclear power plants. 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. The Union is also the ultimate responsible for the safe disposal of radioactive waste. All these activities shall be solely carried out for peaceful uses and always under the approval of the National Congress.

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

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

The plan for Science and Technology envisages also a growing utilization of nuclear technology in other areas such as medicine, industry and food irradiation. To accomplish this, research and development institutions operate research reactors and isotope production facilities, as well as develop the related technology and prepare the necessary manpower.

The National Commission for Nuclear Energy (Comissão Nacional de Energia Nuclear - CNEN) was created in 1956 (Decree 40.110 of 1956.10.10) to be responsible for all nuclear activities in Brazil. Later, CNEN was re-organized and its responsibilities were established by the Law 4118/62 with alterations determined by Laws 6189/74 and 7781/89. Thereafter, CNEN became the Regulatory Body in charge of regulating, licensing and controlling nuclear energy utilization, and the nuclear electric generation was transferred to the energy government sector. CNEN is also responsible for the research and development aspects and the production of radioisotopes. According to Brazilian Legislation, CNEN is also the governmental body responsible for receive and dispose of radioactive waste in the whole country.

A. 2.THE BRAZILIAN NUCLEAR PROGRAMME

A. 2. 1. Nuclear Power Plants

Currently, Brazil has two nuclear power plants in operation (Angra 1, 657 MWe gross/627 MW net, 2-loop PWR and Angra 2, 1350 MWe gross /1275MWe net, 4-loop PWR), and a third plant (Angra 3, 4-loop PWR, similar to Angra 2) whose project implementation has been temporarily interrupted since 1991. The resumption of Angra 3 is presently being considered by the Federal Government, due to the possibility of a shortage of energy supply in the country in the near future. Angra 1, 2 and 3 are located at a common site, near the city of Angra dos Reis, about 130 km south of Rio de Janeiro.

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

Brazil has established a nuclear power utility/ engineering company Eletrobras Termonuclear S. A. (ELETRONUCLEAR), a heavy components manufacturing, Nuclebras Heavy Equipment (Nuclebras Equipamentos Pesados - NUCLEP), a nuclear fuel manufacturing plant (Fábrica de Combustível Nuclear - FCN) and a yellow-cake production plant belonging to Nuclear Industries of Brazil (Industrias Nucleares do Brasil - INB). Brazil has also the technology for Uranium conversion and enrichment, as well as private engineering companies and research and development institutes devoted to nuclear power development. Over 15,000 individuals are involved in these activities. Brazil ranks sixth in world Uranium ore reserves, which amounts to approximate 310,000 t U_3O_8 in situ, recoverable at low costs.

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

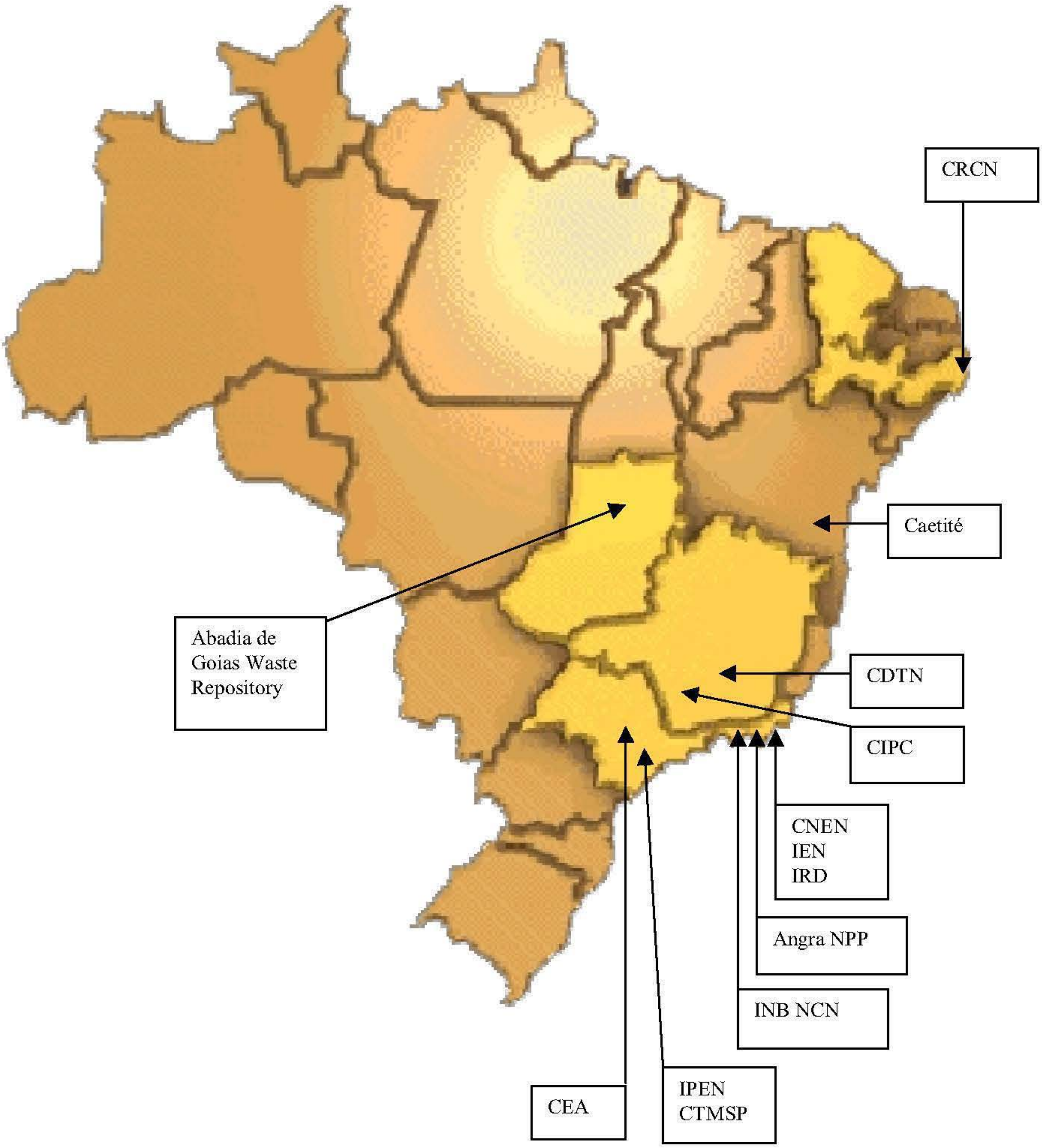


Fig.A.1- Main Brazilian Nuclear Installations and Organizations

A. 2.2. Research Reactors (RR)

Brazil has 4 research reactors operating at CNEN institutes.

A. 2.2.1. IEA- R1

IEA-R1, considered the most important Brazilian RR, is the oldest in the Southern Hemisphere. Located at the Nuclear and Energetic Research Institute (Instituto de Pesquisas Energéticass e Nucleares - IPEN), on the campus of São Paulo University, in São Paulo city, it was started to be built in 1956 within the US program Atoms for Peace. The reactor reached criticality for the first time on September 16th of 1957. Although designed to operate at 5 MW, from 1957 until 1961 the operation of the reactor was mainly for commissioning tests and some nuclear physics experiments. The regime of operation of the reactor was during weekdays, less than 8 hours a day, with power level between 200 kW and 2 MW. In 1961 a program was established to produce ^{131}I, and the reactor began to be operated at a constant power of 2 MW, 8 hours per day, 5 days per week. In 1995 a new program was established with the objective to start immediate production of ^{153}Sm, and to prepare the reactor to produce ^{99}Mo. As result of this decision the regime of operation was changed to continuous 64 hours per week, from Monday through Wednesday, keeping the reactor power at 2 MW. Some modifications were introduced to comply with new national legislation to operate continuously during 120 hours per week at 5 MW. The burn-up rate, which is currently 240 MW-Day per year, is expected to increase to 1100 MW-Day per year.

Initially operating with high-enriched fuel, it has been converted to Low Enriched Uranium (LEU).

A.2.2.2. IPR – R1

The 250 kW Triga reactor operating at the Nuclear Technology Development Centre (Centro de Desenvolvimento de Tecnologia Nuclear - CDTN) on the campus of Federal University of Minas Gerais in Belo Horizonte is mainly used for research. IPR-R1 was the second Brazilian RR. The first criticality was achieved on November of 1960. The regime of operation of the reactor is 4 hours per day, 5 days per week, 40 weeks per year. The integrated burn-up of the reactor since its first criticality until present time is about 130 MW-Days. Due to the low nominal power, except for aging concerns, spent fuel is far from being a problem. The first fuel assembly replacement of the reactor is expected to occur only in 2010.

A.2.2.3. Argonauta – IEN

The third Brazilian RR is named Argonauta, and is located at the Institute of Nuclear Engineering (Instituto de Engenharia Nuclear – IEN) on the campus of the Federal University of Rio de Janeiro, in Rio de Janeiro city. The first criticality of the reactor was reached on February of 1965. The reactor can operate at a maximum power of 1kW during an hour or 500 W continuously. It is usually operated in the range of 170 to 340 W. The accumulated burn-up of the reactor since its first criticality is about 0,25 MW-Day, and as in the case of IPR-R1, due to the low nominal power, storage of spent fuel is not a problem. It is used mainly for training purposes, research and sample irradiation.

A.2.2.4. IPEN MB-01

The most recent Brazilian RR is IPEN/MB-01, located also at IPEN. It is the result of a national joint program developed by the CNEN and the Brazilian Navy. The reactor, a water tank type critical facility rated 100 W, is mainly used for simulation of small LWR and research in reactor physics. It reached criticality for the first time on November of 1988. For IPEN/MB-01 the accumulated burn-up is below 0,1 MW-Day.

A.2.3 Nuclear Installations

A 2.3.1. Mining and Milling

Two facilities have been in operation in Brazil. In Poços de Caldas, a closed mine, was operating from 1982 until 1995. All the economically recoverable Uranium was extracted and currently no mining activity is under way. The site is being prepared to be decomissioned.

A new mining facility has been operational since 2000 in Caetité, with reserves of 100 000 t of U_3O_8, and a capacity of 400 t/year of yellow cake (U_3O_8), which can be expanded to 800 t/year.

A 2.3.2 Monazite Sand Extraction

Brazil has large deposits of monazite sand in its Central–East Coast. These have been in exploration since the 1950's. The only treatment facility in operation is located at Buena, in Rio de Janeiro state. Another facility, in Indianopolis, in São Paulo state, is no longer in operation.

A.2.3.3. Uranium Enrichment and Fuel Fabrication

An industrial complex in Resende contains two units operated by INB related to the fabrication of nuclear fuel for the Brazilian nuclear power plants.

In the first unit, Uranium hexafluoride is converted into UO_2 power, and fuel pellets are fabricated. The current nominal capacity is of 165 t/year of UO_2 powder, and 120 t/year of UO_2 pellets, although only part of this is actually produced.

In a second unit PWR fuel assemblies are fabricated, using fuel pellets from the first unit and additional components imported or produced locally. The nominal capacity is 240 t/y of Uranium. From 1982 to 2003 this unity produced 702 fuel assemblies for Angra1 and Angra 2. In 2004 54 fuel assemblies were produced.

At the same site, installation of a complex for Uranium enrichment based on ultracentrifuge technology developed by the Brazilian Navy is under way, with initial operation scheduled for 2006. The nominal capacity at the initial phase will be 2.4 ton of SWU.

A.2.4. The Navy Program

The Brazilian Navy started in 1979 a research and development program with the objectives of design, construct and operate a nuclear submarine. To coordinate these activities, the Navy Technological Center at São Paulo (CTMSP) was created, comprising facilities in the cities of São Paulo and Iperó (Centro Experimental Aramar – CEA). The most important facilities include offices, laboratories worhshops, a pilot scale fuel fabrication (LABMAT); Uranium Enrichment Laboratories (LEI and USIDE) and a Radio-ecological Laboratory (LARE). Still under construction is the UF_6 conversion facility (USEXA), and a land based prototype reactor (LABGENE) for a nuclear propelled submarine.

A.2.5. Radioactive Installations

In Brazil, the radioactive installations, including the use of radioactive sources, are classified in 5 areas: medical, industrial, research and education, distribution and services.

In 2005, the national registry included 3455 radioactive installations. Table A.1 shows the distribution by areas of application in recent years. It is expected that this growing trend will continue in the following years.

Table A.1 - Distribution of Radioactive Installation Licences by Area (2003-2005).

Area	2003	2004	2005
Medicine	1302	1310	1259
Industry	1041	1144	1167
Research	679	684	706
Distribution	76	77	75
Services	245	245	248
Total	**3343**	**3383**	**3455**

A.2.5.1.Medical Installations

A.2.5.1.1.Radioterapy Services

A total of 1231 sources are in operation. Brazil follows the world trend to substitute the Cobalt sources by linear accelerators. There is also a national plan to re-equip hospitals with 40 oncology centers.

A 2.5.1.2.Nuclear Medicine Services

The use of radioisotopes in medicine is growing steadily, with the substitution of external irradiation by internal therapy using new radiopharmaceuticals, requiring an increased attention to the adaptation of the physical installations, especially with respect to the treatment and storage of waste and the release of effluents.

A.2.5.2 Industrial Installations

A total of 1167 sources are under utilization in industrial installations as described below.

A.2.5.2.1. Industrial Radiography Services

The construction of the Bolivia-Brazil gas pipeline has significantly increased the demand for industrial radiography services. Requiring a large effort to prepare the necessary personnel and develop the necessary procedures, especially for contractors.

A.2.5.2.2.Utilization of Nuclear Measuring Instruments

The chemical, siderurgical, petrochemical, plastic, paper and other industry are increasingly using measuring instruments (gauges) based on radioactive sources. Also portable instruments used for density measurement are becoming more disseminated. Sources such as ^{137}Cs, ^{241}Am, ^{90}Sr and ^{85}Kr are the most utilized.

A.2.5.2.3.Oil Exploration Well Profiling

In 2005, 7 organizations operated 19 bases for prospecting oil in the North, Northeast and the Central coastal region using radioactive sources. Sources such as ^{241}Am, ^{60}Co, ^{226}Ra, ^{137}Cs and Am/Be neutron sources are been utilized.

A.2.5.3. Industrial Irradiators

There are 4 ^{60}Co large size industrial irradiators operating in São Paulo state. They are used for sterilization of medical equipment and food irradiation.

One additional irradiator is installed in Manaus, but its activities are currently halted, due to pending licensing issues.

Regarding smaller irradiators, two units are operative in the country: one at the CNEN’s research center CDTN, in Belo Horizonte, and another in Piracicaba, at the University of São Paulo’s Center of Nuclear Energy for Agriculture, CENA.

A.2.5.4 Research Installations

The use of radioisotopes in research occurs mainly at CNEN research institutes (IPEN, IEN, and CDTN), but also other research centers and universities have some radioactive sources. The research is diverse, including nuclear physics, biology, agriculture, health, hydrology and environment. Small sources of ^{3}H, ^{14}C, ^{22}Na, ^{55}Fe, ^{63}Ni, ^{125}I, ^{226}Ra, ^{35}S e ^{32}P are utilized.

Since 1986, IEN has also a cyclotron (CV-28), which is used in the production of radiopharmaceuticals for use in diagnostic examinations. The Institute has adopted the KIPROS system (Karlsruhe Iodine Production System). This ^{123}I production routine provides conditions for labeling special molecules. The first one was MIBG, which has the main application on cardiology. Presently IEN delivers only to the largest cities in the country. Another important radioisotope for medical purposes to be produced is ^{18}F, considered the newest and most innovative technology in nuclear medicine.

Radioisotopes for medical uses are produced at IPEN in the Cyclotron Accelerators Center and in the Research Reactor Center. These radioisotopes, together with other imported ones, are processed at the Radiopharmacy Center under the requisites of the ISO 9002 standards and distributed just-in-time to hospitals over the country, attending over 2.3 million patients per year. A total of about 6.4×10^{2} TBq of $^{18}F^{-}$, ^{67}Ga, ^{123}I, ^{131}I, ^{99}Mo, ^{153}Sm, ^{35}S, ^{32}P and ^{51}Cr compounds are processed annually at IPEN.

A. 2.6 Waste Repository at Abadia de Goias

Following the 1987 accident with a disused ^{137}Cs source, and a large contamination of the city of Goiania, two near surface repositories containing 3.500 m^{3} of radioactive waste was constructed in Abadia de Goiás in 1995.

A long-term robust safety assessment analysis was done at that time proving the safe of the two disposal repositories. After seven years of disposal, a second safety assessment was performed by the CNEN to re-evaluate the safety of the two systems. This will be described in details in item D.6 and H.7.

A.3. STRUCTURE OF THE NATIONAL REPORT

This First National Report was prepared to fulfill the Brazilian obligations related to the Convention[1]. Section B to K present an article by article analysis of the Brazilian structures, actions and activities related to the Convention's obligations, and follow the revised Guidelines for the preparation of National Reports[2]. In Section B some details are given on the existing policies and practices. Section C defines the scope of application of the Convention in Brazil. Section D presents the inventory of installations and facilities. Section E provides details on the legislation and regulations, including the regulatory framework and the regulatory body. Section F covers general safety provisions as described in articles 21 to 26 of the Convention. Section G addresses the safety of the spent fuel management including during siting, design, construction and operation. Section H similarly addresses the safe management of radioactive waste. Section I covers a case of transboundary movement of spent fuel. Section J details the situation of disused radioactive sources.

Generally the report treats separately different types of facility, whenever necessary. Especially nuclear power plants, due to their complexity, are always treated separately.

Section K describes planned activities to further enhance nuclear safety and presents final remarks related to the degree of compliance with the Convention obligations.

The report also contains 2 annexes where more detailed information is provided with respect to the spent fuel storage and radioactive waste facilities, and the Brazilian nuclear legislation and regulations. A third annex presents a list of used abbreviations.

Section B – POLICIES AND PRACTICES

B.1. INTRODUCTION

Brazilian practices related to spent fuel and radioactive waste management are similar to most international practices.

The policy adopted with regard to spent fuel from nuclear power plants is to keep the fuel in safe storage until an international consensus is reached about reprocessing and recycling of the fuel, or a final disposal as such. Therefore, spent fuel is not considered radioactive waste in the sense of this Convention.

Regarding radioactive waste, the policy is to keep safely isolated from the environment for time being, while a permanent solution is expected on a national level.

The basic legislation governing this policy is the Brazilian Constitution, which establishes in its article 21 that "all the nuclear energy activities shall be solely carried out for peaceful uses and always under the approval of the National Congress"; the Law 6.189 of 16 December 1989, which attributed to CNEN the responsibility for the final disposal of radioactive wastes; and the recent Law n. 10.308 of 20th November 2001 which established rules for the siting, licensing operation and regulation of radioactive waste facilities in Brazil (see also E.2.4).

B.2. RADIOACTIVE WASTE

B.2.1.Types and Classification

The waste classification categories utilized in Brazil are the same adopted by the IAEA.

Radioactive wastes are classified in three categories, as shown on Table B-1below.

In the Table, short lived are those radionuclides which half-lives of approximately 30 years such as: ^{60}Co, ^{90}Sr, ^{137}Cs, etc.

The types of the wastes are those normally generated by the sources presented in section A of this document and are described in more detail in the inventory presented in the section D.

Table B.1 – Waste Classification

Category	Characteristics	Disposal Option
1.Exempt waste	Activity levels equal or bellow the exemption limits that was based in a maximum impact dose of 0,01 mSv/a for public	No radiological restriction
2. Low and Intermediate level 2.1. Short lived 2.2. Long lived	Activity levels above exemption limit and heat generation equal or below 2 kW/m^3. Long lived Alfa emitters contents equal or below 4000 Bq/g and the average specific activity of all radionuclides in the package (immobilised) below 400 Bq/g). Radionuclides alfa emitters concentration above limits cited before for short live	Near surface repository or geological. Geological repository
3. High level waste	Heat generation above 2kW/m^3 and alfa emitters concentration above the limits allowed for low and intermediate level waste – short lived (2.1)	Geological repository

Section C – SCOPE OF APPLICATION

C.1. DEFINITION OF SCOPE

According to the definition of the Convention and the Brazilian policies and practices described in section B, the activities and facilities covered by this report include all spent fuel and radioactive waste related to the Brazilian nuclear programme described in section A.2.

As mentioned in B.1, spent fuel is not considered radioactive waste, pending an international consensus and a national decision about possible reprocessing of this fuel.

Waste containing only natural occurring radioactive material will be included in the scope only to the extent that they are produced in the processing of Uranium and Thorium containing ores, such as Monazite sand processing, as described in sections H.2.2.2, H.2.2.3, and H.2.2.4.

So far, there is no spent fuel within the military or defense programme in Brazil. The management of waste generated in the nuclear submarine programme of the Brazilian Navy, although of minor importance and small quantity, is described in section D.4.

Section D - INVENTORY AND LISTS

This section describes the facilities and activities that produce spent nuclear fuel and radioactive waste, and present a detailed description of the inventories. The same information is presented in a table format in Annex 1.

D.1. NUCLEAR POWER PLANTS

As mentioned in item A 2.1, Brazil has two nuclear power plants in operation (Angra1, 657 MWe gross/627 MW net, 2-loop PWR and Angra 2, 1350 MWe gross/1275 MWe net, 4-loop PWR) and one under planning (Angra 3, PWR, similar to Angra 2, with construction temporarily interrupted). Angra 1, 2 and 3 are located at a common site, near the city of Angra dos Reis, about 130 km from Rio de Janeiro.

D.1.1. Angra 1

Site preparation for Angra 1, the first Brazilian nuclear unit, started in 1970 under the responsibility of FURNAS Centrais Eletricas SA. The initial work for construction of the plant began 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.

CNEN granted the construction permit for the plant in 1974. The operating licence was issued in September 1981, at which time the first fuel core was also loaded. First criticality was reached in March 1982, and the plant was connected to the grid in April 1982. After a long commissioning period due to a steam generator generic design problem, which required equipment modifications, the plant finally entered into commercial operation on 1st January 1985.

In 1998, plant ownership has been transferred to the newly created company ELETRONUCLEAR, which has absorbed all the operating personnel of FURNAS and part of its engineering staff, and the personnel of the design company Nuclebras Engenharia (NUCLEN).

D.1.1.1 Angra 1 Spent Fuel Management

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

The current status at Angra1 fuel pools is presented in Table D.1.

Table D.1. Spent Fuel Assemblies Stored at Angra 1(Dec. 2005)

Storage place	Angra 1	
	Capacity	Occupied
New Fuel Storage Room	45	0
Region 1 Spent Fuel Pool	252	137
Region 2 Spent Fuel Pool	1000	449
Reactor Core	121	121

(1) By definition of INFCIRC/546 "SPENT FUEL" means nuclear fuel that has been irradiated in and permanently removed from a reactor core. Included in this inventory there are fuel assemblies that are not yet considered "spent fuel", since they may be reused in future cycles.

