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Chapter 2. NUCLEAR INSTALLATIONS

2.1. Article 6. Existing nuclear installations

As mentioned in item 1.2, Brazil has two nuclear power plants in operation (Angra1, 657 MWe gross/626 MW net, 2-loop PWR and Angra 2, 1345 MWe gross/1275 MWe net, 4-loop PWR) and one under construction (Angra 3, 1309 MWe gross/1229 MW net, PWR, similar to Angra 2, with construction temporarily interrupted). Angra 1, 2 and 3 are located at a common site, near the city of Angra dos Reis, some 130 km from Rio de Janeiro. More details about these units can be found in Annex 1 or in the PRIS[5], available through the Internet as well as in the ELETRONUCLEAR home page http://www.eletronuclear.gov.br.

Angra 1 and Angra 2 are very important to ensure a reliable power supply to the state of Rio de Janeiro which imports some 70% of its electricity needs from long distance hydro power plants. The plants also play a fundamental role in supplying reactive power to the system near the main load consumption centers, thus becoming a valuable factor in the reliable operation of the interconnected system.

2.1.1. Angra 1

Site preparation for Angra 1, the first Brazilian nuclear unit, started in 1970 under the responsibility of FURNAS Centrais Eletricas SA. The actual construction of the plant began, however, only in 1972, shortly after the contract with the main supplier of equipment, Westinghouse Electric Co. (USA), was signed. The Westinghouse contract included supply and erection of the equipment, as well as engineering and design of the plant on a turnkey basis. Westinghouse sub-contracted Gibbs and Hill (USA) in association with the Brazilian engineering company PROMON Engenharia S.A. for engineering and design. For the erection work, Westinghouse brought in a Brazilian contractor, Empresa Brasileira de Engenharia S.A. (EBE). For the supply of the containment steel structure and the civil works not included in the Westinghouse contract, FURNAS contracted directly, respectively the Chicago Bridge & Iron Company and Construtora Norberto Odebrecht S.A, a Brazilian contractor which eventually also became contractor of the civil works of Angra 2. To assist in the implementation of the overall quality assurance programme, FURNAS contracted an independent consultant, Ebasco Services Co. To assist in the implementation of the nuclear fuel quality assurance programme, NUS Corporation was contracted as an independent consultant.

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

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

The personnel in charge of all modifications and improvements carried out since the first grid connection of the plant, from FURNAS, NUCLEN (now both at ELETRONUCLEAR) and other engineering companies, acquired considerable experience in dealing with the plant's technical matters.

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

Table 1 - Angra 1 Plant Availability

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

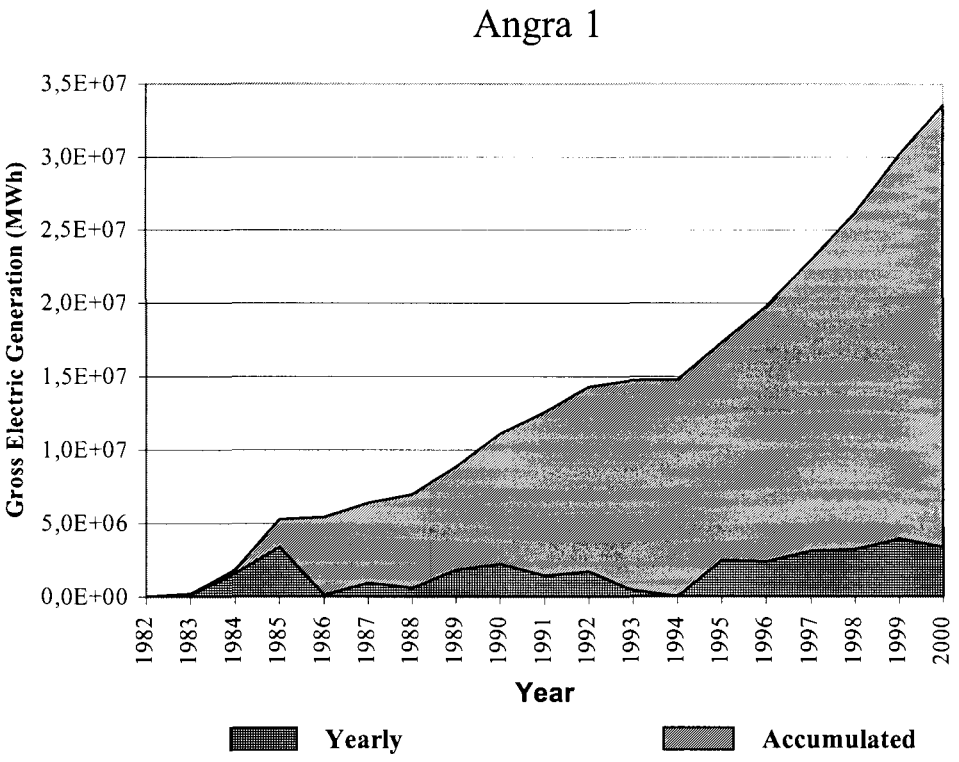

Fig.1 - Angra 1 – Energy Generation

2.1.1.1. Safety improvements at Angra 1.

Angra 1 safety status had been under constant review by FURNAS, and continues to be reviewed by ELETRONUCLEAR. Plant safety upgradings have been carried out during the life of the installation. Major upgrading programmes, still during the construction phase, were carried out after the occurrence of safety significant events in similar plants, such as the fire at Browns Ferry NPP and the accident at Three Mile Island.

During operation, Angra 1 has been reviewed and upgraded based on its own operational experience, on new CNEN requirements, and on the review of international experience in similar plants. Major upgrades refer to the installation of new Titanium condenser tubes, the addition of two new Diesel generators, and new items or design modifications related to the lessons learned from the Three Mile Island accident such as a safety parameters display system, post accident monitoring instrumentation, venting on the top of the reactor vessel, on-line monitoring of H_2/O_2 in the containment, improvements with respect to station blackout, procedure and improvements for ultimate actions like feed and bleed, middle loop operation level monitoring system. Modifications related to evolution of nuclear technology include the replacement of battery banks, installation of anticipated transient without scram (ATWS) mitigation system, cold overpressurization protection, new portal monitors in the controlled area, and new compact storage racks in the spent fuel pool. On the analysis side, a preliminary Probabilistic Safety Analysis (PSA) was conducted using generic plant data. A new detailed PSA study has been completed in 1999 and revised in 2000, which takes into account actual plant data, human reliability analysis, and additional events such as internal flooding.

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

2.1.2. Angra 