D.1.1.2. Angra 1 Radioactive Waste Management

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 cement and conditioned in 200 litter drums (up to 1998) and 1 m^3 steel containers (after 1998). Solid waste may be conditioned in drums or in special boxes. Gaseous waste is 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 waste is being stored on site in a separate storage facility. (See D.1.4).

D.1.2. Angra 2

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

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

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

Hot trial operation was started in September 1999. In March 2000, after receiving from CNEN the Authorization for Initial Operation (AOI) initial core load started, followed by initial criticality on 17 July 2000, and first connection to the grid on 21 July 2000. The power tests phase was completed in November 2000. The commissioning phase was a very successful one. No major equipment problems occurred in spite of the very long storage time (~20 years), indicating the high quality of the component conservation programme. The Angra 2 NPP has been operating at full power since mid November 2000. The Authorization for Initial Operation (AOI) has been extended periodically, due to problems with the environmental licence.

D.1.2.1 Angra 2 Spent Fuel Management

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 initial enrichment. This spent fuel storage capacity is sufficient for about 15 years (14 cycles) 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 current status at Angra 2 fuel pools is presented in Table D.2.

Table D.2. Spent Fuel Assemblies Stored at Angra 2 (Dec.2005)

Storage place	Angra 2	
	Capacity	Occupied
New Fuel Storage Room	75	24
Region 1 Spent Fuel Pool	264	147
Region 2 Spent Fuel Pool	820	210
Reactor Core	193	0

(2) By definition of INFCIRC/546 “SPENT FUEL” means nuclear fuel that has been irradiated in and permanently removed from a reactor core. Included in this inventory there are fuel assemblies that are not yet considered “spent fuel”, since they may be reused in future cycles.

(3) Angra 2 was under outage at the time, reason for the core unloading. Only part of new fuel had been received.

D.1.2.2. Angra 2 Radioactive Waste Management

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 waste is collected in storage tanks for further monitoring and adequate treatment or discharge to the environment. The concentrate resulting from the liquid waste treatment is further processed in order to reduce water content before being immobilized in bitumen and conditioned in 200-liter drums. Spent resins and filter elements are also immobilized in bitumen and conditioned in 200-liter drums. Compactable and non-compactable solid waste is conditioned in 200-liter drums. Gaseous waste is treated in the gaseous waste treatment system, where the radioactive gases are retained in delay beds containing active charcoal to let them decay well below allowable levels, before release into the environment throughout the 150m high plant vent stack. No residues are produced in the gaseous waste treatment system, as all the system's consumables, mainly filter and delay bed fillings, are designed to last for the whole plant lifetime. The drums with waste are initially stored within the plant prior to being transported to the on site 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.

D.1.3 Angra 3

To date (January 2006), the Angra 3 construction programme remains interrupted. Most of its components, of imported scope, were already supplied and are stored in Brazil. The site is ready for concrete pouring. The required engineering documents are already available, since, for standardization reasons, Angra 3 is to be as similar as possible to Angra 2.

According to this concept, Angra 3 is planned to be a twin plant of Angra 2. This concept has been submitted to and approved by CNEN, proposing "Angra 2 as-built" as the reference plant for Angra 3. In this context, the only major technical modification planned for Angra 3 is the replacement of the conventional instrumentation and control by modern digital technique. Another difference between the two units refers to the site: Angra 2 was constructed on pile foundation, while Angra 3 should be built on sound rock.

The Preliminary Safety Analysis Report (PSAR) was already submitted to CNEN to obtain a Construction Licence. An agreement between ELETRONUCLEAR and CNEN, adopts the Angra 2 Final Safety Analysis Report (FSAR) as the bases for the preparation of Angra 3 PSAR.

As a critical path for the construction resumption, the Environmental Impact Study was prepared along 2002 in the frame of the Environmental Licensing Process as described in E.2.

Plant construction is planned for a 66 months duration, from starting of reactor annulus slab concrete work up to end of power tests and start of commercial operation. Effective restart of Angra 3 project depends on final decision of the Brazilian Government authorities, expected for 2006.

D.1.3.1 Angra 3 Spent Fuel Management

The spent fuel will be stored similarly to Angra 2.

D.1.3.2. Angra 3 Radioactive Waste Management

The wastes will be treated and stored similarly to Angra 2.

D.1.4. On Site Initial Storage Facility

The waste of Angra 1 and Angra 2 is being stored in an initial storage facility located at the Angra site. The deposit consists of two buildings, which are submitted to CNEN inspections.

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

For additional information on this deposit, see section H.2.

D.1.5. Waste repository for low and intermediate level waste

The plans for final disposal of waste generated from the Angra nuclear power complex (units 1,2 and future 3), are still under development, as described itens H.3.2 and H.5.2.2.

D.2. RESEARCH REACTORS

D.2.1. Spent Fuel Management

In Brazil, research reactors (RR) have been in operation since the late fifties, and some amount of spent fuel assemblies (SFA) has been accumulated. Table D.3 shows the RR operating in Brazil.

Table D.3. Research Reactors in Brazil

	Facility	*Power (kW)*	*Type*	*Status*
BRA	ARGONAUTA	0.20	ARGONAUTA	OPER
BRA	IEA-R1	5,000.00	POOL	OPER
BRA	IPEN-MB 01	0.10	ZPR TANK	OPER
BRA	IPR-R1	250	TRIGA-Mark I	OPER

As shown in Table D.3, the only RR that has concerns related to spent fuel is IEA-R1. Part of its spent fuel was returned to USA, when in 1999 Brazil shipped 127 LEU and HEU fuel elements. The concerns are based on the fact that in May of 2006 the option to send SFA to USA will cease, and a national solution will have to be adopted. These concerns were the driving force for Brazil to join an IAEA Regional Project. The objectives of the Project are to provide the basic conditions to define a regional strategy for managing spent fuel and to provide solutions taking into consideration the economic and technological realities of the countries involved. In particular, to determine the basic conditions for managing RR spent fuel during operational and interim storage as well as final disposal, and to establish forms of regional cooperation for spent fuel characterization, safety, regulation and public communication.

The Brazilian part of the Latin American Spent Fuel Database is presented in Table D.4, ilustrating the main characteristics of the fuel elements utilized in the RRs of Brazil.

Table D.4. Fuel Elements Characteristics

Facility	Fuel Type	Fuel Material	Enrichment	Cladding Mater.
IEA-R1	MTR	U_3O_8-AL	LEU 19.9%	Aluminum
		U_3Si_2-Al		
IPR-R1	TRIGA Rods	U-Zr-H	LEU 20%	Aluminum
ARGONAUTA	MTR	U_3O_8-Al	LEU-19.0-19.9%	Aluminum
IPEN-MB-01	Pin PWR	UO_2 Pellets	LEU 4.35 %	SS

The present RR spent fuel inventory is shown in Table D.5. The only reactors with reasons for concern related to storage over medium and long-range periods are IEA- R1 and IPR- R1. The others are low and zero power reactors with very low burn up. Taking these facts into consideration and the storage capacities presently available, some projections for the next 10-15 years have been made.

Table D.5. SFA Inventory at Brazilians Reseach Reactors

Facility	*# of FA in Present Core*	*Average # used per year*	*SFA Storage*		*SFA Burnup% Average*
			At RR	Away RR	
IEA-R1	24 LEU, Silicide-7; Oxyde-17	~18, expected for 120 h /week, 5MW	39 wet	0	~30
IPEN-MB-01	680 pins	NA	0	0	NA
IPR-R1	59 rods	NA	0	0	NA
IEN-R1	8 LEU	NA	0	0	NA

Presently, storage facilities at IEA-R1 consist of racks located in the reactor pool with a capacity of 156 assemblies. Figure D.1 illustrates the storage area in the IEA-R1 reactor. According to the newly proposed operation schedule (5 MW, 120 hrs per week), 18 to 20 assemblies will be burnt up annually. Currently, 21 storage positions are occupied, suggesting that in 7-10 years the wet storage facility at the reactor will be full. If no provisions are made for increasing storage facilities, the reactor may have to be shut down. Although there are 50 dry storage horizontal tubes (where 3 standard spent fuels per tube can be stored) located in the reactor building, significant modifications will be required before any decision to store spent fuels in these tubes can be taken. In view of these facts, a project to assess and define an "at-reactor" dry-storage, with a capacity for~200 SFA has been initiated (the present dry storage could be refurbished or a new dry storage built in a building close to the reactor building).

The IPR-R1 has no short and medium range storage problems, due to its low nominal power. The first fuel assembly replacement is expected to occur only in 2010.

Finally, Brazil has not yet defined a policy regarding spent fuel or high-level waste disposal. However, given that the Brazilian legal framework regarding waste disposal has been defined, this issue will be discussed at the national level.

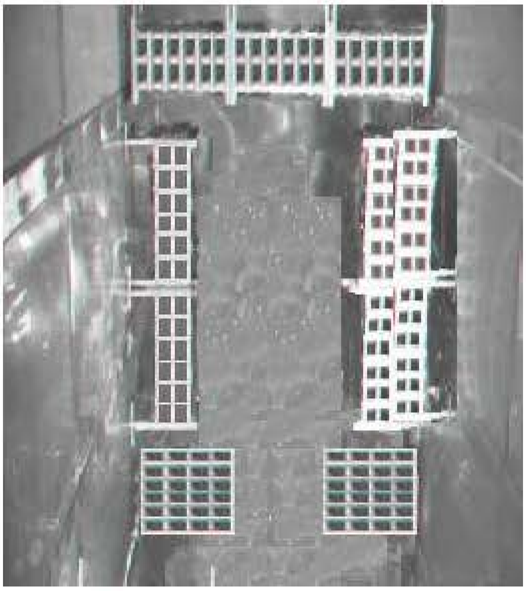


Figure D.1: IEA-R1 wet storage

D.2.2. Radioactive Waste Management

The waste of the research reactors is managed together with the radioactive waste of the institutes to which they belong, as described in section D.5.1.

D.3. OTHER NUCLEAR INSTALLATIONS

D.3.1. Indústrias Nucleares do Brasil (INB)

D.3.1.1. Waste from Fuel Cycle and Monazite Processing Facilities

The Uranium mining and milling industrial complex (Complexo Industrial de Poços de Caldas - CIPC), located at the Poços de Caldas *plateau*, in the state of Minas Gerais, has produced, from 1982 to 1995, 1170 tons of ammonium diuranate (yellow cake). The waste generated in this process is kept in a 29,2 ha dam system, with an actual volume capacity of 1 million cubic meters. It is estimated that 4.8 TBq (130 Ci) of ^{238}U, 15 TBq (405 Ci) of ^{226}Ra and 4.2 TBq (112 Ci) of ^{228}Ra were disposed of in this site, to date (See also H.2.2.4).

The new mining facility located in Caetité (URA) does not have radioactive waste storaged until this moment. There are about 5 millions ton of waste rock and lixiviated ore.

The operation of the rare-earth production line of Usina Santo Amaro (Santo Amaro Mill - USAM) in São Paulo has generated Mesothorium (a ^{228}Ra containing material) and Cake II (called *Torta II* – composed basically of Thorium hydroxide concentrate). These materials, although not formally classified as waste, are presently storaged in Poços de Caldas (CIPC) and São Paulo (USIN and Botuxim).

In Poços de Caldas (CIPC) there are presentely storage of about 1200 m^3 of Mesothorium and 7250m^3 of Cake II.

In the Interlagos facility (USIN), there are presentely storage of about 39 m^3 of Mesothorium and 325 m^3 of Cake II and in the Botuxin deposit (São Paulo) there are presentely storage of about 2190 m^3 of Cake II. (See H.2.2.2.).

D.3.1.2. Fuel Element Fabrication Facilities

The waste volume generated by the fuel elements assembly unit as well as by all the other pilot scale fuel cycle facilities is negligible when compared to the above-mentioned figures. All the material is currently stored inside the production facility. An intial storage facility under construction within INB protected area (See H.2.1).

D.4. NAVY INSTALLATIONS at São Paulo (CTMSP) and Iperó (CEA)

The waste volume generated by these activities is also negligible when compared to the other mentioned figures. All the material is currently kept on an initial storage on both sites.

At CTMSP the radioactive waste, mainly contaminated laboratory material, is transferred no nearby IPEN.

At CEA, an initial waste storage facility is available in form of a hangar. Eighty-one drums containing about 6916 kg of waste are currently (March 2005) stored there. These are mainly contaminated materials such as plastics, paper and tools (See also H.2.3).

D.5. CNEN INSTITUTES

D.5.1. IPEN

IPEN has been storing the radioactive waste generated at its own installations since the beginning and is also receiving and storing the radioactive waste generated by applications users like hospitals, industry and research centers. The existing facility, an Integrated Plant for Treatment and Storage of Radioactive Waste, has a total built area of 1450 $m^{2.}$ For further description see item H.2.4.1.

D.5.2. CDTN

Besides the radioactive waste generated at its own laboratories, CDTN has received disused sealed sources from other users, like industries, hospitals and universities. These sources include, among others, radioactive lightning rods, smoke detectors, nuclear gauges and teletherapy units, which are stored at CDTN's waste intermediate storage hall (see H.2.4)

The strategy devised and implemented for the management of radioactive waste at CDTN is based on the standard CNEN-NE-6.05 and takes into account the available infrastructure. The main aspects of the management program are:

- registry of the waste and disused sealed sources inventory using an electronic database.
- waste generation minimization by asuitable segregation and characterization.
- volume reduction by chemical treatment for the aqueous liquid waste and compaction and cutting for solid waste;
- cementation of sludges arising from the chemical treatment and immobilization of the non-compactable solid waste in cement/bentonite matrix.

D.5.3. IEN

IEN has a small area (40 m^2) for storage of radioactive waste. This waste has similar characteristics with the waste received at the other CNEN institutes. Additionally, IEN also stores the radioactive waste generated in its own installations.

D.6. WASTE REPOSITORY AT ABADIA DE GOIAS (Closed)

The waste generated in the decontamination process following the radiological accident with a ^{137}Cs medical source in Goiania are currently stored in a final repository at Abadia de Goias, a small town circa 23 km of Goiania.

Approximately 3,500 m^3 of waste were generated, with an estimated overall activity lying between 47.0 TBq (1270 Ci) and 49.6TBq (1340 Ci).

The waste were temporarily stored in open-air concrete platforms, occupying an area of about 8.5 x 10^6 m^2 at a site near the village of Abadia de Goiás. (Figure D.2)

Fig.D.2 – Temporary Storage

Taking into account the decay period necessary for the contents of all packaging to reach a Cs^{137} concentration level not greater than 87 Bq/g, it was possible to classify the drums and the metal boxes in 5 groups, as described in the Table D.6:

Table. D.6. Waste from Goiania Accident

GROUP (Time in years)	Number of Metallic Boxes	Volume (m^3)	Number of Drums	Volume (m^3)	Total Activity (TBq)*	Total Volume (m^3)
I (t=0)	404	686.8	2710	542	0.06	1228.8
II (0 < t < 90)	356	605.2	980	196	0.476	801.2
III (90 < t < 150)	287	487.9	314	62.8	1.44	550.7
IV (150 < t < 300)	275	467.5	217	43.4	13.67	510.9
V (t > 300)	25	42.5	2	0.4	30.064	42.9
Total	1347	2289.9	4223	844.6	45.71	3134,5

** NOTE: Activity at the time of storage.*

Also the following packages were used in Goiânia:

- 1 metal package for the headstock, with the remaining source (4.4 Tbq and with 3.8 m^3 from Group V);
- 10 ship containers (374 m^3 with 0.4 TBq from Group I); and
- 8 special concrete packages (1.4 m^3 and 0.7 Bq from Group V)

According to the IAEA classification, all the radioactive waste collected in Goiânia fall into the category of “low level – short lived” waste and this allows the disposal at shallow depths, in engineered storage facilities. The Group I waste, having specific activities below 87 Bq/g, could actually be exempted from regulatory control – what means that they could effectively be released into ordinary waste systems.

Nevertheless, it was decided to build in Goiânia two repositories: a more simplified one, called *Great Capacity Container* (Figure D.3) for the disposal of Group I waste (about 40% of the total) and a repository with more elaborate engineered barriers for the disposal of Groups II to V waste, called *Goiania Repository* (Figure D.4).

Fig. D.3. Great Capacity Container

Fig. D.4. Repository at Abadia de Goiás

In conclusion, the problem of providing final disposal for the waste generated in the Goiânia Accident is thoroughly addressed. All waste has been disposed in both near surface repositories, which have already been closed and with environmental recomposition performed. More information on the environmental monitoring program for the repository is provided in section H.7 of this document.

Section E - LEGISLATIVE AND REGULATORY SYSTEM

E.1.Article 18. IMPLEMENTING MEASURES

To implement the obligations of the Convention, Brazil has taken legislative, regulatory and administrative measures to ensure the safety of its nuclear installations, including irradiated fuel and radioactive waste.

The Federal Constitution of 1988 specifies the distribution of responsibilities among the Federal Union, the States and the Municipalities with respect to the protection of the public health and the environment, including the control of radioactive products and installations (Articles 23, 24 and 202). As mentioned in item 1.1, the Government is solely responsible for nuclear activities related to electricity generation, including regulating, licensing and controlling nuclear safety (Articles 21 and 22). In this regard, the Comissão Nacional de Energia Nuclear (Brazilian National Commission for Nuclear Energy - CNEN) is the national regulatory body, in accordance with the National Nuclear Energy Policy Act.

Furthermore, the constitutional principles regarding protection of the environment (Article 225) require that any installation which may cause significant environmental impact shall be subject to environmental impact studies that shall be made public. More specifically, for nuclear facilities, the Federal Constitution (Article 225, Paragraph 6) provides that a specific Law shall approve the siting of any new installation. Therefore, licensing of nuclear installations are subject to both a nuclear licence by CNEN and an environmental licence by the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (Brazilian Institute for the Environment and Renewable Natural Resources – IBAMA), with the participation of state and local environmental agencies as stated in the National Environmental Policy Act. These principles were established by the Federal Constitution of 1988, at the time that Angra 1 had already been in operation, and Angra 2 was already under construction. Therefore, licensing of these power plants followed slightly different procedures, as described below.

CNEN is under the Ministry of Science and Technology (MCT). The relation amongst regulatory organizations and operators is shown in Figure E.1.

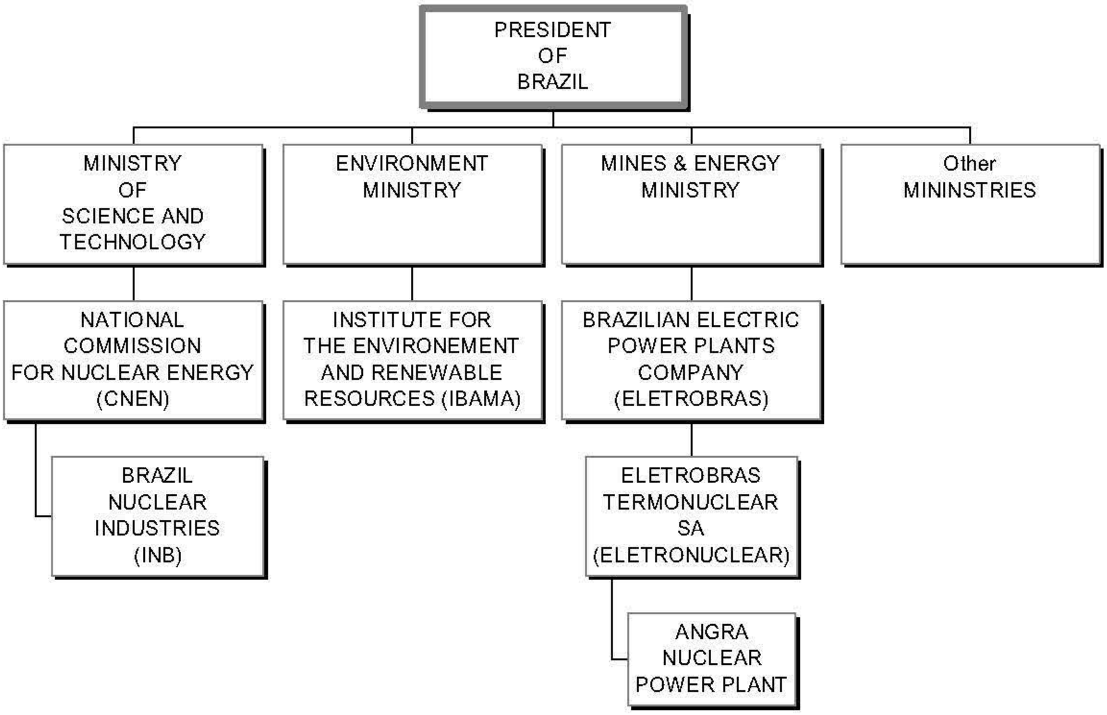


Fig. E.1 – Brazilian Organizations Involved in Nuclear Safety

E.1.1 Nuclear licensing process

CNEN was created in 1956 (Decree 40.110 of 1956.10.10) to be responsible for all nuclear activities in Brazil. Later CNEN was re-organized and its responsibilities were established by Law 4118/62 with alterations determined by Laws 6189/74 and 7781/89. Thereafter, CNEN became the Regulatory Body in charge of regulating, licensing and controlling nuclear energy. Since 2000, CNEN is now reporting to the Ministério da Ciência e Tecnologia (Ministry of Science and Technology - MCT).

CNEN responsibilities related to this Convention include, among others:

- the preparation and issuance of regulations on nuclear safety, radiation protection, radioactive waste management and physical protection;
- accounting and control of nuclear materials (safeguards);
- licensing and authorization of siting, construction, operation and decommissioning of nuclear facilities;
- regulatory inspection;
- 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 facilities, safety during operation, management of radioactive waste, siting of waste repositories, quality assurance, reporting requirements, plant maintenance, and others (see Annex 2. Item 2.3 for a list related of CNEN regulations).

The licensing regulation CNEN-NE-1.04[3] establishes that no nuclear installation shall operate without a licence. It also establishes the necessary review and assessment process, including the specification of the documentation to be presented to CNEN at each phase of the licensing process. It finally establishes a system of regulatory inspections and the corresponding enforcement mechanisms to ensure that the licensing conditions are being fulfilled. The enforcement mechanisms include the authority of CNEN to modify, suspend or revoke the licence.

The licensing process is divided in several steps:

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

Federal Law 9756, approved in 1998, establishes 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 power plant to be licensed.

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

For the authorization for initial operation, CNEN reviews the construction status, the commissioning programme including results of pre-operational tests, and updates its review and assessment of facility design based on the information submitted in the Final Safety Analysis Report (FSAR). Startup is closely followed by CNEN inspectors, and hold points at different stages are established.

Authorization for permanent operation is given after a complete review of commissioning test results and the solution of any deficiencies identified during construction and initial operation. The authorization establishes limits and conditions for operation and lists the programmes which should be kept active during operation, such as the radiological protection programme, the physical protection programme, the quality assurance programme for operation, the fire protection programme, the environmental monitoring programme, the qualification and training programme, the preventive maintenance programme, the retraining programme, etc. Reporting requirements are also established through regulation CNEN-NE-1.14[5]. These reports, together with a system of regulatory inspections performed by resident inspectors and headquarters personnel, are the basis for monitoring safety during operation.

The main tasks during the licensing process are the safety evaluation of the applicant documentation and the regulatory inspections. During the period of 2003-2005, 75 Evaluation Reports were issued related to Angra Unit 1, out of which 3 related to the radioactive waste systems. For Angra 2, 79 Evaluation Reports were issued, 5 of them related to radioactive waste. Also 77 regulatory inspections were conducted in both units, 34 in Unit 1, 40 in Unit 2 and 3 for issues related to both units. Of these, 5 were related to the radioactive waste area.

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

E.1.2. Environmental licensing

IBAMA was created through Law n. 7735 of 22 February 1989 under the Ministério do Meio Ambiente (Ministry for Environment - MMA) with the responsibility to implement and enforce the National Environmental Policy (PNMA) established by Law N^{o}. 6938/81. The objective of the PNMA is to preserve, improve and recover the environmental quality, ensuring the conditions for social and economic development and for the protection of human dignity.

The PNMA established the National System for the Environment (SISNAMA), which is composed by the Conselho Nacional para o Meio Ambiente (National Council for the Environment - CONAMA) and executive organizations at the federal, state and municipal levels. The central executive body for SISNAMA is IBAMA, which is, therefore, responsible for the environmental licensing process of any installation with potentially significant environmental impact.

The environmental licensing process includes the following steps:

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

- Installation Licence, authorizing the construction of the installation in accordance with the approved specifications, programmes and projects including measures that are considered essential to protect the environment.

- Operating Licence, authorizing the operation of the installation after the verification of the effective fulfillment of the previous licence conditions, and the effective implementation of measures to protect the environment during operation.

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

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

E.1.2.1 Environmental Licensing of Angra 1, 2 Radioactive Waste Deposits

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

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

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

Currently the low and intermediate radioactive waste from the nuclear power plants are storaged in two deposits named Deposit 1(DIRR-I) and Deposit 2 (DIRR-II), with modules 2A under operation and module 2B under licensing.

Deposit 1 (DIRR I) entered operation in 1981, with the operation of Angra 1 and is almost completely full (Figure E-2). The Deposit 2A (DIRR-II) also contains waste from Angra 1. Both deposits are “initial” in nature, since the waste should be later removed to a final repository. For both deposits, ELETRONUCLEAR must submit basic documentation that will permit IBAMA to evaluate the environmental impact of their operation. This documentation will also serve as a basis to define plans and programs detailed in a Basic Environmental Project (PBA) for obtaining a formal Operating Licence, according to the current regulation.

Fig. E.2 Angra 1, 2 Radioactive Waste Deposit

There is a proposal from the operator for the expansion of the storage capacity of the site through the construction of a third deposit (Deposito 3 - DIRR-III) at the same location. The Environmental Impact Study (EIA) and the Report on Environmental Impact (RIMA) were prepared and submitted to IBAMA.

The RIMA served also as a basis for the public hearings, which took place in the surroundings of the plant, within the environmental licensing process. Based on these evaluations and taken into consideration the discussion during the hearings, IBAMA will issue an Installation Licence. ELETRONUCLEAR expects to have IBAMA licence in the first semester of 2006.

Since CNEN has the technical competence for the evaluation of radiological impact in the environment, IBAMA and CNEN have established a formal agreement to specify the respective scope of action and to optimize both licensing processes.

E.1.2.2 Environmental Licensing of the Repository at Abadia de Goias.

The repository at Abadia de Goias, which belongs to CNEN, has received an Installation Licence from IBAMA in 1996. At present, IBAMA is following up the initial operation of the repository through reports and inspections. An Environmental Plan including air samples, sediments samples, surface water and underground water as well as external radiation doses around the two repositories has been executed every year since its construction. More detail of this enviromental plan can be seen on item H of this report

E.1.2.3. Other Pre-existing Deposits

Other radioactive pre-existing waste deposits, that are now also under licensing by IBAMA, are located at IPEN, CDTN and IEN (see D.5. and H.2.2). In 2002, IBAMA licensed CDTN's facilities, including the radioactive waste storage hall (IBAMA Operation License Nr. 225/2008, of August 8, 2002). The other two deposits are in a process of adequating the existing situation to the current legislation to obtain an Operating Licence. This is done through a legal instrument called "Termo de Compromisso" (Term of Commitment), in which the organization commits itself to fulfill specific requirements established by IBAMA.

E.1.3. Emergency preparedness legislation

With respect to emergency preparedness, additional requirements have been established by the creation of the System for Protection of the Brazilian Nuclear Programme (SIPRON) through Law 1809 of October 7, 1980. The subsequent Decree Nr.2210 of April 22, 1997 defined the Secretaria de Assuntos Estratégicos (Secretariat for Strategic Affairs - SAE), directly linked to the Presidency of the Republic, as the Central Organization of SIPRON responsible for the general supervision of the preparedness and response to nuclear emergencies in the Country.

More recently, the Governmental restructuring through Law Nr. 10.683 of May28, 2003 has designated the Ministry of Science and Technology (MCT) as the state department with competence for nucler energy policy. And SIPRON, which now stays under the Coordination of Technical and Scientific Nuclear Program of MCT (See Fig. E.3).

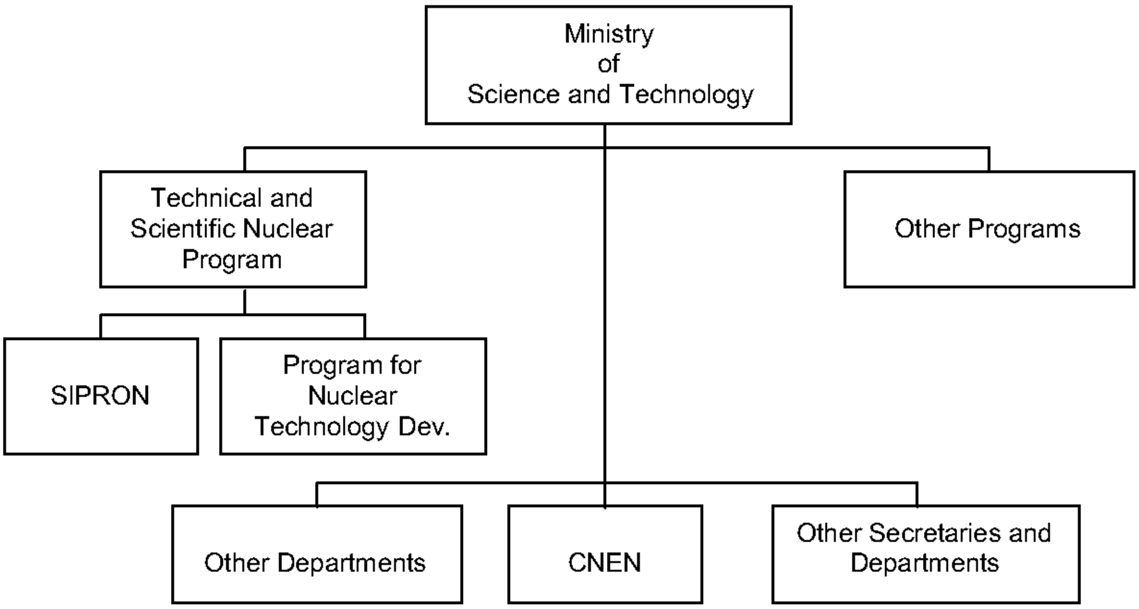


Figure E.3 – SIPRON position within the MCT Structure

The Decree Nr. 2210 also established a Coordination Commission (COPRON) composed of representatives of the agencies involved. Besides ELETRONUCLEAR, as the operator, and CNEN, as the nuclear regulatory body, other agencies are involved as support organizations of SIPRON, such as the municipal civil defense, the state civil defense, the Angra Municipality, the IBAMA, the National Road Authority, the National Army, Navy and Air Force, and the Ministries of Health, Foreign Relations, Justice, Finance, Planning and Budget, Transportation and Communications.

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

E.2.Article 19. LEGISLATIVE AND REGULATORY FRAMEWORK

Brazil has established and maintained the necessary legislative and regulatory framework to ensure the safety of its nuclear installations, including irradiated fuel and radioactive waste.

A list of existing norms and regulations are presented in Annex 2.

As mentioned before, the recent Law n. 10.308 of 20 November 2001 establishes the new legal framework for the solution of the radioactive waste issue in Brazil.

The Law confirms Government responsibility for the final destination of radioactive wastes, through the action of CNEN. However, it also opens the possibility for the delegation of the administration and operation of the radioactive waste deposits to third parties.

The Law recognizes 3 types of deposits: initial, operated by the waste generator; intermediate; and final (also called repository). A fourth type of provisional deposit may be established in case of accidents with contamination.

The Law establishes the rules for site selection, construction and operation, and the licensing and control of the deposits by CNEN.

The Law also establishes the financial arrangements for the transfer of the waste to CNEN and the compensation to the municipalities that accept in their territory the construction of the waste deposits.

Additional regulation related to waste disposal was already issued by CNEN and they are now been revised to conform to the new Law 10.308. These include regulations CNEN-NE-6.05 on Management of Radioactive Waste in Radioactive Installations[6], CNEN-NE-6.06 on Site Selection for Radioactive Waste Deposits, and NN-6.09 on Acceptance Criteria for Deposition of Low and Intermediate Level radioactive Waste[7].

E.3.Article 20. REGULATORY BODY

As mentioned in item E.1.1, the Brazilian National Commission for Nuclear Energy (CNEN) has been designated as the regulatory body entrusted with the implementation of the legislative framework related to safety of nuclear and radioactive installations. Other governmental bodies are also involved in the licensing process, such as the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA).

E.3.1. CNEN

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

Effective separation between the functions of the regulatory body (CNEN) and the organization concerned with the promotion and utilization of nuclear energy for electricity generation (ELETRONUCLEAR) is provided by the structure of the Brazilian Government in this area. While CNEN is linked to the Ministry of Science and Technology (MCT), ELETRONUCLEAR is fully owned by ELETROBRAS, a national holding company for the electric system, which is under the Ministry of Mines and Energy (MME) (see Figure E.1).

The structure of CNEN is presented in Figure E.4. The organizational unit involved with the licensing of nuclear installations is the Directorate for Radiation Protection and Nuclear Safety (DRS). Review and assessment is performed mainly by the divisions of the General Coordination for Reactors and Fuel Cycle (GCRC). CODRE (Reactor Coordination) is in charge of nuclear power plants and research reactors. CODIN (Nuclear Installation Coordination) is in charge of other nuclear installations. CGMI (General Coordination for Medical and Industrial Installations) is in charge of radioactive installations and medical uses. DIREJ (Waste Division) is in charge of waste disposal facilities. In the areas of radiation protection and environmental monitoring, technical support is obtained from the Institute for Radiation Protection and Dosimetry (IRD). The necessary regulations and standards are developed by working groups under the coordination of the Norms Division (DINOR).

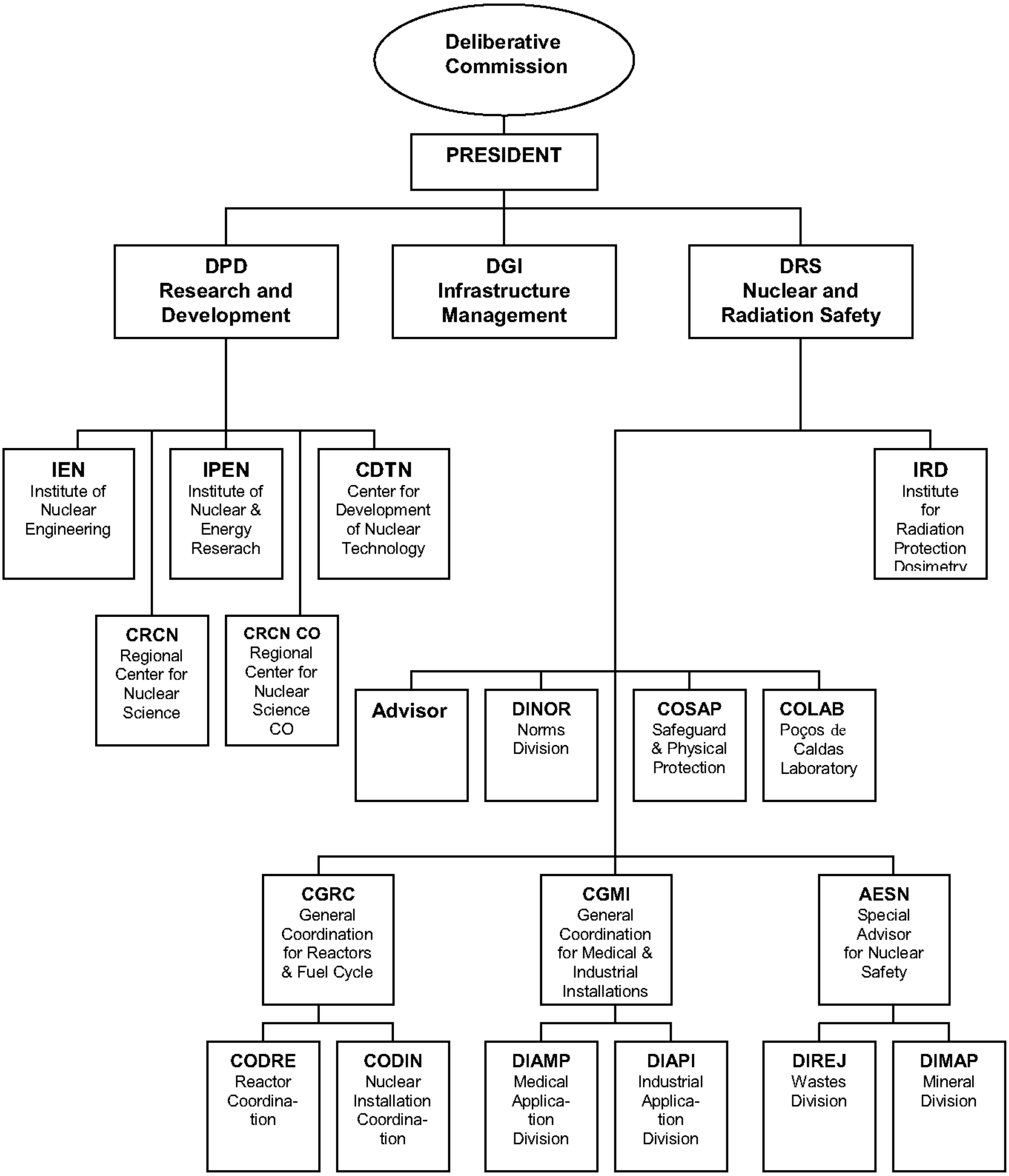


Fig. E.4 - Simplified CNEN Organization Chart

Adequate human resources are provided to CNEN. A total staff of 2756 people, of which 85% are technical staff, is available at CNEN and its research institutes. Forty eight percent (48%) of the staff is university graduates, 17% having a master degree and 7% having a doctoral degree. GCRC itself comprises 183 people, 149 of which are technical.

The main activities are review and assessment of the submitted documentation, and inspection of licensee's activities. Inspection activities are conducted periodically for all installations and for nuclear power plants on a permanent basis by a group of resident inspectors at plant site. Complementary to field activities, operation follow up is performed also based on licensee reports, as required by licensing conditions and regulation CNEN-NN.1.14[5].

DRS 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 the period of 2000 - 2005, 7 technical assistance missions were conducted by the IAEA and the Gesellschaft für Reaktor Sicherheit – GRS.

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

Salaries of CNEN staff are subject to the Federal Government policies and administration.

E.3.2 IBAMA

The licensing structure of IBAMA is presented in Figure E.5. The environmental licensing for nuclear installations is conducted by the Directorate for Licensing and Environmental Quality, more specifically by its General Coordination for Environmental Licensing. This Coordination has a multidisciplinary technical staff of 70 professionals (8 PhD, 17 MSc, 15 Specialists and 30 Graduates), 15 of which are dedicated to the licensing of nuclear power plants (2 PhD, 5 MSc, 8 Graduates). There is an effort to adequate these human resources to an increased demand of evaluation in the nuclear area.

For the licensing process of Angra 2, IBAMA worked in close cooperation with CNEN in relation with the radiological impact aspects. Both also cooperated with the Rio de Janeiro State Foundation for Environmental Engineering (FEEMA) and the Angra dos Reis Municipal Secretary for Environment and, in the case of the Final Repository at Abadia de Goias, with the Goias State Foundation for the Environment (FEMAGO).

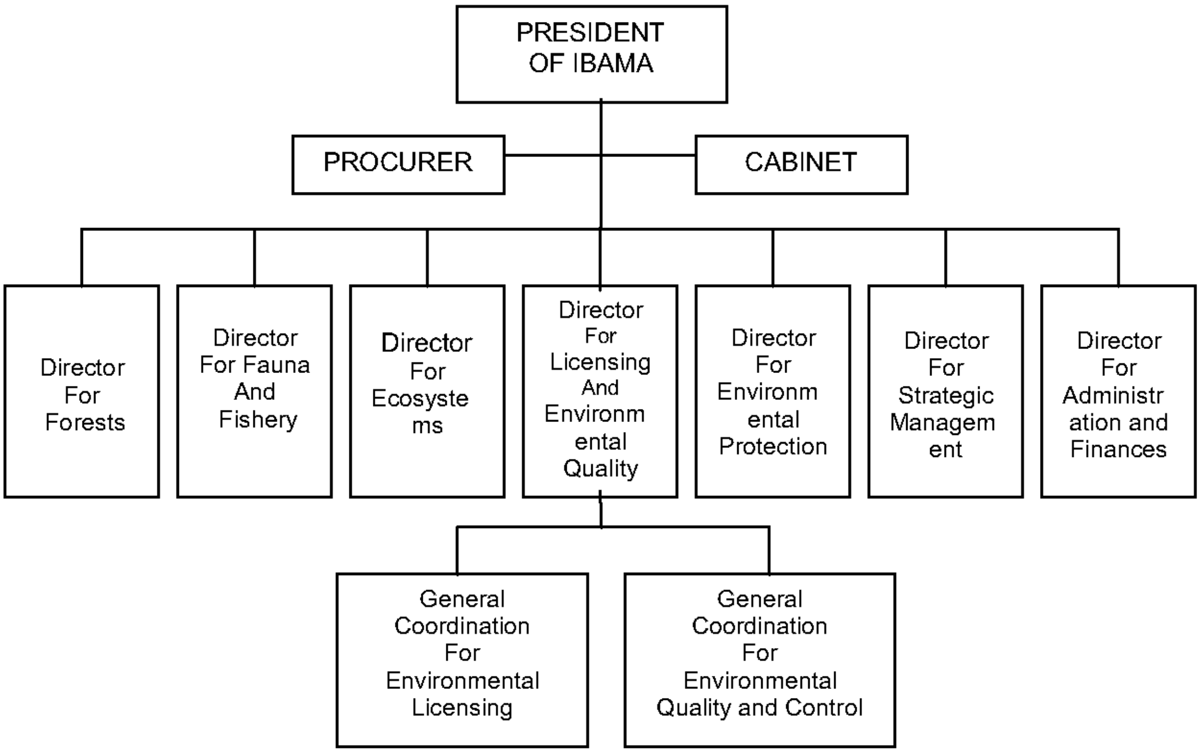


Fig. E.5 – IBAMA Structure

Section F - OTHER GENERAL SAFETY PROVISIONS

F.1. Article 21. RESPONSIBILITY OF LICENCE HOLDER

The Brazilian legislation defines the operating organization as the prime responsible for the safety of a nuclear or radioactive installation, including the management of spent fuel and radioactive waste.

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

F.1.1 Nuclear Power Plants

More specifically for nuclear power plants, the regulation CNEN-NE-1.26 [8] defines the operating organization as the prime responsible for the safety of a nuclear installation by stating: "**The operating organization is responsible for the implementation of this regulation.**"

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

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

It states further that:

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

This company policy statement is fully based on the IAEA INSAG-4 publication on Safety Culture.

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

CNEN, through the licensing process, and especially through its regulatory inspection programme, ensures that the regulatory requirements for safe operation are being fulfilled by the licensee. The licensee reports periodically to CNEN in accordance with regulation CNEN-NE-1.14 [5]. 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.

F.2.Article 22. HUMAN AND FINANCIAL RESOURCES

F.2.1. Human resources

F.2.1.1. Nuclear Power Plants

Adequate human resources are available at ELETRONUCLEAR with its own personnel or from contractors. Currently ELETRONUCLEAR has a total of 1976 employees on its permanent staff, distributed as folows:

- 583 (30%) have a university degree;
- 943 (48%) are technicians;
- 181 (9%) are managers, most of them with university degree;
- the remainder 269 (14%) are administrative personnel.

A Project called "Determination of the Technological Know-how of ELETRONUCLEAR" was initiated in 2001, which aims the identification, in a formalized and systematic way, of the existing know-how within the company. The gaps have been identified and actions to fulfill these gaps are being implemented.

In particular, loss of knowledge due to the personnel retirement has to be considered. This is a pilot project with a main objective of introducing Knowledge Management as a systematic approach in the company, in order to preserve the essential knowledge necessary for the safe and efficient construction and operation of its nuclear installations.

Activities related to qualification, training and retraining of plant personnel are performed by the Training and Simulator Department of ELETRONUCLEAR. Three main areas exist at the training facilities, close to the site:

- General Training Center
- Angra 2 Simulator Training Center
- Maintenance Training Center.

The requirements for organization and qualification of Angra 1 and Angra 2 staff are established in the chapter 13 of the FSAR. Implementation and updating of these requirements are subject to CNEN audits.

Specialized training is also provided for the different groups of plant personnel, as listed below:

- Maintenance and Chemistry personnel follow an extensive qualification programme established in the Plant Operations Manual, which is subject to CNEN audits.
- Radiological Protection technicians, the Fire Brigade and Security personnel follow an extensive qualification programme based on CNEN regulations, which is also subject to CNEN audits.

Technical Exchange Visits and Reviews of the training programme and training center by experts from International Atomic Energy Agency, the Institute Of Nuclear Power Operations (INPO) and the World Association of Nuclear Operators (WANO) have provided valuable contribution to the identification and implementation of good practices for enhancing the quality of the training activities.

A total of 36 qualified personnel are directly involved in waste and spent fuel management, as described in the table F.1 below:

Table F.1. Personnel involved in spent fuel and radioactive waste management

QUALIFICATION OF PERSONNEL DIRECTLY INVOLVED WITH WASTE AND SPENT FUEL MANAGMENT, AT ANGRA 1 AND ANGRA 2		
Qualified personnel	Quantity	**Educational Background**
Radiological Protection Supervisor	02	University degree
Senior Reactor Operator	02	University degree
Nuclear Physicist	02	University degree
Nuclear Engineering	04	University degree
Engineering Support	01	University degree
Operators	07	Technician
Radiological Protection Technicians	08	Technician
Auxiliary Technicians	10	Secondary school

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

Radiation Protection Supervisors certification is done in accordance with regulation CNEN – NN 3.03 “Certification of the Radiation Protection Supervisor Qualification”[9]. With the beginning of Angra 2 commissioning tests, Radiation Protection Supervisors had to be trained for their qualification also in this unit. In 1999, 4 Radiation Protection Supervisors were qualified from Angra 1 to Angra 2 and a new one was approved for actions in the two plants. In August 2004, ELETRONUCLEAR submitted the nomination of 2 technicians as candidates to the CNEN licence. These candidates are presently being submitted to the training programme provided by ELETRONUCLEAR in order to fulfill the requirements for the CNEN qualification examination.

F.2.1.2. Other Installations

All other nuclear or radioactive installations licensed by CNEN must have a certified Radiation Protection Supervisor, authorized in accordance with regulation CNEN-NN-3.03 [9]. The regulation requires different qualification for each different type of installation.

Besides that, sufficient qualified staff should be available for the handling of radioactive waste. For instance, at IPEN, the total staff of the radioactive waste unit includes 12 persons, out of which 2 have a PhD degree, and 3 MSc.

F.2.2. Financial Resources

F.2.2.1. Nuclear Power Plants

As a governmental enterprise, ELETRONUCLEAR has its financial situation subjected to the holding company ELETROBRAS, which controls all federal electric utilities in Brazil.

Its basic source of revenue comes from the selling of electricity, namely the energy from Angra 1 and Angra 2 (1901 MWe of net installed capacity), through a long-term energy supply contract ending in 2014, at a guaranteed minimum rate, which is 98.64R$/MWhr (~43US$/MWhr, in December 2005).

The long-term contract is one of the mechanisms applied to protect the nuclear generation from the unforeseeable situations that might occur with the ongoing liberalization of the Brazilian electricity market.

Adequate funds are made available through annual budgets, which include the waste management programme. For illustration, the 2006 ELETRONUCLEAR budget for the waste management programme is estimated in about R$14 million (~US$ 6 million).

The provision of funds for decommissioning activities is to be obtained from ratepayers, and is included in the tariff structure, during the same period of depreciation of the plant (3.3%/year). For Angra 1, presently, a reference decommissioning cost of 180 million dollars is estimated, corresponding to about 10% of the construction cost. For Angra 2 the decommissioning costs are estimated in about 240 million dollars.

F.3.Article 23. QUALITY ASSURANCE

The requirement for a quality assurance programme in any nuclear installation project in Brazil is established in the licensing regulation[3]. Specific requirements for the programs are established in a specific regulation, Quality Assurance for Safety in Nuclear Power Plants and Other Installations, CNEN-NN-1.16[10], which is based in the IAEA code of practice 50-C-QA Rev.1 - Quality Assurance for Nuclear Power Plants, but with the introduction of the concept of an

Independent Technical Supervisory Organization (Organização de Supervisão Técnica Independente - OSTI)[11].

F.3.1. Nuclear Power Plants

Former FURNAS and now ELETRONUCLEAR have established their quality assurance programmes according to these requirements. The corresponding procedures have been developed and are in use. The programme provides the control of the activities influencing the quality of items and services important to safety. These activities include both spent fuel storage and radioactive waste management. The quality assurance programmes are described in Chapter 17 of the FSAR.

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

The ELETRONUCLEAR Quality Assurance Advisory (AGQ.T) is responsible for the coordination and performance of internal and external audits in order to verify compliance with all aspects of the quality assurance program. All audits are performed in accordance with written procedures. In case of internal audits, persons involved with the activities being audited have no involvement in the selection of the audit team. Audit reports are distributed to, and formally reviewed by organizations responsible for the area being audited and also by the CAON. In the three-year period 2003-2005, 271 external audits and 116 internal audits were conducted.

Audits and inspections by CNEN verify that quality assurance requirements are being implemented and that the quality assurance has been effective as a management tool to ensure safety. During the same period of 2003-2005, CNEN conducted 30 audits or regulatory inspections in Angra 1 and 22 in Angra 2. Of these audits 2 in Angra 1 and 3 in Angra 2 were dedicated to radioactive waste issues.

F.3.2. CNEN Installations

CNEN has also established its own Nuclear Safety Policy[17] and Quality Assurance Policy[18]. Under these policies, all units have to establish their own quality assurance system.

Besides that, some units which are involved with industrial production have been independently certified by external organizations, such as the ISO 9000 certification obtained in 2002 by IPEN for its 4 centres: Cyclotron Accelerator Centre, Nuclear Engineering Centre, Radiopharmacy Centre and Research Reactor Centre.

As another example, the Radioactive Waste Management Program of CDTN is also subject to Quality Assurance procedures. Specific procedures exist to regulate the operational activities, such as waste segregation, pick up and treatment, and tests for waste product quality assessment. To date, 37 technical and administrative procedures are in force within the scope of the Program, establishing the applicable standards and the responsibilities of the different institute's sections involved.

F.3.3. Quality Assurance at Navy Installations

The necessary quality for the projects developed at the Navy Technological Center has been assured by the application of procedures and instructions established from a Quality Management System, since the beginning of the activities, in accordance with Standard CNEN-NE-1.16 – Quality Assurance for Safety of Nuclear Power Plants and Other Installations [10], applicable to constructions, services, material purchases and internal activities related to projects under development.

In the CTMSP structure, the Quality Superintendence, directly under the Director, is responsible for the Quality management System, being independent of all other organizational sectors from CTMSP.

F.4.Article 24. OPERATIONAL RADIATION PROTECTION

Radiation protection requirements and dose limits are established in Brazil in the regulation for radiation protection[12]. These require that doses to the public and to the workers be kept below established limits and as low as reasonably achievable (ALARA).

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

The Role of CNEN

Regulation CNEN-NN-3.01 - Basic Standards of Radiation Protection[12], from July 2005, is the primary regulatory standard with which all practices have to comply with. The main aspects regarding radiation protection and discharge requirements are as follows:

- ❖ Controls are established in terms of effective dose equivalent for all nuclear facilities on annual basis, considering rolling year (12 consecutive months);

- The primary annual dose limit to members of the public is 1 mSv effective dose equivalent applied to all practices during all their life stages, i.e., past, present and future;
- For each single justified practice, the discharges should meet activity concentrations levels, in such a way that the maximum authorized annual limit of 0.3 mSv to the critical group is achieved, taking into account all exposures pathways and all radionuclides present in the effluents. The assessment shall consider conservative hypotheses. This limit is intended to be applied during the licensing stage and used as a ceiling in the optimization process;
- Exemption to demonstrate optimization process must comply with:
  - An effective dose equivalent to workers less than 1mSv/y; and
  - An effective dose equivalent to public less than 10 μSv/y; and
  - A collective effective dose equivalent less than 1man-Sv/y.

Dose constraint is used to establish, upper operational levels of activity concentration for effluent discharges to the environment. There are two ways to establish such levels:

- The operator proposes the upper levels, based on environmental modeling during the licensing. The whole process is verified and approved by the regulatory body.
- In cases where the procedure is not presented or is not accepted, the regulatory body establishes these levels.

In both cases, CNEN performs an independent assessment to establish or approve upper levels for effluent discharges to the environment. The procedure used is based on the critical group approach and follows the model proposed by IAEA as described in Safety Series 57, adapted to local conditions and uses of the environment. The definition of the critical group follows the recommendations of ICRP Publication 43.

As far as possible, local data is used in the model. These data are assessed from licensing documentation provided by the operator, from the documentation provided to IBAMA on the Environment Impact Assessment Report (RIMA).

Basic controls for effluent releases required by the regulation CNEN-NN 3.01 - Basic Standards of Radiation Protection [12] includes:

- Nuclear installations that release radioactive effluents into the environment should make use of internal and external monitoring and control systems;
- All radioactive material discharged into the environment should be analyzed, accounted and registered;
- Periodic inspections are carried out by the regulatory authority in order to verify compliance with the standards;

CNEN regulation NE1.04 - Licensing of Nuclear Installations[3] also states the need of basic controls such as:

- The installation must provide systems to control and limit radioactive releases into air and water;

- ❖ Technical specifications related to the release limits and monitoring of radioactive effluents must be approved by CNEN;

- ❖ The operator must establish and carry out appropriate monitoring programs;

- ❖ Documented management systems to ensure compliance with authorization conditions are required;

- ❖ Effluents release accounting, dose calculation, environmental monitoring and the amount of disposed waste shall be registered and made available for further inspections;

- ❖ Operational reports that shall be provided by the operator according to regulation CNEN-NE 1.14[5] include:

  - Monthly historical operation report;
  - Half-yearly Effluents Release Report;
  - Dose Assessments to Critical Group
  - Annual Environmental Monitoring Program Report – Impact Evaluation
  - Unusual Events Report

For nuclear installations, the Institute of Radiological Protection and Dosimetry of CNEN (IRD) performs independent assessment of the radiological protection aspects, including analysis of licensing documents, such as safety analysis reports, and operational documents such as radiation protection plan, monitoring programs and operational procedures.

During the operational period, IRD establishes a specific routine program for each nuclear installation to control the execution and the adequacy of the program performed by the operators. The program includes occupational monitoring control and environmental monitoring control:

- auditing of data records of the radiation protection service, including assessment of worker's doses;
- auditing of data records of training program of the radiation protection service;
- inspection and execution independent area monitoring program;
- assessment of results of the area monitoring program, and comparison with results provided by the operator;
- assessment of the periodical reports provided by the operator on workers monitoring;
- independent effluent monitoring, based on composed samples, to be compared with the values reported by the operator;
- dose assessment based on actual effluent release data;
- programmed inspection including a joint environmental sampling, together with the operator;

- assessment of results of the environmental monitoring program, and comparison with results provided by the operator;
- auditing records and laboratories related to the effluents and environmental controls of the installation performed by the operator;
- assessment of the periodical reports provided by the operator on effluents and environmental monitoring.

During the decommissioning period, the program usually implemented by IRD includes occupational monitoring control and environmental monitoring control:

- analysis and approval of decommissioning documents, such as safety analysis reports, and operational documents such as monitoring programs;
- auditing of data records of the radiation protection service, including assessment of worker's doses;
- evaluation special proceedings by decontamination;
- regulatory inspections and execution independent area monitoring program;
- assessment of results of the area monitoring program, and comparison with results provided by the operator;
- assessment of the periodical reports provided by the operator on workers monitoring;

The joint sampling program takes into account main relevant pathways, critical group's location, the diversity of environmental media, and the maintenance of an independent historical record database.

Except for the Waste Repository at Abadia de Goias and USIN, no specific program addresses specifically to the temporary waste storage inside the installations. Rather, all procedures related to the verification of compliance to national regulations performed by IRD are applied to the nuclear installation as a whole.

For the nuclear medicine practices, IRD performs a biannual inspection at each licensed installation. The objective of the inspections is to verify compliance with CNEN regulatory standards defined on regulation CNEN-NE-6.05 that defines the exemption levels for solid and liquid waste. The inspections verify the records and inventories of sources and waste, and independent radiometric and surface contamination measurements are performed on the waste storage room and other laboratories.

F.4.1. Nuclear Power Plants

The Health Physics Programme of Angra 1 and Angra 2, included in Chapter 12 of the Final Safety Analysis Reports, sets forth the philosophy and basic policy for radiation protection during operation. The highest level policy is to maintain personnel radiation exposure below the limits established by CNEN and to keep exposures to as low as reasonably achievable (ALARA), taking into account technical and economical considerations.

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

The actual personnel radiation doses at Angra Nuclear Power Plants are much lower than the established limits. The dose distribution for workers at the Angra site demonstrates an adequate radiological protection programme, with almost all averaged annual accumulated individual doses below 5 mSv and no one with radiation dose above the annual administrative dose limit (20 mSv). The annual collective doses for the last 3 years have usually been lower than 1,30 Man.Sv and 0,20 Man.Sv, respectively during a year with and without outage. Actual dose distribution for the year 2005 is presented in Figure F.1 and F.2. The collective dose variation along the last years is shown in Figure F.3 and F.4.

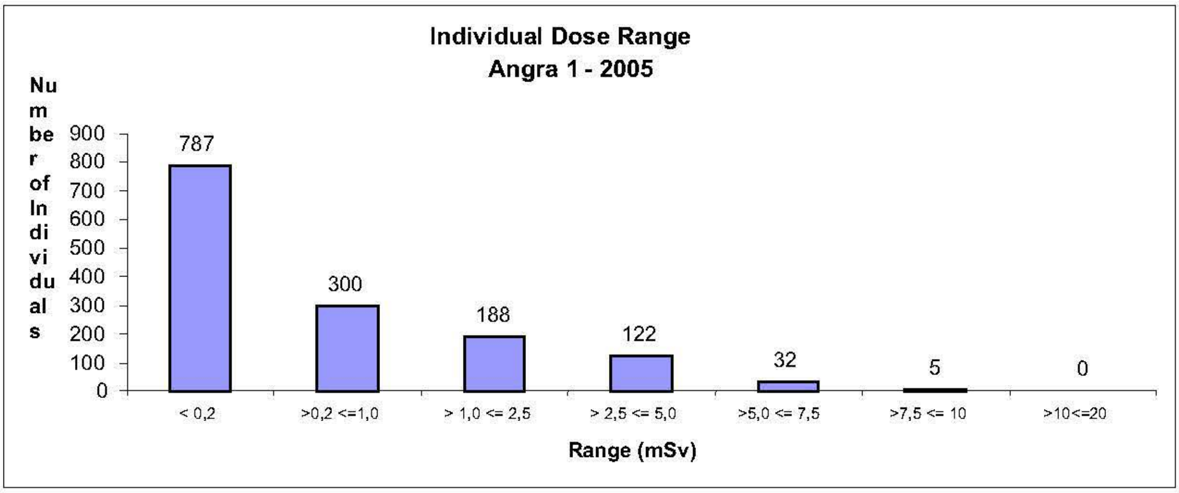


Fig. F.1 Individual Dose on Angra 1

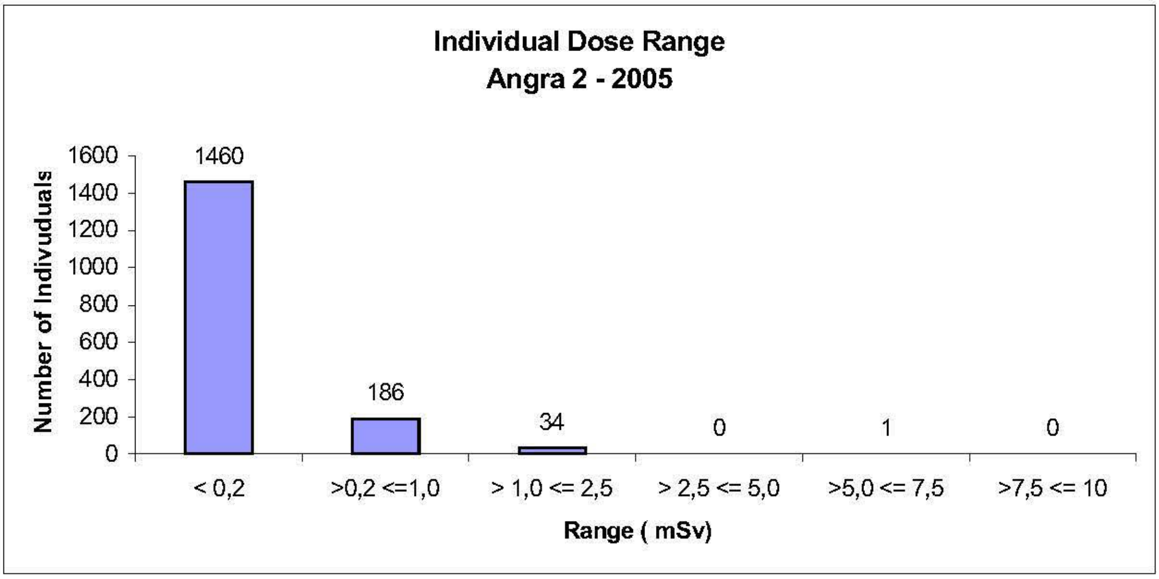


Fig. F.2 Individual Dose in Angra 2

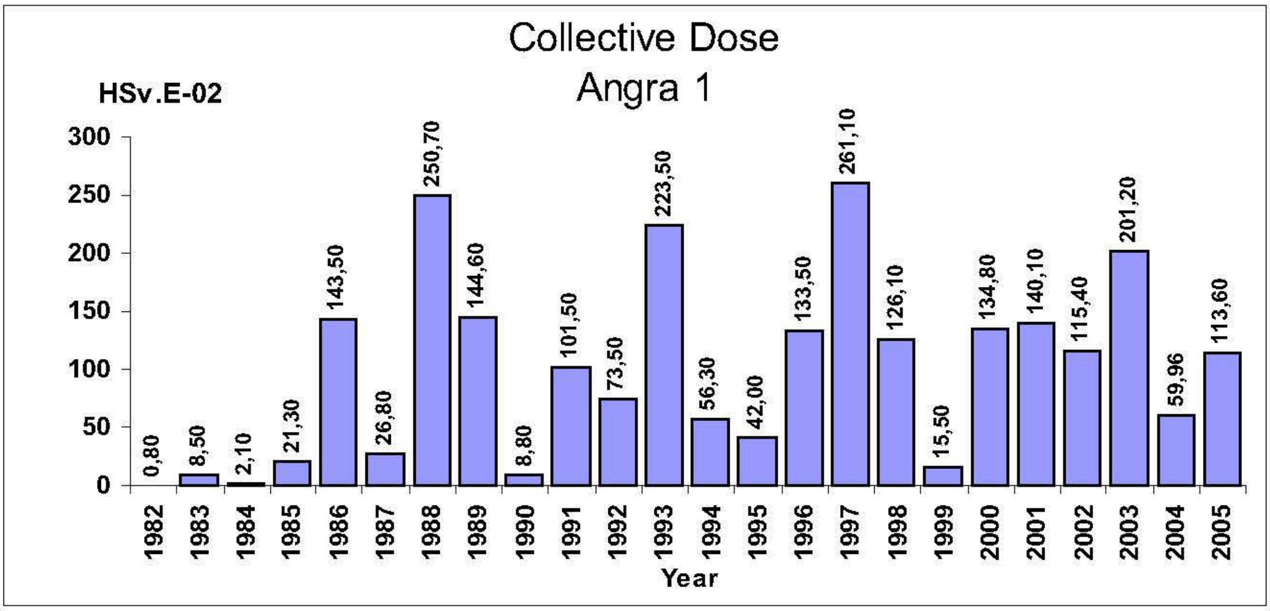


Fig. F.3 Collective Dose in Angra 1

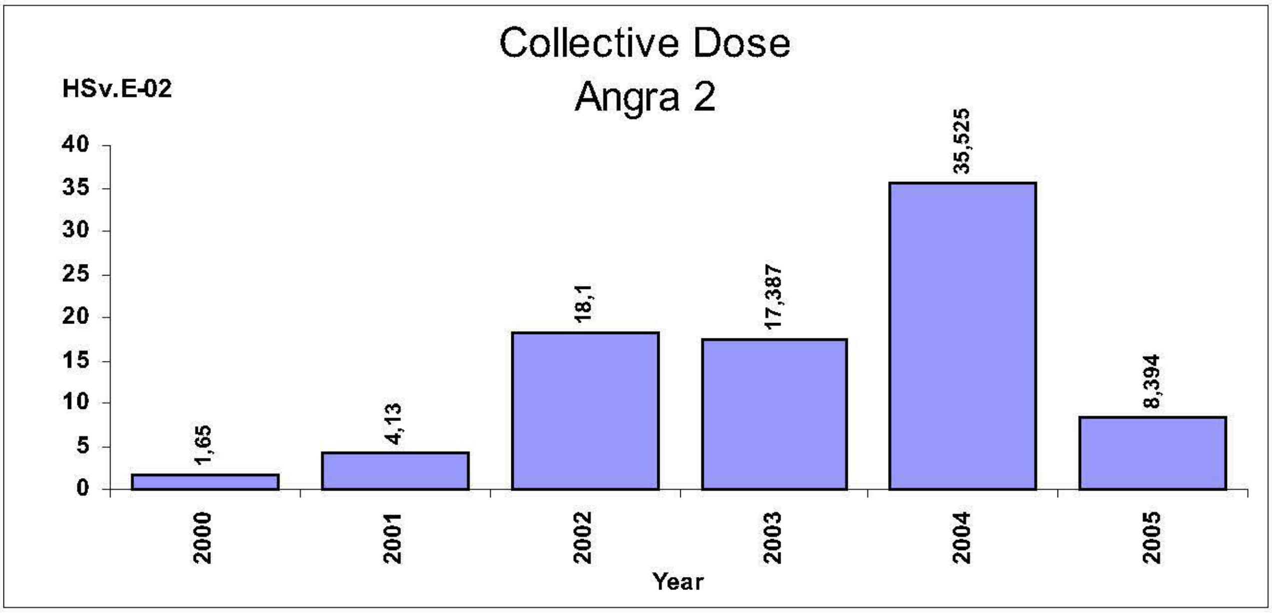


Fig. F.4. Collective Dose in Angra 2

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

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

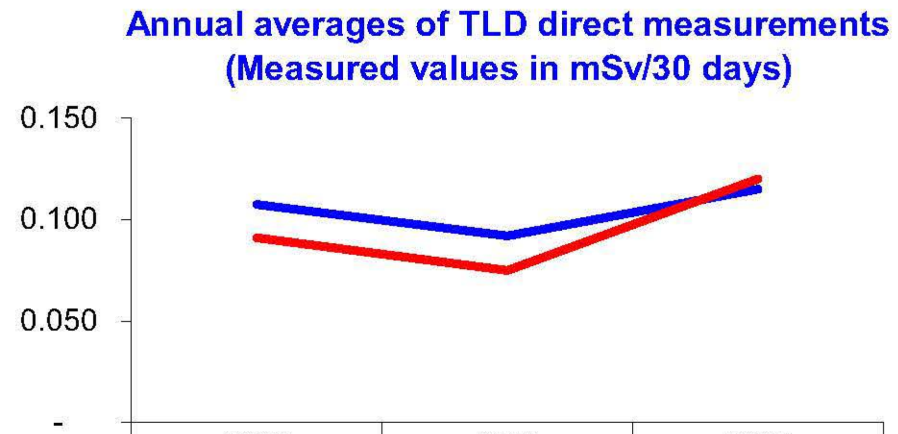
According to the CNEN regulation[5], an Effluents Releasing and Waste Report is issued every semester, documenting the liquid, gaseous and aerosol effluents – batch number, present radionuclides and concentration, waste quantity and type sent to the repository and the meteorological data in the period. Also, the effective equivalent dose for the critical individual is presented. In the period of 2002-2004, this dose reached the average 7 x 10^{-4} mSv, which is much lower than the 1 mSv value established in regulation CNEN-NE-3.01[12].

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

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

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

Typical results of the monitoring programme are presented in Figure F.5.



	2003	2004	2005
Impact	0.107	0.092	0.115
Control	0.091	0.075	0.12

Fig. F.5 – Environmental Monitoring Programme Results for 2003-2005

F.5. Article 25. EMERGENCY PREPAREDNESS

As mentioned in E.1.3, Brazil has established an extensive structure for emergency preparedness under the so-called System for Protection of the Brazilian Nuclear Programme (SIPRON). This includes organizations at the federal, state and municipal level involved with licensing and control activities as well as those involved with public safety and civil defense. Operators of nuclear installations and facilities and supporting organizations are also part of SIPRON.

SIPRON was established by Law Nr.1809 of October 7, 1980. Recently, a Governmental restructuring through Law Nr.10.683 of May 28, 2003 has designated the Ministry of Science and Technology (MCT) as the state department with competence for nucler energy policy. And SIPRON now stays under the responsibility of a Special Advisor to the Minister as a part of the coordination of Technical and Scientific Nuclear Program of MCT.

The Decree Nr.2.210 of April 22, 1997 also establishes a Coordination Commission (COPRON) composed of representatives of the agencies involved. Besides ELETRONUCLEAR, as a nuclear power plant operator, and CNEN, as the nuclear regulatory body, other agencies are involved as support organizations of SIPRON, such as the municipal civil defense, the state civil defense, the Angra Municipality, the IBAMA, the National Road Authority, the National Army, Navy and Air Force, and the Ministries of Health, Foreign Relations, Justice, Finance, Planning and Budget, Transportation and Communications.

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

A National Center for Management of Nuclear Emergency Situation (CNAGEN) has been created in Brasilia, in the MCT, in order to coordinate the actions. A State Center for Management of Nuclear Emergency Situations (CESTGEN) has been established in Rio de Janeiro. A Center for Coordination and Control of Nuclear Emergency Situation (CCCEN) and a Center for Information in Nuclear Emergency (CIEN) have been established in the city of Angra dos Reis.

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.

F.5.1. Nuclear Power Plants

Within SIPRON, the Central Organization issued a General Norm for Emergency Response Planning (SIPRON- NG-02)[13] and has prepared specific guidelines for Angra site emergency planning (Diretriz Angra 1 and Diretriz Angra 2)[14], consolidating all requirements of related national laws and regulations and stating the responsibilities of each of the involved organizations. Additional norms, related to emergency centers, communications, intelligence and information to the public, were also issued by the Central Organization.

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

At the off-site level, the National Center for Management of Nuclear Emergency Situation (CNAGEN), mentioned above, coordinates the actions. A

State Center for Management of Nuclear Emergency Situations (CESTGEN) has been established in Rio de Janeiro. A Center for Coordination and Control of Nuclear Emergency Situation (CCCEN) and a Center for Information in Nuclear Emergency (CIEN) have been established in the city of Angra dos Reis. These centers' activities during an emergency have been established in the revised Rio de Janeiro State Plan for External Emergency, approved by the state governor through the Decree n.26586 of 21 June 2000.

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

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

F.5.2. Other Facilities (Research Reactors)

The safety analysis performed for other installations such as research reactors indicates that only "on-site emergency is required". The on-site emergency plan covers the area within the operator's property, and comprises the reactor building and surroundings. It involves several levels of activation, from single alert status, to reactor building evacuation and isolation.

Specific Emergency Groups, under the coordination of the COGEPE (General Coordinator for Emergency Plan), are responsible for the implementation of the actions of the on-site emergency plan. COGEPE is also responsible for plant personnel emergency training and exercises planning.

IPEN also maintains a Nuclear and Radiological Emergency Response Team. Training activities in nuclear and radiological emergency for fire brigade companies, professionals of medical area, safety officers and employees are carried out systematically, with the participation of qualified observers.

At CDTN, a radiological emergency service is also available around the clock, including weekends and holidays. The emergency team is made up of 18 trained people and who are able to deal with situations arising from radioactive source losses, en route accidents with vehicles transporting radioactive sources, or sources mishandling at the user's premises. The most common tasks carried out so far by the CDTN response group are the investigation of possible site contamination in airports, stealing of lightning rods, possible presence of orphan radiation source in junkyards and industrial areas and the disappearance of medical sources from hospitals. The response group members also give lectures on emergency response, radiation protection and radiation sources handling to specific groups, e.g. firefighters and Army special battalions.

F.6.Article 26. DECOMISSIONING

Brazil does not have yet a national regulation that establishes rules for the composition of funds for decommissioning spent fuel and waste management facilities.

F.6.1. Nuclear Power Plants

A recent study made by ELETRONUCLEAR have established the alternatives for the future decommissioning of Angra 1 and Angra 2 Nuclear Power Plants, analyzing the financial resources, based on 17 American Nuclear Power Plants, 10 European Nuclear Power Plants and the specific study elaborated by Krsko Nuclear Power Plant, similar to Angra 1.

ELETRONUCLEAR considers as the best alternative the SAFSTOR (Safe Storage), which consists of the confinement of the Plant for a period of 10 up to 30 years, to reduce the amount of contaminated material, and radiation exposure.

The financial resources for the decommissioning of Angra 1 and Angra 2 would be subsidized through electrical energy taxes from those plants, with governmental authorization.

The national approach on waste from the above mentioned decommissioning is on a latent status, to be analyzed and defined later, after the definition and conclusion of the final disposal site for the LLW-Low Level Waste and MLW-Middle Level Waste from Angra Nuclear Power Plants.

F.6.2. Research Reactors

No decommissioning policy has been adopted.

F.6.3. Nuclear Installations

F.6.3.1. Decommissioning of Usina de Santo Amaro (USAM)

Up to now, the Santo Amaro monazite sand treatment facility (USAM) is the only decommissioned nuclear facility in Brazil. USAM operated since 1950's in a small town near São Paulo, separating rare earth materials from monazite sand coming from the Buena Beach in Espirito Santo state. The growing of urban areas around the site led to the decision to decommission the facility.

The facility went through a complete decommissioning process. After transporting all separated useful material and the waste to other site at USIN (see H.2.2.2), the buildings were demolished and the site decontaminated. A detailed radiation monitoring program was conducted and the site was declared free for irrestricted usage. The formal decommissioning process was formalized through a resolution of the Deliberative Commission of CNEN in January 1999. A view of the area involved is show in Figure F.6.

Fig F.6. Area occupied by USAM in Santo Amaro, SP.

Before decommissioning, the monitoring program, proposed by the operator and approved by CNEN, fulfilled the need for follow up environmental behavior of the soil contamination of the site and to evaluate the radiological impact on the environment, as a result of the previous site contamination and due to radiation emitted by the stored radioactive materials in Hangar A. A program for occupational exposure assessment was also implemented by the operator.

The monitoring program performed by the operator analysed the concentrations of soluble ^{226}Ra and ^{228}Ra in water from wells around the site, wells inside the Hangar A and a creek close to the site area. External doses were measured by a TLD net around the site and around Hangar A.

An occupational control performed by IRD included the assessment of reports provided by the operator and regulatory inspections, where the access control for restricted areas was verified, and measurements of dose rates inside and surrounding Hangar A were performed.

On December 1997, INB submitted a comprehensive plan for the demolishing of the USAM buildings and some soil samples were sent for laboratory analysis, especially for the determination of existing radionuclides and total alpha and beta/gamma activities.

CNEN also required from INB the submission of: (i) a detailed decommissioning plan, including waste management and radiological procedures for the demolishing of the buildings (floors, walls, sanitary system, water distribution system, etc); (ii) procedures that would be adopted for the radiological characterization of the site (deepness of soil samples, frequency, etc) and frequency of reports to be submitted to CNEN; (iii) the radiological criteria to be used for clearance; (iv) a radioactive waste plan including the necessary and appropriate description of packages; (v)description of the scenarios that would be used for the determination of soil clearance values (cutoff limit) due to necessity to liberate the area for unconditional use; (vi) radiological procedures for the workers involved in the clean up; and (vii) procedures to control and guarantee that the doses on the neighbouring population would not exceed 1 mSv/y.

In 1997, an environmental monitoring control program was implemented by IRD for the USIN site, including the assessment of documents provided by the operator, auditing records related to the environmental monitoring program and a joint sampling procedure for well and surface water.

The duplicate sampling program has shown that the results obtained by INB were compatible with those obtained by the regulatory body and that the area was adequately controlled.

On March 1998, CNEN authorised the demolition of the area occupied by the monazite physical treatment unit, with the exception of some compartments in the area of thorium crystallisation, since detected contamination levels were above the established clearance levels. It was also detected some soil contamination. On June 1998, CNEN authorised the complete demolishing of these compartments.

On July 1998, another room, from the monazite chemical treatment unit was demolished, after the procedures proposed by the operator were approved by CNEN.

On August 1998, the last room and the administrative building were demolished, also after specific authorisation by CNEN.

The radioactive waste generated from these decommissioning steps were placed in metallic boxes and metallic containers, transported to another INB installation, USIN, and stored in a shed. All the conditioning and transport of the waste were inspected by CNEN.

The scenarios calculations performed by the Institute of Radiological Protection and Dosimetry (IRD), based on unconditional use of the area (soil), led to a clearance value of 600 Bq/kg of ^{226}Ra, for soil.

All the clean up work of the soil was inspected and audited by CNEN during the months of January through December 1998.

On December of 1998, experts from IRD conducted a complete radiometric survey of the soil within the plant, concluding that the clean-up work performed at the soil surface was sufficient to reduce the superficial contamination of the area to the same levels of the natural background of the region. Figure F.7 shows the site after the end of the decommissioning activities of the USAM monazite processing plant.

Figure F.7 –Clean area after USAM decommissioning work

A total of 13,000 m^2 of constructed area were demolished and an area of 16,503 m2 of soil was removed (an average of 50 cm of soil depth, resulting in a waste volume of the order of 8,250 m^3). The waste slightly contaminated and classified as radioactive, occupying a volume of 372 m^3, is kept under storage in a shed of INB in São Paulo.

One hundred and thirty four workers from INB (operator) were involved in the decommissioning work and their registered doses can be seen in Table F.1, which shows that all of them received radiation doses far below the Brazilian dose limit of 50 mSv/a adopted at the time. These dose values are also below the new limit of 20 mSv/a to be adopted by Brazil at the present.

Table F.1– Radiation doses to workers involved in the decommissioning of USAM

Dose	Number of workers
>10 mSv	0
> 5 mSv and ≤ 10 mSv	8
> 1 mSv and ≤ 5 mSv	46
> 0.1 mSv and ≤ 1 mSv	30
Undetectable	50

INB successfully performed the decommissioning of a monazite processing plant in Brazil, over a period of time of approximately 5 years, under close surveillance of CNEN.

F.6.3.2 Decommissioning of the Mineral Treatment Facility at Poços de Caldas (UTM).

Parts of the old Mineral Treatment Facility (UTM) at Poços de Caldas mining and milling complex is currently under decommissioning by INB.

Section G - SAFETY OF SPENT FUEL MANAGEMENT

G.1.Article 4. GENERAL SAFETY REQUIREMENTS

Since the current situation is the storage of spent fuel in the plant pools, the general safety requirements for the management of spent fuel are contained in the safety requirement for siting, design and operation of the nuclear reactors. Regulation CNEN-NE-1.04[3] applies to the fuel stored in the nuclear power plant. Additional requirements are established in Regulation CNEN-NE-1.26[8], for the operational phase, and Regulation CNEN-NE-1.14[5] establishes the necessary reporting requirements.

G.2. Article 5. EXISTING FACILITIES

G.2.1. Nuclear Power Plants

The design of the fuel pools and associated cooling systems and fuel handling systems assure adequate safety under authorized operation and under postulated accident conditions.

Both units are provided with facilities that enable the safe handling, storage and utilization of nuclear fuel. The facilities are designed, arranged and shielded such us to rule out inadmissible radiation exposure to staff and environment, the release of radioactive substances to the environment or criticality accidents.

In Angra 1 the new fuel dry storage room and the spent fuel pool are located in the Fuel Handling Building, having connections with the reactor via the fuel transfer system and the refueling machine. The path of the nuclear fuel inside the plant up to the reactor is: the entrance gate, the cask opening area inside the fuel building, the new fuel storage area, transfer canal (or temporarily in the spent fuel pool), the fuel transfer system, the refueling machine and the reactor core.

In Angra 2 the dry new fuel storage room and the spent fuel pool are located inside the Reactor Building. The path of the nuclear fuel inside the plant up to the reactor is: the entrance gate, the auxiliary portico, the equipment lock, the cask opening area, the new fuel storage area, the refueling machine, the spent fuel pool, and the reactor core.

In both Units the Spent Fuel Pools are equipped with fuel storage racks of two different designs. The first group, named Region 1, or compact racks, is designed to receive fresh and irradiated fuel assemblies at maximum reactivity for the specified core design, without taking credit for burnup. The second group, named Region 2 or supercompact racks, is designed to receive fuel assemblies that have reached a certain minimum burnup.

The compact and supercompact racks, made of stainless steel, have boron cupons between the storage cells in Angra1. In Angra 2 the compact and supercompact racks use borated steel plates as the construction material of the cells. The technical specifications have curves of discharge burnup versus initial enrichment, to direct the storage of fuel assemblies in region 2 because the smaller center-to-center distance of the cells.

Structures, components, and systems are designed and located such that appropriate periodic inspection and testing are performed.

In both units all storage places are supported by criticality safety studies. Criticality in new and spent fuel storage areas is prevented both by physical separation of fuel assemblies by boron shields and by borated water as appropriated.

The evaluated multiplication factors of the fuel storage configurations include all uncertainties arising from the applied calculation procedure and from manufacturing tolerances. The factors are less than or equal to the adequate upper bound margin of subcriticality (1-deltaK), under all conditions: normal operation and all anticipated abnormal or accident conditions.

The criticality evaluation codes used by the ELETRONUCLEAR are all international industry accepted codes and also licensed by CNEN.

The storage capacity is described in the table G.1. below:

Table G.1. Spent Fuel Storage Capacity at Angra

Angra 1 and Angra 2 – Number of Fuel Assemblies Storage Capacity		
	Angra 1	Angra 2
New Fuel Storage Room	45	75
Region 1 Spent Fuel Pool	252	264
Region 2 Spent Fuel Pool	1000	820
Reactor Core	121	193

Assuming a regular lifetime of 32 operating cycles for each unit and that in each cycle 1/3 of the core is replaced, then Angra 1 has an storage capacity for its entire lifetime and Angra 2 has an storage capacity for about 14 cycles.

Both units have redundant residual removal systems fed by redundant electrical safety buses, with provisions from the plant house load supply, redundant external electrical supplies and redundant Diesel generators. The sources of cooling water are closed circuits, cooled by open circuits from seawater.

Instrumentation in the fuel pools cooling and purification systems detects radiation, excessive temperatures or low levels ant then issues alarms to warn the operator, for actions.

Each unit is designed for a regular lifetime of 32 operating cycles. According to the national electrical demand, the actual refueling policy is to operate with 11 equivalent full power month cycles and one month refueling outage. Studies are being carried out to increase the cycle lengths gradually up to 18 months, since longer cycles reduce waste generation and doses during refueling outages. Shutdowns, refueling and startups of the plants are conducted in such a way to reduce the amount of radioactive waste (See also item D.1.1.1 and D 1.2.1).

The role of the ELETRONUCLEAR on the nuclear fuel management can be summarized as follows:

- Definition of operating strategy
- Definition of core composition
- Procurement of fuel fabrication together with manufacturers.
- Follow up of fuel fabrication
- Transport of new fuel from the factory to the site.
- New fuel reception on site
- Fuel storage on-site
- Fuel operation
- Refueling Operations

The supply of the fuel for nuclear power plants is planned several years ahead. In-core fuel management provides the basic data for this long-term planning. For this purpose, several burnup cycles have to be calculated in advance. The corresponding core loading schemes, or loading patterns, have to be determined considering safety-related and operational requirements as well as economic aspects. The main results of long-term fuel management are the required numbers of reload fuel assemblies and their enrichments for future cycles.

Of special interest in long-term fuel management are the equilibrium cycles. To calculate equilibrium cycles, the same loading pattern is used for several successive cycles. The equilibrium cycle is reached when the characteristic parameters do not change (significantly) from cycle to cycle. The most important characteristic parameters are:

- Type of loading strategy
- Number and enrichment of the reload fuel assemblies
- Natural length of the cycle
- Average discharge burnup for the fuel assemblies
- Availability of storage places. In this sense the interdependence of spent fuel (non-returnable to the reactor core) management is to be defined with the CNEN, which has the responsibility for the spent fuel destination.

G.2.2. Research reactors

See item D.2.1

G.3. Article 6. SITING OF PROPOSED FACILITIES

Siting requirements for the existing spent fuel storage facilities at reactor sites are the same for siting the nuclear power plants or research reactor, respectively.

If the decision is taken to store fuel in “dry storage” on site, new detailed requirements will have to be established by CNEN.

G.4. Article 7. DESIGN AND CONSTRUCTION OF FACILITIES

Design and construction requirements for the existing spent fuel storage facilities at reactor sites are the same for design and construction of the nuclear power plants or research reactor, respectively.

The spent fuel storage racks are easily installed and removed. They are manufactured from stainless steel. Their purpose is to receive and store fresh and irradiated fuel assemblies as well as any core inserts, like control rods, primary and secondary sources and flow restrictors that be inserted into fuel assemblies.

The storage racks consist of loading bearing structure supporting non-load bearing absorber cells. The loading bearing structures comprise:

- The lower support structure (base plate)
- Rack foot
- Centering grid
- Steel channels

The non-load bearing structures are provided with features to assure safe subcriticality, each fuel assembly position is provided with one absorber cell. The absorber cells are made of neutron absorbing sheets, with grooved edges. The absorber sheets are fabricated from a boron-alloyed austenitic stainless steel.

The absorber cells are fixed within the rack structure by means of welded clamps. To facilitate the insertion of one fuel assembly into the absorber cell the upper part of the cell is provided with lead-in slopes, or chamfers and where applicable, with guide for the refueling machine centering device.

Only about 40% of the volume of a fuel assembly consists of fuel rods, the remainder volume is empty and surrounded by water.

By plant design the storage and management of spent fuel assemblies can be enhanced by fuel assembly consolidation to reduce volume. For this purpose the fuel rods can be removed from the fuel assembly structure and packed as densely as possible into a canister. The canister can be stored and handled like a fuel assembly. In this way the fuel rods of two fuel assemblies can be consolidated to occupy the space required for one in a specified number of storage cells.

If the decision is taken to store fuel in “dry storage” on site, new detailed requirements will have to be established by CNEN.

G.5.Article 8. ASSESSMENT OF SAFETY OF FACILITIES

A comprehensive safety assessment is a requirement established by the licensing regulation in Brazil [3].

G.5.1. Nuclear Power Plants

For the Angra 1 and Angra 2 plants, both a Preliminary Safety Analysis Report (PSAR) and a Final safety Analysis Report (FSAR) were prepared. The FSARs followed the requirements of US NRC Regulatory Guide 1.70 - Standard Format and Contents for Safety Analysis Report of LWRs.

Chapter 9 of the SAR contains the information related to spent fuel storage on site, including cooling requirements, subcriticality requirements, and radiation protection aspects.

These reports were reviewed and assessed by CNEN, and extensive use was made of the US NRC - Standard Review Plan (NUREG - 800).

G.5.2. Research Reactors

The design and additional modifications of the Brazilian Research Reactors have been made in accordance with IAEA Safety Standards, Safety Guides and Safety Practices of IAEA Safety Series, in particular Safety Guide 35-G2 (Safety in the Utilization and Modification of Research Reactors), Safety Guide 35-S2 (Code on the Safety of Nuclear Research Reactors: Operation), Safety Series 116 (Design of Spent Fuel Storage Facilities), and Safety Guide 117 (Operation of Spent Fuel Storage Facilities). Such documents present the fundamental principles of safety for research reactors and associated facilities for handling, storage and retrieving of spent fuel before it is reprocessed or disposed of as radioactive waste. The adoption of these principles assure that the spent fuel represents no hazard to health or to the environment, and the maintenance of the following conditions for the spent fuel:

- Subcriticality
- Capacity for spent fuel decay heat removal
- Provision for radiation protection
- Isolation of radioactive material.

G.6.Article 9. OPERATION OF FACILITIES

Operational requirements for the existing spent fuel storage facilities at reactor sites are the same for operating the nuclear power plants or research reactor, respectively.

Detailed limits and conditions for operations (LCO's) are established for the nuclear power plant spent fuel pools, including the related surveillance requirements and the actions to be taken in case of deviations.

G.7.Article 10. DISPOSAL OF SPENT FUEL

Decisions regarding reprocessing or disposal of spent fuel has not yet been taken in Brazil. It is believed that the solution of this issue may take some time, until international consensus is achieved.

Meanwhile, Brazil continues to monitor the international situation. For the nuclear plants, if storage in the existing spent fuel pools at the sites becomes critical, there exists a possibility to design and construct dry storage facilities at the current Angra site.

The situation of research reactors was discussed in item D.2.1

Section. H - SAFETY OF RADIOACTIVE WASTE MANAGEMENT

H.1.Article 11. GENERAL SAFETY REQUIREMENTS

General safety requirements for the management of radioactive waste are established in regulation CNEN-NE-1.04 Licensing of Nuclear Installations[3] and CNEN-NE-6.05. Management of Radioactive Waste in Radioactive Installations[6]. Additional requirements for Nuclear Installation are established in the regulation CNEN -NE- 1.26 Operational safety in Nuclear Power Plants[8].

H.2.Article 12. EXISTING FACILITIES AND PAST PRACTICES

H.2.1.Nuclear Power Plants

H.2.1.1. Gaseous Waste

To minimize the radiation doses in the environment and to prevent the formation of explosive mixtures with a high hydrogen concentration, the gases are removed from the primary systems and processed in the Gaseous Waste Processing System, before discharged.

In Angra 1, the Gaseous Waste Treatment System removes the fission gases and stores them in the gas decay tanks. The discharge of these gases to the environment is not frequent, occurring as function of operational tests. The safety criteria are the assumption of 1% of fuel failures being released to the Reactor Coolant System.

In Angra 2, in order to avoid a release of radioactive gases to the building atmosphere and consequently to the environment, or formation explosive mixture with a high concentration of hydrogen inside the tanks in the auxiliary systems, the gaseous waste disposal system removes such gases by continuos purging with nitrogen and also processes the dissolved gases released from the reactor coolant. To fulfill the required functions the gaseous system has the following tasks:

- To retain radioactive gases until they have largely decayed before discharging then to the exhaust air stack.
- To prevent releases of radioactive gases from the components into the building atmosphere.
- To limit the hydrogen and the oxygen concentrations in the connected components in order to prevent the formation of explosive mixtures and to reduce the absorption of oxygen by the reactor coolant, which would lead to corrosion in the reactor coolant system.
- To operate with the hydrogen reducing system following a loss of coolant accident.

Also, in Angra 2, the gaseous effluents are released continuously through the vent stack. Discharges occur according to the ventilation systems pressure limits.

H.2.1.2. Liquid Waste

The Liquid Waste Processing and Storing Systems in Angra 1 and in Angra 2 are designed to collect the active and inactive liquid waste, produced in the controlled area, treating them when necessary. After that they may be discharged from the power plants in accordance with the safety rules, established by CNEN.

According to the activity and the chemical characteristics of the liquid waste, the following process are provided for treatment:

- Evaporation
- Mechanical filtration
- Ion exchange de-ionization using mixed bed filters
- Chemical precipitation

In Angra 1 the Liquid Waste Processing and Storing Systems are designed to transfer leakages from any point of the controlled area to specific storage tanks, and to separate different types of liquid waste for further processing.

In Angra 2 the Liquid Waste Processing and Storing Systems are designed to process approximately 20000 m^3 of liquid waste per year.

The system is sufficiently automatic, to minimize the human intervention, consequently reducing the occupational doses. The capacity is determined by the amount of liquid waste arising from the controlled area during normal plant operation and outages. The liquid waste is collected separately in two groups of storage tanks, in accordance with its chemical and radiological composition.

To assure the protection of the workers, of the population and of the environment against the effect of the ionizing radiation, the treated liquid waste intended for discharge is collected in monitoring tanks. Recirculation and discharge pumps are connected to the monitoring tanks to mix the liquid waste or to return it to the storage tanks.

Before discharge from the monitoring tanks, samples are taken for analysis in the laboratory. Based on the results of the analysis the radiation protection supervisor decides whether the discharge may be made. The discharge, as function of individual nuclides, is performed in accordance with technical specification for the plants, based on CNEN regulations and the environmental legislation in force.

The released activity is monitored on-line. If the maximum allowable value of the activity concentration for undiluted discharge water is exceeded an alarm is initiated and the discharge is automatically interrupted.

To optimize doses to Public Individuals, CNEN set an authorized limit of 0,25 mSv/year for each plant.

H.2.1.3. Solid Waste

To reduce the potential of migration and dispersion of radionuclides and to minimize the dose in the environment, both plants are equipped with Solid Waste Treatment Systems. These systems process the concentrated liquid waste and the solid waste produced in the operation and maintenance of the plant, and confine them in special containers and drums.

In Angra 1, the concentrates, resins and contaminated filters, from the purification systems are immobilized in concrete and conditioned in containers and drums, within prescribed requirements for transportation and storage.

In Angra 2, this waste is immobilized in bitumen and conditioned in special metallic 200-liter drums.

The compressible solid waste are compacted by a hydraulic press, in both plants and conditioned in special metallic 200-liter drums.

To minimize the accumulation of radioactive solid waste, the entrance of materials to be used in the controlled area is limited and controlled. Also, all the material collected in the controlled area is monitored and segregated, according to its physical and radiological features. Whenever possible, such material is decontaminated and reused or released as non-radioactive waste.

Since there is no definitive destination, the produced radioactive solid waste from Angra 1 is stored in an on-site storage facility. This facility is composed of two installations, called Deposit 1 (DIRR-I) and Deposit 2 (DIRR-II), with module 2A under operation and module 2B under licensing. (See Fig. E.2). A new storage building is also under construction.

In Angra 2, all the produced waste is stored in a compartment inside the plant, called in-plant storage facility or Initial Deposit (UKA Building).

All packed radioactive waste are monitored to assure that the surface dose rate, for transportation, does not exceed the established values in regulation CNEN-NE-5.01[15] and the resultant occupational exposure are in accordance with the values established in regulation CNEN-NE-3.01[12].

Up to 1999 in Angra 1 the radioactive concentrate produced in the evaporator unit and the spent resins were packed in 200 liters drums. As the mixture was not homogeneous, the immobilization process was considered improper, because the matrix was not in accordance with the established standard of Regulatory Body. As a consequence all the drums of concentrate and spent resins produced shall be encased in VBA.

The installed new Solid Waste Processing System encapsulates the concentrates and spent resins mixed with cement, inside 1 m^3 shielded liners. The new system, besides generating a more homogeneous product, reduces the occupational dose during the operational process, due to improved shields.

The Deposit 1 of the storage facility was built in 1981, with a designed capacity for 2432 drums, being 1488 of low level activity and 944 of medium level activity. At that same time the perspective of construction of a definitive national repository was in discussion.

As the construction of a final national repository in Brazil is still under discussions, to increase the storage capacity, drums are being stored in the inspection and backup areas destined to damaged drums.

In this way, the Deposit 1 has now 6752 stored drums. As the medium activity area is totally occupied, the medium activity drums are being stored in the low-level activity area. This fact contributes to the increase of the dose rate at the Deposit 1 external walls. Another restriction is the impossibility for visual inspections in all stored drums.

These and other non-conformities were pointed out, with recommendations, in the IAEA Inspection of May 2000, through the report Safety of Processing and Storage of Radioactive Waste from the Angra 1 Nuclear Power Plant. To fulfill these recommendations a new deposit is under construction.

In 1992, the Deposit 2A, with capacity to store 621 liners was built, with the improvement of remote operation capability, to minimize occupational doses. At the moment (December 2005) this Deposit holds 578 packages.

The Inventory of waste stored at Angra site is presented in table H.1

Table H.1. Stored Waste at Angra Site

Angra 1

Waste	Quantity (drums)	Localization
Concentrate	2774	Deposit 1/ Deposit 2
Primary Resins	660	Deposit 1/ Deposit 2
Filters	391	Deposit 1
Non- compressible	739	Deposit 1/ Deposit 2
Compressible	2329	Deposit 1
Secondary Resins	237	Deposit 1
TOTAL	7333	*(Includes 201 Inactive drums)*

Angra 2

Waste	Quantity (drums)	Localization
Concentrate	74	In Plant Storage
Filters	1	In Plant Storage
Compressible	86	In Plant Storage
TOTAL	161	*(Total Capacity1644)*

H.2.2. INB

The INB units store nuclear material of low activity. The waste produced is of minor quantity since there is a high value in the nuclear material stored. The recovery of Uranium in all phases of the process is a constant objective not only due to the economic value, but also to avoid the presence of effluents.

The inventory of material is presented below, although not all this material is “radioactive waste” in the sense of the Convention.

H.2.2.1 Fuel Element Factory (FCN)

The waste is packed in 200-liter metal drums with metal cover and rubber sealing.

Only 76 drums have been produced so far. They contain contaminated material (gloves, shoes, tools, filters) containing UO_2 (with up to 3.8% enrichment) in powder form.

The drums are stored inside the production facility. An initial storage facility is under construction within FEN protected area.

All waste is considered low-level radioactive solid waste (SBN – Table 2, CNEN- NE-6.05 [6])

H.2.2.2. Interlagos Plant (USIN) and Botuxin Deposit

In 1992, there was the deactivation of the Usina Santo Amaro (Santo Amaro Mill -USAM) that had processed monazite sand for the separation of rare earths. Works were developed in this area to subsidize the decision-making process aiming to the recovery of the area, with the objective of releasing the areas for unrestricted use. Mathematical models were applied for the dose calculation, considering different scenarios of the area occupation. The dose criterion used was of 1 mSv/year in the critical group for the more conservative occupation scenario, in agreement with the possibilities of occupation of the area, located in an eminently urban environment. The need to dispose, even in a temporary way, of the waste generated by the decommissioning process led to the choice of the USIN and Botuxim sites as interim waste repositories.

The area of USIN has about 60 000 m^2. The terrain, located in an urban industrial area and unused at the time, had 3 hangars. Hangars B and C were disassembled. The Hangar A, with 2060 m^2, was renovated to receive the waste originating from the decommissioning of the USAM. This process initiated in 1993.

Although belonging to the same company as USAM, the USIN site was not under regulatory control by CNEN, because the process of rare earths separation that use to take place in USIN did not involve significant amount of radioactive elements, since they were eliminated in previous stages of the process at USAM. In some moment of the operational period of USIN, however, some leakage of stored material led to a contamination of the area surrounding the Hangar A and also to a radioactive contamination of the sub-surface water of the site. From 1998 until 2002 the area was partially decontaminated. This operation generated 170 plastic drums with radioactivity material. The others 1,717 plastic drums stored in USIN were generated during decontamination of the USAM facilities.

Besides this occurrence, the USIN site received large amounts of the light fraction of monazite sand, as landfill to the swampy areas around the hangars. As a result of these landfills, activity concentrations up to 33000 Bq of ^{228}Ra per kg of soil could be measured. The need to clean the area in order to release it for unrestricted use had already been defined by CNEN and the operator decided to keep that area under regulatory control and use it as a temporary waste repository for the USAM decommissioning waste.

Besides the temporary storage of waste, Hangar A is also used to store radioactive material that can still be used as source for nuclear material and other applications, such as sub-products of the USAM process, mainly sodium phosphate and a material called Cake II (Torta II) composed basically of Thorium hydroxide concentrate. The inventory of Cake II awaits development of improved technology to allow its economical use.

The types and amounts of material stored in Hangar A are presented bellow.

Packages (100 l plastic drums)

• Cake II	3283
• Mesothorium	760
• Non-Contaminated Trisodium Phosphate	760
• Contaminated Trisodium Phospate	69
• Radioactive Waste (clothes, equipment, wood, soil)	1887
Total	6759

Maritime Containers (30m^3 capacity)

- Contaminated press-filter canvas - 3.5
- Contaminated wood - 1.5
- Contaminated metal parts - 7
- Other materials - 3

  Total 15

Metal Boxes (1m^{3}capacity)

- Metal boxes - 6

The area of Botuxim deposity has about 284,000 m^2, where there are 7 silos where ca. 3,500 ton of Cake II are stored:

Concret Silos (ton)

- Silo 1 321.48
- Silo 2 376.93
- Silo 3 374.97
- Silo 4 504.32
- Silo 5 479.33
- Silo 6 778.85
- Silo 7 664.19

  Total 3500.07

H.2.2.3. Poços de Caldas Industrial Complex (CIPC)

The first Uranium mine of Brazil has finished operation and is under preparation for decommissioning. As the licensing process took place before the present radiological protection criteria were established in Brazil, there was no previous planning for this phase. The main areas that will need attention include the open pit mining area, the waste rock piles and the tailings dam. Up to this moment, the whole area is still under control by the operator, and radiological control is maintained at effluents discharge points, mainly for the waste dam and for units of treatment of rainwater drainage from the mining area and waste rock piles.

At the CIPC, the following materials and/or by-products that may be considered tailings, radioactive waste or even raw material, are currently found:

1 – Mesothorium, stored in different conditions, namely:

a – Deposited by CNEN on the waste dam during the 1980 decade, there exist around 13,000 50-liter drums corresponding to 1,300 tons of this product.

b – Stored in five (5) silos excavated on a clay bank on the slope of the CIPC waste dam, there exist 2,700 50-liter drums, corresponding to 280 tons of the material. The silos are lined and covered with a layer of clay and soil 3 meters thick. This operation was performed in 1987.

c – Placed in a trench on the slopes of the waste dam, in 1984. There are 5,750 50-liter drums corresponding to a total of 600 tons of mesothorium. This trench is covered with a layer of clay and soil 2 meters thick.

2 – Cake II

a – Approximately 11,000 tons of Cake II (wet base) are currently stored in sheds, packed in 200-liters drums (19,400 units) and 100-litre plastic drums (16,250 units). Other 1,734 tons placed in 4 concrete silos, in bulk, are currently in the process of treatment (Operation of Cake II).

b - Additionally, there are 1,600 200-liter drums of Goianite Cake II resulting from experiments for the extraction of rare earths from Goianite mineral, which presents a low thorium content; as well as 3,560 200-liters drums of Cake II, corresponding to 534 tons, stored in silos close to the CIPC waste dam.

c - Finally, there are 824 200-liter drums (124 tons) of Inaremo, named after the process used by Nuclemon for extracting rare earths from Goianite. Inaremo is characterized by a very low thorium content, being a neutralized waste.

3 – Thorium

a – Approximately 80 tons of ThO_2, resulting from Cake II processing in two periods: In 1990, 32.9 tons were deposited in a pond; in 1995/1996, 46.58 tons were stored in 148 concrete containers.

H.2.2.5 Lagoa Real Complex – Uranium Concentration Unit (URA)

The Uranium Concentration Unit (URA) is located at the uraniferous province of Lagoa Real in the Center-South region of Bahia state. The ore bodies have average U_3O_8 concentrations of about 0.3%. Mining activities are developed at an open pit cast and expected to continue over 16 years. Uranium extraction is made by the Heap Leach method. The solubility of this method is estimated to be about 70%. The exhausted ore is disposed off in piles along with the waste rocks from the mining activities. The leaching solution is captured in holding tanks that are covered with geo-synthetic membranes (PEAD). The liquor is then pumped to the milling unit where the uranium is isolated by means of organic solvent extraction and then precipitated as ammonium di-uranate.

The licensing process was focused only on the aerosol and gamma exposure pathways, because the facility is not supposed to release any liquid effluent to the environment, since all the processed water has to be pumped back to the process. Thus, no major impacts are expected in the local water river that is not perennial. On the other hand, intervening facts showed that impacts into the aquifers needs attention since these water bodies are also the source of water to local communities. Besides the influence of mining activities in the groundwater other pollutant sources have to be assessed like the waste-rock/leached ore piles as well as the leaching tanks. In order to assess any impact into the groundwater a monitoring program is carried out by the mining operator under regulatory surveillance. Groundwater samples are collected monthly from monitoring wells placed close to the area of direct influence of the facility and close to population groups living at the site surroundings. Run-off samples are also collected close to the main sources to determine the concentrations of dissolved radionulides, assessing the drainage contribution to groundwater pollution.

Data from the environmental monitoring program, carried out by the mining operator under regulatory surveillance, are from around 30 sampling sites with the following issues: groundwater; rainwater; aerosol; radon; gamma exposure (TLD); sediments; soils; pasture; corn; bean; milk; manioc and manioc flour.

The objectives of the monitoring control are: 1) to keep under control the radionuclide fluxes from mining and milling activities to atmosphere and groundwater compartments, according to the release limits prescribed in the nuclear licensing, 2) to assess the potential impacts of the pollutant sources by means of mathematical simulation and 3) to establish the overall environment management strategy for the uranium production.

H.2.3. Navy Facilities

As mentioned before, the amounts of waste generated by the naval program are very small. The waste generated in controlled areas is stored in identified containers. The containers are transferred to the Radioactive Waste Deposit within CEA. The handling, storage and accounting are under responsibility of the Radiation Protection Division. The liquid waste is treated in a thermo-solar evaporator and the sludge is later classified as solid waste.

The Deposit is a metallic structure, with asbestos tile roof with the capacity for 256 200-liter drums. There is a drainage system to avoid flooding. The ventilation is natural, and equipments for fire protection and physical protection are available.

The current inventory is presented in table H.1.

Table H.1. Waste Inventory at CEA (March 2005)

Type of Waste	Mass (kg)	Number of Drums
Plastic	843.9	23
Paper	3016.8	26
Evaporator Sludge	2773.7	24
Other	282.2	8
TOTAL	**6916.6**	**81**

H.2.4. CNEN Institutes

H.2.4.1. IPEN

IPEN has been storing the radioactive waste generated at its own installations since the beginning of operations in 1956. At the present, IPEN is also in charge of receiving and storing part of the radioactive waste generated by other users, such as hospitals, industries and research centres. The existing facility, an Integrated Plant for Treatment and Storage of Radioactive Waste, has a total built area of 1450 m^2 and comprises the following units:

Changing rooms and radiation protection control: To allow the controlled access to the working area.

Reception and segregation unit. To receive, classify and distribute the waste through the proper treatment. If necessary, waste segregation is carried out.

Liquid waste storage and treatment/conditioning: Provided with suitable containers or devices for operational storage and pre-conditioning of liquids, either for immobilization or for release to the retention tanks for further discharge to the sewage system.

Immobilization and encapsulation in cement. Cementation was the process chosen for the conditioning and encapsulation of some kinds of wastes such as liquids, wet solids, including ion-exchange resins and activated charcoal generated in the reactor operation, sludge, biological and some non-compressible waste.

Compression of solids. Provided with a 10-ton hydraulic press. Compressible solids are collected in 60L transparent polyethylene bags and pressed into 200L metallic drums. The volume reduction factor achieved is about 4-5.

Lightning rod dismantling and conditioning. Provided with 3-cell glove-box, where ^{241}Am sources are removed from the device and conditioned in a small shielded container.

Dismantling and encapsulation of disused source. The dismantling hot-cell was designed to handle source activity up to about 4TBq ^{60}Co equivalent, each time. Sources will be withdrawn from original shielding or device and encapsulated in a more adequate and retrievable package for interim storage. This unit will start operation in 2006.

Analytical and radiochemical laboratories. For characterization of primary waste and waste form.

Storage sheds. For interim storage of drums containing treated waste.

The wastes are characterized by a wide diversity in nature, forms, radionuclide contents and activities, so that, for some types of waste, specific methods of treatment and conditioning had to be developed.

In general, solid and liquid waste managed at IPEN are treated and packaged in a 200 L steel drum as follow:

- Compressible solids: segregation at the generator installation, compactation and packing.
- Non-compressible solids: dismantling and encapsulation in concrete.
- Wet solids: chemical conditioning and immobilization in cement matrix.
- Liquids: Waste of short half-lives are discharged to the environment as liquid effluent after temporary storage for radioactive decay; all the liquid waste releases are done according to the proper radiation protection standards. Waste of longer half-life is immobilized in cement matrix.

Another common type of waste is lightning rods and disused sealed sources. Lightning rods with ^{241}Am sources were fabricated in Brazil until 1989. In that year, CNEN issued a resolution suspending the authorization for fabrication of such devices. Since then, the owner of such device should have replaced it for a usual lightning rod and the radioactive one delivered to IPEN or to other installations of CNEN. The estimated amount to be collected, spread out in Brazil, is about 80,000 pieces. From this amount, IPEN has already collected about 13,000. Considering the high amount and volume to be stored, IPEN developed a process for dismantling the rods, to remove the ^{241}Am sources and to recycle the remainder metal structure as a metal scrap. Sources are then stored in a shielded container. Until 1993 this process was carried out in a usual chemical fume hood. In order to improve the workers safety, aer careful evaluation of the working condition, this process was redesigned and transferred to a glove-box, where more suitable radiological safety conditions were achieved.

Disused sealed sources represent for IPEN and CNEN by far the major problem from the non-power applications, specially the long life radionuclides such as ^{226}Ra and ^{241}Am. Sources with low activity or low exposure rate received until 1993 were already conditioned and immobilized in cement as well as the ^{226}Ra needles collected up to that date, meaning in the last case about 1000 needles or 200GBq. In 1994, following the CNEN and IAEA recommendations to not immobilize definitively, IPEN suspended both treatment processes and begun to study an alternative process, which would permit the retrieval of the sources in the future or at any time, without committing the control and safety of the storage. In both cases packages were modified to a retrieval package. The spent sealed sources dismantling and conditioning unit is by now on construction. Spent ^{226}Ra needles collected from 1993 to 2002 were already encapsulated and resulting packages about 1500 sources, 300 GBq of activity stored in the interim storage shed.

Fig. H.1. Lightning rods dismantling glove-box

Fig. H.2. Interim Storage of Treated Waste at IPEN

The facilities for waste management are located inside IPEN, as part of its several nuclear and radioactive installations, properly certified by CNEN.

H.2.4.2. CDTN

CDTN's waste treatment and storage facilities and its support laboratories, are shown in Table H.1.

Table H.1. CDTN Storage Facilities

Facilities	Characteristics
Chemical treatment	200 L batch, main components: tanks, filters, pumps, control panel and sample system
Cementation, out-drum mixture	200 L batch, main components: tanks, mixer, pump, automatic weighing system and control panel
Compaction	16 t press
Cutting/shredding	Cutting mill, output 80-130 kg/h
Lightning rod dismantling	Glove box equipped with unbolting system, electrical scissors and other tools
Nuclear gauges dismantling	Hot cell with shielded windows, manipulators, pneumatic system, and control panel
Package testing	Facilities for Type A and Type B packages testing
Supporting laboratories	**Main equipment sets**
Chemical treatment	Lab hood with filtration system, pHmeters, analytical scale, pumps, jar-test equipment, magnetic stirrers
Cementation	Lab hood, glove box, lab oven and diverse equipment sets for physical-chemical and mechanical testing
Storage facility	**Description**
Intermediate storage building (Figs. H.1 and H.2)	450 m^2 surface hall with control system for effluents, fence, natural ventilation, appropriate lighting and alarm system

Fig. H.3. Intermediate Storage Building

Fig. H.4. Inside the intermediate Storage Building

Besides the radioactive waste generated at its own laboratories, CDTN has received disused sealed sources from other users, like industries, hospitals and universities. These sources include, among others, radioactive lightning rods, smoke detectors, nuclear gauges and teletherapy units, which are stored at CDTN's waste intermediate storage hall. The main nuclides are ^{60}Co, ^{137}Cs, ^{226}Ra and ^{241}Am.

The strategy devised and implemented for the management of radioactive waste at CDTN is based on the standard CNEN-NE-6.05 and takes into account the available infrastructure. The main aspects of the management program are:

- registry of the waste and disused sealed sources inventory using an electronic database;
- waste generation minimization by an adequate segregation and characterization;
- volume reduction by chemical treatment for the aqueous liquid waste and compaction and cutting for solid waste;
- cementation of sludges arising from the chemical treatment and immobilization of the non compactable solid waste in cement/bentonite matrix;
- quality control of the final product in order to guarantee safety during storage and to minimize doses to workers and individuals of the public.

Regarding sealed sources, lightning rods and smoke detectors management, the guidelines are:

- suitable conditioning of brachitherapy and teletherapy sources. The later ones are stored in their original shields;
- dismantling of the lightning rods, smoke detectors, and nuclear gauges and removal of the source in order to reduce the stored waste volume. The sources from the gauges are assessed for possible further use.

Fig.5 Laboratory for treatment of used sources

The segregation is carried out taking into account the physical, chemical and radiological characteristics of the waste. The liquid waste is segregated into aqueous or organic and the solid waste into compactable and non-compactable. Besides, short-lived waste is segregated from long-lived waste, the former being stored for decay and then released from radiological control. Each waste package is identified according to the origin and type of waste it contains.

After being monitored, the segregated waste are transferred to the treatment facilities. All relevant data, like origin, composition, volume or weight, chemical contaminants are registered in a specific form – GUIARR.

A hot cell for the dismantling of nuclear gauges is in operation at CDTN. The removed sources are checked for leaks and their activity is determined for possible reutilization. A glove box for ^{241}Am lightning rods and smoke detectors dismantling is already operative at CDTN.

Fig. 6. Hot cell for dismanteling used sources

Regarding ^{226}Ra sources, they are conditioned in such a way that retrievability is maintained. The sources are inserted in leaktight stainless steel capsules, which are placed in lead shields; once loaded, the shields are put inside the cavity of an internally shielded 200-liter drum.

The waste containing packages are identified, monitored and stored at the CDTN's waste intermediate storage hall. The relevant data about the prepared packages are stored in a specific form – GUIART. The information of both forms – GUIARR and GUIART – is used as input to the CDTN's waste electronic database. With this robust database, complex searches can be performed and all information about the stored waste inventory can be easily retrieved.

Another database – named SISFONTE – contains data about the sealed sources from other users received and stored at CDTN. Among other features, this database performs an on-line update of the activity stored.

H.2.5. Research Institutions

The Program for Waste Management in Research Institutions (Programa de Gerenciamento de Rejeitos em instalações de Pesquisa - PROGER) started in 1996 with the objective of controlling the radioactive waste management in research institutions throughout Brazil, and to establish common procedures and standards.

In 1999 PROGER was implemented at the Brasilia University with the construction of adequate installations and the establishment of proper working procedures to manage and control the waste generated in research activities. The model has now been extended to other institutions.

H.2.6. Waste Repository at Abadia de Goias.

For the repository of the waste from Goiânia accident, also the 0,3 mSv/y dose constraint defined by the Regulatory Body based on regulation CNEN-NE-3.01[12] was used during the design of the installation. As the installation contains two buildings, each one related to different activity concentration of ^{137}Cs in the waste, as already described in this report. The design basis for the first repository (Waste Group 1) a dose limit of 0,05 mSv/y has been applied to critical members of the public while a level 0,25 mSv/y was used to the main repository, in agreement with the Technical Instruction CNEN IT-01/91[16].

H.3.Article 13. SITING OF PROPOSED FACILITIES

H.3.1 Nuclear Power Plants

The On-Site Storage facility was built at the north side of the Angra site. This area is part of the southeastern part of the Brazilian Platform. Studies made in 1982 had demonstrated that there is no sign of failure occurrence or another tectonic activity in the region of Itaorna beach, since the inferior cretacic period.

Given the geologic formation of the region, predominantly crystalline rock, there is little indication of underground waters. Due to the geology and the morphology, composed by granites and residuals soils, the region has some damage associated to the high pluviometric rate.

Landslides and cracks that occurred in the area have been corrected with superficial and deep draining systems, as well the construction of gabion walls. Specifically, the hillside where the Storage facility is located was technically certified for stability and safety conditions.

The Deposit 1 of the storage facility was built in 1981. The Deposit 2 is composed by the old Deposit 2A constructed in 1992 and a new Deposit 2B. Both were licensed by CNEN.

To erect the Deposit 2B, IBAMA, the National Environmental Agency, required an Environmental Control Plan, which was submitted and accepted.

To improve the waste management facilities, a Monitoring Building and the Deposit 3 Intermediate Radioactive Waste Storage will be erected.

H.3.2. Medium and Low Level Waste Repository (under planning)

The site selection process for waste repositories requires a series of sequential activities: the identification of regions of interest, of preliminary areas, of potential areas, and of candidate-sites. The selection should take into account 4 factors: ecological, geological, fisiografic and socio-economical.

Some regions of interest for a low and intermediate radiation level waste repository were identified in Brazil. Potential areas were identified in two of these regions. The process was temporarily halted, pending the approval of a specific law on nuclear waste. With the approval of Law n. 10.308, in 2001, establishing the responsibilities, funding and licensing process for waste repositories, the work can now proceed.

For the low level waste resulting from the operation of Angra-1, 2 and future Angra 3 nuclear power plants and from the use of radionuclides in medicine, industry and research, a technical discussion about the necessity of construction of a single national near surface vault repository (for all this LLW) or two different repositories are being analysed (one near surface vault for the LLW resulting from the nuclear power plants operations and a second one type borehole or vault near surface repository for the medical, industrial, etc LLW). The location and design have not yet been selected.

It is worth mentioning that political and psycho social aspects related to the subject of radioactive waste disposal (“Not in my backyard syndrome”) contribute enormously to the difficulties faced by the Brazilian Government in the establishment of a national waste management policy.

H.4. Article 14. DESIGN AND CONSTRUCTION OF FACILITIES

Design criteria and conception of the radioactive waste facilities are based on a comprehensive survey done on the volume and physic-chemical and radiological characteristics of the waste to be received and managed in the life of the facility, and an estimation of the future demand.

H.4.1. Nuclear Power Plants

Angra waste is mixed with cement or bitumen before transfer to the On-site Storage Facility. This operation is performed under requirements for protection of the workers, the public and the environment, according to approved plant procedures.

All packed radioactive waste are monitored to assure that the surface dose rate, for transportation, does not exceed the established values in regulation CNEN-NE-5.0[15] and the resultant occupational exposure and contamination are in accordance with the values established in regulations CNEN-NE-3.01[12] and CNEN-NE- 6.05 [6].

The storage of the waste is done according to a layout established previously, to reduce the dose rate in external areas of the building.

The possibility of the environmental contamination in terms of the storage is remote, since all the waste is in the solid form and is conditioned in certified containers. For additional precaution the units of storage are equipped with internal drain directed to sumps subjected to inspections and release control.

The inventory control of the stored waste is made with the aid of validated managing software. The data bank includes information on the physical, chemical, radiological and mechanical features of the packed waste.

Periodic visual inspections are performed to verify possible alterations in the stored packed waste. Moreover, quarterly inspections are performed on the general conditions of the building and the installations.

For Deposit 2 it is foreseen the installation of:

- Remote automatic visual inspection equipment
- On-line external radiation monitoring system
- Ventilation system to assure negative pressures, including high efficiency filtering system.

H.5. Article 15. ASSESSMENT OF SAFETY OF FACILITIES

A comprehensive safety assessment is a requirement established by the licensing regulation in Brazil[3].

H.5.1. Nuclear Power Plants

For the Angra 1 and Angra 2 plants, both a Preliminary Safety Analysis Report (PSAR) and a Final safety Analysis Report (FSAR) were prepared. The FSARs followed the requirements of US NRC Regulatory Guide 1.70 - Standard Format and Contents for Safety Analysis Report of LWRs.

Chapter 11 of the SAR deals with radioactive waste management issue, including waste generation, treatment, in plant storage and the radiation protection aspects.

These reports were reviewed and assessed by CNEN, and extensive use was made of the US NRC - Standard Review Plan (NUREG - 800).

H.5.1.1. Onsite Storage facility

Before the startup operation of Angra 1 the documentation for the installation of the Deposit 1 of the On-Site Storage Facility, establishing the design, security and radiological protection plans, was submitted and approved by CNEN. The Deposit 1 was built in 1981. Later, the Deposit 2A module was also approved by CNEN built and built in 1992.

To erect the Deposit 2B, besides the CNEN license, IBAMA, the National Environmental Agency, required an Environmental Control Plan, which was submitted by ELETRONUCLEAR and accepted by IBAMA.

The safety and environmental licensing process for the construction of the Monitoring Building and the Deposit 3 is under way. This process include as minimum:

- A safety evaluation submitted to the Nuclear Regulatory Body
- An environmental impact study
- An environmental impact report
- A set of Public Hearings for discussions with the Public and local and state Organized Society Members.

H.5.2. Other Facilities

H.5.2.1. Fuel Cycle Facilities

The management of radioactive waste is considered a part of the Safety Analysis Report of all fuel cycle facilities. The information submitted is evaluated by CNEN during the licensing process.

H.5.2.2.Radioactive Waste Repositories

As mentioned before, the environmental licensing process of any waste repository in Brazil is responsibility of the Brazilian Environmental Agency (IBAMA). When radioactive waste is involved, CNEN acts in accordance with IBAMA, assisting this institution in nuclear matters.

In the implementation phase of the National Repository for Radioactive Waste, the Waste Management Division (DIREJ) of CNEN will be called upon to perform the evaluation of the Safety Analysis Report of the installation.

Two projects were implemented by CNEN, in the field of safety assessment of final disposal facilities. The first project had the assistance of the IAEA.The second is being conducted within the Federal University of Rio de Janeiro.

The project with IAEA aims at improving the national capability for assessing the safety of waste disposal facilities, and for this purpose, a multidisciplinary expert group was created and was trained in safety assessment methods, including the use of the relevant computer codes as well as laboratory and field measurements techniques.

In 2002 the International Atomic Energy Agency (IAEA) launched a new co-ordinated research project in the field of safety assessment for near surface radioactive waste disposal facilities (ASAM – Application of Safety Assessment Methodologies for Near Surface Waste Disposal Facilities) with the participation of Brazilian experts.

The primary objectives of the project are: to investigate the application of safety assessment methodologies used for post-closure safety assessment, in particular the methodology developed under the IAEA's ASAM project, to a range of near surface disposal facilities; and to develop practical approaches to assist regulators, operators and other specialists in their review of such safety assessment.

In 2004, a special group, named Repository Safety Assessment Group was created to improve CNEN capabilty in this field.

H.5.2.3.Safety Assessment of Goiânia Repositories

CNEN conducted two safety assessements of the Goiânia repositories, one in the year 1995 and another one in the year 2002, as described below.

- THE FIRST SAFETY ASSESSMENT (1995)

A robust model or screening model was developed considering that one of the main scenarios for the prediction of the impact of a near surface repository is related with the water pathway. The following scenarios related with the water pathway were considered:

(a) water ingestion;
(b) ingestion of contaminated vegetables due to water irrigation;
(c) ingestion of contaminated animal;
(d) inhalation of contaminated soil due to irrigation;
(e) external irradiation due to contaminated soil.

The dose factor was calculated considering a steady concentration of 1000 Bq/m^3 in the water well, the scenarios above, resulting in:

Annual Effective Dose Equivalent =4.19×10^{-5} Sv
Effective Dose Equivalent Commitment = 2.93×10^{-3} Sv.

The three pathways were also considered for intrusion.

The following hypothesis were considered for the geosphere in the analysis:

- The establishment of an Institutional Control Period;
- The continuos linear degradation of the cap, after construction of the repository allowing a higher infiltration rate each year (after 30 years the cap would completely fail);
- The infiltration rate at the surface of the cap would be only a function of the water balance between water fall and evapotranspiration;
- The unsaturated zone thickness bellow the repository bottom at the beginning of the analysis was neglected;
- The concentration inside the repository in the water phase, each year, was calculated taking into consideration the adsorption coefficient of the waste (kd) and the available quantity of water, which is a function of the water balance and the permeability of the

cap.

Two cases were studied:

- Model 1: Neglecting the permeability of the top of the vault due to the concrete thickness and applying Darcy law on the bottom of the repository to calculate the flow to the water table;
- Model 2: Neglecting the permeability of the top and bottom of the vault and considering that all the water infiltrated each year leaches the waste based on the adsorption coefficient and flows to the aquifer.

A plume model was used in the aquifer.

- RE-ASSESSMENT OF THE GOIÂNIA REPOSITORIES (2002)

The source term considered on this model was conservative: An annual leaching fraction of the waste considers that all the water that enters in the repository leaves the disposal and enters the geosphere (neglects cap and the engineered barriers).

The unsaturated zone thickness below the landfill was considered only at the end of the analysis, based on a transit time.

The model adopted for the saturated zone, to be coupled with the source term, takes into consideration the well-known one dimensional transport equation including dispersion, retention and decay of the contaminant in the aquifer.

The same data for the geosphere and biosphere used in the 1995 safety assessment was used in the 2002 assessment.

For the modelling of the biosphere, two kinds of scenarios were considered:

(a) Intrusion on the site resulting in: (i) direct inhalation of particulate due to contaminated soil, (ii) deposition on vegetables and ingestion by man; (iii) deposition on vegetables, ingestion by animals, meat consumption by man; (iv) deposition of grass, ingestion by the cow, transfer to milk and ingestion by man; (v) ingestion of contaminated soil due to ressuspension and (vi) external dose due to the radioactive hazardous materials.

(b) A residential scenario, that is, the existence of a house near the site (at the border) using water from a well, resulting in: (i) Irrigation, ressuspension and inhalation; (ii) direct consumption of the water well – ingestion; (iii) irrigation of vegetables and consumption by man; (iv) irrigation of vegetables, consumption by animals, consumption of contaminated meat by man; (v) surface water contact, transfer to fish and to man; (vi) irrigation of vegetables, consumption by animals, transfer to milk and ingestion by man; (vii) irrigation and accidental ingestion of contaminated soil; (viii) irrigation and external exposure in the case of radioactive

It should be pointed out that an agriculture scenario can only occur when the engineering barrier is completely destroyed (the concrete is transformed in sand and mixed with the waste). Many countries establish a period between 300 and 500 years for the complete transformation of the concrete barriers, although cracks and modification on its permeability can occur before this period of time. The results showed that, after approximately 280 years, the doses related to a probable agriculture scenario would be lower than the established limit for intrusion of 1 mSv/y. It should also be pointed out that on the post drilling scenario analysis a limit of 1 mSv/y is used, resulting in the necessity of establishing an institutional control period of 50 years, confirming the results obtained in 1995.

Based on a discovery scenario, a limit dose for intruder of 5 mSv is applied due to a single acute dose and an institutional control period of 40 years would be necessary (in the case of no waste dilution). Under the assumption of 0.25 dilution factor no institutional control period is necessary in this case.

The safety re-assessement of the Goiânia repositories confirmed the results obtained in 1995 that is:

- The water pathways related to a possible residential scenario near the site is negligible when considered the retention factor (transit time of ^{137}Cs) of the unsaturated zone (natural barrier). The maximum concentration below the repository, at any time, would be under the maximum allowed value of 25000 Bq/m^3 – (6,8 x10^{-7} Ci/m^3), that could result in a dose for an individual of the critical group of 0.25 mSv/y;
- The consumption habits of the individual of the critical group was over estimated when compared to the real consumption habits of the population nearby the site today;
- Three intrusion scenarios were considered and the most critical one would be the agriculture scenario. If this is assumed to happen only after the complete degradation of concrete (300 to 500 years), it would be of no importance, since after 280 years the doses would be lower than the allowed limit of 1 mSv/y. If in the case of Goiânia the concrete transforms into sand before the usual time of 300 to 500 years, an institutional control period of approximately 280 years would be necessary;
- If one neglects this possibility (degradation of concrete in time lower than 300 years) the most important scenario would be the post drilling scenario and an institutional control period of 50 years would be necessary;
- It should also be pointed out that the results of seven years of environment monitoring plan (EMP) at the site proved that it is very unlikely to find in the future concentrations of ^{137}Cs in the aquifer which will be dangerous to the population living near the site (Concentrations lower than the detection limit of 200 Bq/m3 - 5.4x10^{-9} Ci/m^3 were obtained until today).

Finally, it is important that, before the end of the institutional control period of 50 years, a new evaluation of the safety of the Goiânia repositories be conducted by CNEN, based not only on the probably improved local data such as: (i) geosphere information (ii) demographic grown information; (iii) variation of possible consumption habits by the population, but also based on the improving capability and knowledge of CNEN.

H.6.Article 16. OPERATION OF FACILITIES

The responsible for the safety of the radioactive waste facilities is the operator. Information on the conduct of operation is submitted to CNEN in the corresponding Safety Analysis Report, and is reviewed during the licensing process. The operation is subject to CNEN regulatory inspection program, and periodical reports have to be submitted according to regulation CNEN – NE - 1.14[5] and specific licensing conditions.

H.7.Article 17. INSTITUTIONAL CONTROL AFTER CLOSURE

H.7.1. Repository at Abadia de Goias

In 1988, the IRD/CNEN, through its Department of Environmental Radiological Protection began the implementation of the Environmental Monitoring Program around the temporary deposit of radioactive waste from the decontamination of the areas affected by the radiological accident of Goiania.

Due to the need of characterization of the area that would site the definite repository, the results obtained in that Program for the period between 1988 and 1992 were used as a pre-operational Program for the repositories.

IRD/CNEN continued with the environmental monitoring program until 1996, when the responsibility for the program was transferred to the Regional Center of Nuclear Sciences of the West-Center (CRCN-CO) of the District of Goiânia.

The program includes a TLD net around the site, and analyses of samples of surface and underground water, soil, sediments, pasture and milk to determine the quantity of ^{137}Cs.

IRD/CNEN implemented a monitoring control program in 1998, including auditing records related to the monitoring of the site and the duplicate sampling program, that includes all environmental medias included in the monitoring program performed by CRCN-CO. Results of this control program atest the good performance of the laboratory in charge of the monitoring program and the integrity of the repository.

Although not required by regulation, the laboratory of CRCN-CO participates from the National Intercomparison Program sponsored by IRD/CNEN. The results are presented regularly at the annual environmental monitoring report and indicate a good performance.

The repository structures are not supposed to have any release of radioactive material. Therefore, no operational level on activity concentration was defined for the installation. Any increase of the background levels shall be considered as a violation of the integrity of the repository and will demand further investigation of the situation.

According to an agreement formalized between CNEN and the Goias State, this control will be maintained for the next 50 years, with the possibility of being extended for another 50 years,

Section I – TRANSBOUNDARY MOVEMENT

I.1. Article 27. TRANSBOUNDARY MOVEMENT

The Brazilian policy related to transboundary movements of spent fuel and radioactive waste follows international practices. According to this policy, no readioactive waste shall be imported into the country.

The following section describes a case of shipment of spent nuclear fuel from a research reactor to the original supplyer country.

I.1.1. Shipment os IPEN spent fuel to the original supplyer country.

After 40 years of the IEA R-1 reactor operation, 127 Spent Fuel Assemblies (SFA's) had been stored at the facility, being 40 in a dry storage and the others 87 in the reactor storage pool. In 1996 CNEN started negotiation with US-DOE to return the SFA's of IEA-R1 to USA. Finally, in 1998, an agreement was achieved between CNEN and US-DOE and in November 1999 the shipment was successfully performed. This section describes the operational and logistic experience of the SFA's transport.

I.1.1.1. Companies Contracted for the transport Operation

The contract between CNEN and DOE was signed in 1998. Edlow International Co. and the German Consortium formed by Nuclear Cargo & Services (NCS) and Gesellschaft fur Nuklear-Service (GNS) were hired to perform the transport. Tec Radion Comercial Ltda (TRION) was subcontracted by Edlow to provide the necessary infrastructure for loading, transport within Brazilian territory, and customs documents.

The German Consortium provided 4 transport casks (two GNS-11 and two GNS-16), one transfer cask, equipment and experts to handling their equipment. IPEN performed the necessaries tasks to fulfill the Brazilian legislationreuirements, suvch as: the export license, a detailed Transport and Security Plan, safeguards documents, as well as operational and radiological protection support to the entire operation.

I.1.1.2.Transport Equipment Description

The transport casks were designed in a "sandwich" construction. The cylindrical cask consisted of the following components: inner liner with inner liner bottom, lead filling, wall with bottom plate, side wall cover sheet with spacer wire, head ring, primary lid and protective plate. The maximum weight of the cask was 13230 kg. The capacity of each cask was 33 spent fuel assemblies.

I.1.1.3. Fuel Cutting Equipment

Before the beginning of the loading operation, 19 control fuel assemblies were cut 1.27 cm from the cut line to the interior fuel plates. The cutting operation of the five control fuel assemblies stored in the dry-storage was performed in the first floor of the reactor building.

For the cutting of the 14 control fuel assembies stored in the reactor pool, it was used an underwater saw machine specially designed and constructed in Brazil under supervising of Edlow/Trion.

I.1.1.4. Loading and Transportation

On September 16, 1999, four containers, two with the GNS-11 casks and two with equipment arrived at IPEN. The two GNS-16 casks arrived on October 7. German experts supported by IPEN technicians and the transportation company staff hired by Edlow/Trion removed the equipment from the containers and placed on a truck, which were transported to the reactor building.

On September 21, the rotary lid was positioned on top of the first transport cask to be loaded, and some cold tests, with a dummy element, were performed. A transfer cask, 4-ton weight was used to transfer the assemblies from the wet storage to the transport cask. The SFAs were lifted from the storage racks inside the reactor pool with a special tool and positioned inside a plastic tube located on a metallic plataform located at 2 meters from the pool surface. The transfer cask was submerged inside the reactor pool over the assembly to be removed. The assembly was guided to one of the 33 positions of the cask. After the cask loading, a water tank was positioned above the cask and filled with 4000 liters of water. Finally, the cask was closed and the water was drained from it and from the water tank.

This operation was repeated for the 87 assemblies stored in the wet storage. For the others 40 SFAs stored in the dry storage, the transfer cask was not used.

On October 15 the four GNS casks had been loaded with a total of 127 Brazilian spent fuel assemblies. Then, decontamination procedures were performed.

On October 20 all the equipment and cask were removed from the reactor building to the containers. The casks were stamped and controlled by safeguards inspectors from ABACC (Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials) supervised by IAEA.

On November 3, the transport operation was initiated after approval from the Brazilian regulatory bodies (Nuclear and Environmental). The licenses were issued by CNEN and IBAMA (Environmental Brazilian Agency), which required the proper documents relative to transport, radiation and physical protection as well as an evaluation of the environmental impact. Also the GNS 11 and GNS 16 certificates issued by American and German authorities had to be revalidated in Brazil. Opposition from environmental organizations, local politicians and harbor union demanded a comprehensive public information work, including debates and press briefing, to overcome this opposition and avoid legal action against the operation.

On November 4 at down a huge convoy consisting of 5 trucks (one spare) escorted by Federal, State and County Police arrived in the port of Santos. It is also worthwhile to mention that the highway and the main avenues and streets in São Paulo and Santos were closed for trafic during the operation. Loading trucks were available at strategic places, to be used in case of necessity. Loading of the containers in the ship was concluded in 42 min. Before and during all shipment operation, the workers were monitored by the CNEN radiation protection personnel. At 4:50 am, the ship left the port escorted by boats of the federal police. At the exit of the port, these boats were replaced by a frigate of the Brazilian Navy, which followed the ship until a distance of 200 miles away from the Brazilian coast. At this point the Brazilian responsibilities over the fuel were terminated.

Section J – DISUSED SEALED SOURCES

J.1. Article 28. DISUSED SEALED SOURCES

All the disused sealed sources that are not returned to the manufactor have been or will be dismounted from its device or shielding, for further disposal. Meanwhile, disused sources are stored in provisional deposits at CNEN Institutes.

J.1.1. Disused Source Storage

The inventory of disused sources stored at CNEN institutes in December 2005 is presented in Table J.1. The occupational rate of the deposit is also presented.

Table J.1. Disused Sources in Storage (December 2005)

INSTITUTE	NUMBER OF SOURCES	TOTAL VOLUME (m^3)	TOTAL ATIVIDADE (Bq)	OCUPATION RATE (%)
IPEN	138 840*	125	1.5E+14	~95
CDTN	4 957	76	1.46 E+14	~20
IEN	7567	114	7,60 E+12	~99

** This includes 131 500 ^{241}Am and ^{226}Ra sources from lightning rods and smoke detectors*

IRD/CNEN performs a biannual inspection on every authorized radiotherapy installation, comprising the verification of sources inventory, the safety of the storage area and radiometric survey of the area. It is usually recommended that unused sealed sources should be transferred to CNEN, but there are some disused sealed sources stored in hospitals, mainly brachytheraphy sources.

Nuclear medicine installations have usually just weak calibration sources. Disused sources are stored in the installation but the main concerns are towards the quality of those sources still in use.

J.1.2 Program for Collecting of Disused Sources and Radioactive Waste

After the large radiological accident in Goiania with a disused ^{137}Cs source in 1987, CNEN contacted all users of radioactive material in the country to participate in the effort to soluve the problem of the disposal of disused radioactive sources.

Periodically, CNEN conducts regional operations to collect radioactive waste from several radioactive installations. This waste includes disused sources from medical, industrial and agricultural applications.

Two big campaigns were conducted, one in 1998 in the South Region and another in 1989 for the Northeast to collect disused radioactive sources. For this operation, an especial truck (Fig J.1) and Type A containers (Fig J.2) were purchased. Since then, smaller campaigns have been conducted in all national territory. In 2001 a campaign was conducted in the Central-West region and in 2002, two campaigns, one for the Northeast and another for the South regions, were carried out.

In the year 2003, experts from the CNEN, recovered 230 spent sources, as shown on detailed on Table J.2.

Table J.2 – Number of Recovered Spent Sources Collected in 2003

RAD	Type of Source	Quant.	Activity-unitary (mCi)]	Total Activity (mCi)	Storage Place	Date of Storage
Sr-90	Sealed source	1		100	IEN	22-01-03
Am-241	Lightning rod	15	0.57	8.55	CDTN	16-10-03
Cs-137	Tube	30		784	CDTN	10-10-03
Sr-90	Ophatalmic aplicator	2	10	20	CDTN	13-10-03
Ra-226	Needle	68		134	CDTN	08-10-03
Ra-226	Tube	26		195	CDTN	08-10-03
Sr-90	Ophatalmic aplicator	1	10	10	CDTN	15-10-03
Sr-90	Dermatologic Plate	1	20	20	CDTN	15-10-03
Cs-137	Tube	20		829.22	CDTN	17-10-03
Cs-137	Humidity Gauge	3	1500	4,500	CDTN	07-10-03
Am/Be	Humidity Gauge	3	500	1,500	CDTN	07-10-03
Ra-226	Calibration Source	4	1	4	CDTN	07-10-03
Am/Be	Neutron Source	1	100	100	CDTN	07-10-03
Am-241	Lightning rod	53	0.57	29.6	CDTN	07-10-03
Cs-137	Radioimunoassay	2	0.04	0.08	CDTN	21-10-03
TOTAIS		**230**	**2,142.18**	**8,234.45**		

In the year 2004, 848 spent sources with a total activity of 3,7 Ci was recovered as shown on Table J.3.

Table J.3 – Number of Recovered Spent Soucrces Collected in 2004

RAD	Type of Source	Quant.	Activity (mCi)]	Storage Place	Date of Storage
Cs-137	Level gauge	6	2,400	CDTN	17/02/04
Ra-226	Lightning rod	4	4	CDTN	17/02/04
Am-241	Lightning rod	1	0,57	CDTN	17/02/04
Am-241	Smoke Detector	59	0.24	CDTN	17/02/04
Cs-137	Tubes	26	745	CDTN	18/02/04
Ra-226	Needles	26	98.2	IEN	28/07/04
Ra-226	Tubes	6	105	IEN	28/07/04
Am-241	Lightning rod	5	2.85	IPEN	26/08/04
Am-241	Smoke Detector	2	~0	IPEN	26/08/04
Ra-226	Lightning rod	16	16	IPEN	26/08/04
Sr-90	Ophatalmic aplicator	3	150	IPEN	26/08/04
Am-241/Be	Humidity Gauge	2	20	IPEN	26/08/04
Am-241	Lightning rod	125	71.25	IPEN	31/08/04
Am-241	Smoke Detector	420	0.38	IPEN	31/08/04
Ra-226	Lightning rod	124	124	IPEN	31/08/04
Ni-63	Radar	23	0.02	IPEN	31/08/04
TOTAIS		**848**	**3,737.51**		

The type of sources collected includes small Radium needles, static lightning rods, and large sources used in radiotherapy. The sources are later transferred to the deposits existing at CNEN institutes (see Fig J.3).

Fig J.1 CNEN Truck for Disused Source Collection

Fig J.2. Type A Waste Containers

Fig J.3 Disused Sources Deposit at CDTN

Section K. PLANNED ACTIVITIES TO IMPROVE SAFETY

K.1. IMPROVEMENTS IN THE POWER PLANTS

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

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

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

The replacement of the two steam generators of Angra 1, foreseen for 2007, will improve the plant safety margins and, as a byproduct, will provide a revised safety analysis, to be performed with newer methods and codes. The subject of radioactive waste is an important aspect and the storage of the old steam generators is a major challenge for the future.

K.2. ADOPTION OF ICRP60 AND BASIC SAFETY STANDARDS (BSS)

In the supplement to the Brazilian Third National Report to the Nuclear Safety Convention, it was reported that a working group had been formed to adapt the existing Radiation Protection Regulation [17] to the new requirements of the IAEA – Basic Safety Standards (BSS) for Radiation Protection. The work of the group was concluded last year and a new regulation was issued in 2005.

However, as reported in the supplement to the National Report, some of the new concepts and limits of BSS had already been implemented earlier through other regulations such as the control of x-ray installations by the Ministry of Health.

K.3.IMPROVEMENT IN RADIOACTIVE WASTE AREA

In the last four years, since the creation of the Waste Management Division, a systematic approach has been applied to the radioactive waste management activities in Brazil, aiming at the development of a coordinated effort to harmonize all the activities involved in radioactive waste management.

Several activities were identified as necessary to be carried out. Among these were:

- The need to enhance the capacity of CNEN institutes to perform treatment and storage of waste;
- The need to review the regulatory approach for the research &

development installations, performing a closer surveillance of their waste management activities;

- The need to implement the National Repository for Radioactive Waste, providing final disposal for low- and intermediate level radioactive waste in Brazil.

The first of these activities has already been performed. The second one is under development and for this purpose the PROGER Project has been created. The aim is to cover all research & development installations in Brazil helping them to solve the problem of historic wastes and giving them directions on how to comply with the regulations established by CNEN.

Nevertheless, the main challenge is the estalishment of a National Repository for Radioactive Waste. The Project involves several specialities in different professional fields. In each one of them CNEN and other Brazilian institutions have different degrees of accomplishment. A coordinated effort is being carried out to make possible to have the repository operational in the first decade of XXI century.

K.4. FINAL REMARKS

Brazil has demonstrated that the Brazilian nuclear power programme and the related nuclear installations met the objectives of the Convention.

Based on the safety performance of nuclear installations in Brazil, and considering the information provided in this National Report, the Brazilian nuclear organizations consider that their nuclear programmes have:

- achieved and maintained a high level of safety in the area of spent fuel and waste management on its nuclear and radioactive installations;

- established and maintained effective defenses against potential radiological hazards in order to protect individuals, the society and the environment from harmful effects of ionizing radiation;

- prevented accidents with radiological consequences and is prepared to mitigate such consequences should they occur.

Therefore, Brazil considers that its nuclear programme has met and continues to meet the objective of the Join Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.

REFERENCES

[1] Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management – INFCIRC/546 - International Atomic Energy Agency - Vienna – 24.12.1997.
[2] Guidelines Regarding the Form and Structure of National Reports - INFCIRC/604 - International Atomic Energy Agency - Vienna – 1.07.2002.
[3] Licensing of Nuclear Installations - CNEN-NE-1.04 - July 1984.
[4] Siting of Nuclear Power Plants - Resolution CNEN 09/69.
[5] Operational Reporting for Nuclear Power Plants - CNEN-NN-1.14 – January 2002
[6] Management of Radioactive Waste in Radioactive Installations – CNEN – NE 6.05 – December 1985.
[7] Site Selection for Radioactive Waste Deposits – CNEN – NE 6.06 – December 1989.
[8] Operational Safety in Nuclear Power Plants - CNEN-NE-1.26 - October 1997.
[9] Certification of Qualification of Radiation Protection Supervisors - CNEN-NN-3.03 - October 1997.
[10]Quality Assurance for Safety in Nuclear Power Plants and other installations - CNEN-NN-1.16 - September 1999.
[11]Qualification of Independent Technical Supervisory Organizations in Nuclear Power Plants and Other Installations - CNEN-NE-1.28 - September 1999
[12] Basic Radiation Protection Directives - CNEN-NN-3.01 - August 2005.
[13] General Norm for Planning of Response to Emergency Situations – SIPRON – NG–02 - 1996
[14] Directive for the Preparation of Emergency Plans related to the Unit 1 of Almirante Alvaro Alberto Nuclear Power Plant – SIPRON Directiva Angra – 1997.
[15] Transport of Radioactive Materials – CNEN-NE-5.01 – August 1988.
[16]Radiation Protection and Safety for the Final Disposal of Radioactive Waste at Abadia de Goias – CNEN – IT – 01 – December 1993.
[17]Safety Policy of CNEN – Directive n.295 of 23 December 1996.
[18]Quality Assurance Policy of CNEN – Directive n.296 of 23 December 1996.

Annex 1

Present Inventory

The following table presents the inventory of radioactive waste in Brazil as of the end of 2005.

Source/ Type	Present Situation	Inventory as of December 2005	Treatment	Intermediate Storage	Final Disposal (proposal)
ANGRA I NPP					
Spent Fuel	**Storage inside reactor pool (Spent fuel pool)**	**586 fuel assemblies**	**Waiting for decision concerning reprocessing. Under Brazilian regulation is not considered waste.**	**Inside reactor pool**	**Deep geological disposal**
Filters	**Stored in 200 l drums at plant site**	**391 packages/ 81.5 m^3 / 1.8E+13 Bq**	**Cementation and encapsulation in steel drums**	**At plant site**	**Brazilian Repository**
Evaporator concentrates	**Stored in 200 l drums and 1000l liners at plant site**	**2774 drums / 779 m^3 / 5.8 E+13Bq**	**Cementation and encapsulation in steel drums/schilded leiners**	**At plant site**	**Brazilian Repository**
Non-compressibles	**Stored in 200 and 1300 l metallic boxes at plant site**	**739 packages/ 395 m^3 / 6.7 E+12 Bq**	**Cementation and encapsulation in steel drums/metallic boxes**	**At plant site**	**Brazilian Repository**
Resins	**Stored in 200 l drums and 1000 l liners at plant site**	**660 packages/ 237 m^3 / 2.3E+14 Bq**	**Cementation and encapsulation in steel drums/schielded leiners**	**At plant site**	**Brazilian Repository**
Compressibles	**Stored in 200 l drums at plant site**	**2329 drums/ 483.8 m^3 / 1.8E+12 Bq**	**Cementation and encapsulation in steel drums**	**At plant site**	**Brazilian Repository**
ANGRA II NPP					
Spent fuel	**Storage inside reactor pool (Spent fuel pool)**	**357 fuel assemblies**	**–**	**–**	**Deep geological disposal**
Filters	**Stored in 200 l drums at plant site**	**1 package**			**Brazilain Repository**
Evaporator concentrates	**Stored in 200 l drums at plant site**	**74 drums / 14.8 m^3 / 1.1 E+10 Bq**	**Betumization and encapsulation in steel**	**At plant site**	**Brazilian Repository**

			drums		
Compressibles	Stored in 200 l drums at plant site	86 drums / 117.2 m^3 / 1.8 E+11 Bq	Betumization and encapsulation in steel drums	At plant site	Brazilian Repository

RADIONUCLIDE APPLICATION IN MEDICINE, INDUSTRY AND RESEARCH					
Waste generated by radioactive installations, research institutes (including those belonging to CNEN) and lightning rods	Stored in the institutes of CNEN: IPEN(SP), CDTN(MG) and IEN(RJ)	IPEN:400m^3/7.5.0E+14Bq CDTN: 76m^3/1.46E+14Bq IEN: 114m^3 / 7.6E+12Bq	According to type of waste	Institutes of CNEN	Brazilian National Repository
FUEL CYCLE INSTALLATIONS					
Poços de Caldas Mining and Milling Industrial Complex – Uranium and Thorium concentrates	Stored in shed and trenches	7250 m^3 / 119288GBq (3224 Ci) (Low level waste)	-	-	-
Poços de Caldas Mining and Milling Industrial Complex – Mesothorium	Talings dam	1500 ton (Low level waste)	-	-	-
Poços de Caldas Mining and Milling Industrial Complex – Mesothorium	Trenches	880 tons (Low level waste)			
Poços de Caldas Mining and Milling Industrial Complex – Waste Generated in the Process	Tailings dam	2 111 920 tons (Low level waste)			
Poços de Caldas Mining and Milling Industrial Complex – Calcium Diuranate (DUCA) Poços de Caldas Mining and Milling Industrial Complex – Contaminated Filters and Other Materials	Tailings dam and Mine Pit Isolated areas on the site	120 000 tons (197 tons of U3O8) Approximately 50 tons (Low level waste)			

Poços de Caldas Mining and Milling Industrial Complex – Thorium (ThO_2)	**Pond and 148 concrete containers**	**79.48 tons (Low level waste)**			
INB Nuclear Fuel Factory – FCN Resende: Filters of the ventillation system, filters of the air conditioned system, and filters of portable dust vacuum cleaners)	**Disposed of in 7 (seven)- 200 liter drums, temporalily inside the Reconversion plant**	**454 kg (Low-level solid waste)**			
INB Nuclear Fuel Factory – FCN Resende: Non compactable waste (metal pieces, wood, glass, plastic pieces, and others)	**Disposed of in 5 (five) 200-liter drums, temporalily inside the Reconversion plant**	**327 kg (Low-level solid waste)**			
INB Nuclear Fuel Factory – FCN Resende: Compactable solids (plastic sheets, gloves, clothes, and others)	**Disposed of in 23 (twenty five) 200-liter drums, temporalily inside the Reconversion plant**	**1738 kg (Low level solid waste)**			
INB Nuclear Fuel Factory – FCN Resende: Refractory material (bricks)	**Disposed of in 6 (six) 200-liter drums, temporalily inside the Reconversion plant**	**1241 kg (Low level solid waste)**			
INB Nuclear Fuel Factory – FCN Resende: Dried lime cake	**Disposed of in 11 (nineteen) 200-liter drums, temporalily inside the Reconversion plant**	**1754 (Low level solid waste)**			
INB Nuclear Fuel Factory – FCN Resende: Dried ammonium fluoride cake	**Disposed of in 2 (two) 200-liter drums, temporalily inside the Reconversion plant**	**449 kg (Low level solid waste)**			
MONAZITE SANDS PROCESSING INSTALLATIONS					
Interlagos Facility (USIN/SP) –	**Stored in plastic drums**	**325 m^3 /5069 GBq(137Ci)**	**-**	**-**	**-**

Uranium and Thorium concentrates					
Interlagos Facility (USIN/SP) – – Mesothorium	**Stored in plastic drums**	**39 m^3 / 222 GBq(6Ci)**			
Interlagos Facility (USIN/SP) – Others contaminated matrial	**Stored in plastic drums, maritime containers and metal boxes**	**1585 m^3 / ?? GBq (?Ci)**			
Botuxim Desposiy (São Paulo) Uranium and Thorium concentrates	**Stored in concrete silos**	**2,190 m^3/ 32856 GBq(888Ci)**	**-**	**-**	**-**
			-	**-**	**-**
RADIOLOGICAL ACCIDENT IN GOIÂNIA					
Low level wasts (^{137}Cs) below exemption level	**Final disposal concluded**	**1525 m^3 / 2 Ci**	**Encapsulation in steel and concrete drums**	**Open air at Abadia de Goiás**	**Great Capacity Conteiner (CGP)**
Low level waste (^{137}Cs) above exemption level	**Final disposal concluded**	**1975 m^3 / 1338 Ci**	**Encapsulation in steel and concrete drums**	**Open air at Abadia de Goiás**	**Goiânia Repository**

Annex 2

LIST OF RELEVANT CONVENTIONS, LAWS AND REGULATIONS

2.1. RELEVANT INTERNATIONAL CONVENTIONS OF WHICH BRAZIL IS A PARTY

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

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

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

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

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

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

Join Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. Ratification: 14/11/2005.

2.2. Relevant National Laws

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

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

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

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

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

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

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

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

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

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

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

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

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

Law 10.308 of 2001.11.20 – Establishes rules for the site selection, construction, operation, licensing and control, financing, civil liability and garanties related to the storage of radioactie waste.

2.3. CNEN Regulations

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

NN 3.01 - Diretrizes básicas de proteção radológica - Resol. CNEN 48/2005 - ***(Radiation protection directives). January 2005***

NE 3.02 - Serviços de proteção radiológica - ***(Radiation protection services). August 1988***

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). September 1999***

NE 5.01 - Transportes de materiais radioativos - Resol. CNEN 13/88 - ***(Transport of radiaoctive materials). August 1988***

NE 5.02 - Transporte, recebimento, armazenamento e manuseio de elementos combustíveis de usinas nucleoelétricas - ***(Transport, receiving, storage and handling of fuel elements in nuclear power plants). February 2003***

NE 5.03 - Transporte, recebimento, armazenagem e manuseio de ítens de usinas nucleoelétricas - ***(Transport, receiving, storage and handling of items in nuclear power plants). February 1989.***

NE 6.02 Licenciamento de instalações radioativas – ***(Licensing of radioactive installations). July 1998***

NE 6.05 - Gerência de rejeitos radioativos em instalações radioativas - ***(Radioactive waste management in nuclear installations). December 1985***

NE 6.06 – Seleção e escolha de locais para depósitos de rejeitos radioativos. - ***(Site Selection for radioactive waste deposits).- December 1989***

NN 6.09 – Critérios de aceitação para deposição de rejeitos radioativos de baixo e médio níveis de radiação - ***(Acceptance criteria for deposition of radioactive waste of low and intermediate radiation level). – Setember 2002***

2.4. CONAMA Regulations

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

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

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

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

CONAMA-06/87 – Dispõe sobre licenciamento ambienatl de obras de grande porte e especialmente do setor de geração de energia elétrica - ***(Regulates environmental licensing of large enterprises, specially in the area of electric energy generation)*** - (16/09/1987).

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

2.5. SIPRON Regulations

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

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 Nr. 01 of 19.07.1996.

NG-04 - Norma Geral para situações de emergência nas unidades de transporte - ***(General norm for emergency situations in the transport units).*** Resol. SAE/COPRON Nr. 01 of 19.07.1996

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

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

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

NG-08 – Norma Geral para o planejamento e a execução da proteção ao conhecimento sigiloso ***(General norm for planning and execution of classified knowledge protection).*** Port. SAE Nr. 145 of 7.12.1998.

NI-01 – Norma Interna que dispõe sobre instalação e funcionamento do Centro para Gerenciamento de Emergência Nuclear ***(Internal norm on the installation and operation of teh national Center for Nuclear Emergency Management).*** Port. SAE Nr.001 of 21.05.1997.

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

Annex 3

List of Abbreviations

Abreviation	Portuguese	English
ABACC	Agência Brasileiro - Argentina de Contabilidade e Controle de Materias Nucleares	Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials
ALARA	Tão baixo quanto razoavelmente exeqüível	As Low As Reasonable Achievable
AOI	Autorização para Operação Inicial	Initial Operation Licence
AOP	Autorização para Operação Permanente	Permanent Operation Licence
BSS	Padrões Básicos de Segurança (da IAEA)	Basic safety Standards (of IAEA)
CEA	Centro Experimental de Aramar	Aramar Experimental Center
CDTN	Centro de Desenvolvimento de Tecnologia Nuclear	Nuclear Technology Development Center
CGRC	Coordenação Geral de Reatores e Ciclo do Combustível	General Coordination for Reactors and Fuel Cycle
CICP	Complexo Industrial de Poços de Caldas	Poços de Caldas Industrial Complex
CNEN	Comissão Nacional de Energia Nuclear	National Commission for Nucelar Energy
CTMSP	Centro Tecnologico da Marinha em São Paulo	Navy Technology Center in Sao Paulo
DIREJ	Divisão de Rejeitos Radioativos	Radioactive Waste Division
DIRR	Deposito Inicial de Rejeitos Radioativos	Radioactive Waste Initial Repository
DRS	Diretoria de Radioproteção e Segurança Nuclear	Radiological Protecion and Nuclear Safety Directorate
EIA	Estudo de Imapcto Ambiental	Environmental Impact Study
ETN	ELETRONUCLEAR - Eletrobras Termo Nuclear LTDA.	Eletrobrás Thermal Nuclear LTDA.
FEEMA	Fundação Estadual de Estudos do Meio Ambiente	State Foundatioin for Environmental Studies
FSAR	Relatório Final de Análise de Segurança	Final Safety Analisys Report
IAEA	Agência Internacional de Energia Atômica	International Atomic Energy Agency
IBAMA	Instituto Brasileiro de Meio Ambiente	Brazilian Institute for the Environment
ICRP	Comissão Internacional de Proteção Radiológica	International Commission on Radiological Protection
IEN	Instituto de Engenharia Nuclear	Nuclear Engineering Institute
IPEN	Instituto de Pesquisas Energéticas e Nucleares	Institute for Energy and Nuclear Research
IRD	Instituto de Radioproteçao e Dosimetria	Radiation Protection and Dosimetry Institute
MCT	Ministério de Ciencias e Tecnologia	Ministry for Science and Technology
OSTI	Órgão de Supervisão Independente	Insdependent Supervision Organization
PSAR	Relatório Preliminar de Análie de Segurança	Preliminary Safety Analysis Report
RIMA	Relatório de Impacto Ambiental	Environmental Impact Report
RR	Reator de Pesquisa	Research Reactor
SFA	Elemento Combustível Usado	Spent Fuel Assembly
SIPRON	Sistema de Proteção do Programa Nuclear	System for the Protection of the Nuclear Program
USAM	Usina de Santo Amaro	Santo Amaro Processing Plant
USIN	Usina de Interlagos	Interlagos Processing Plant
USNRC	Comissão de Regulação Nuclear dos Estados Unidos	United States Nuclear Regulatory Commission

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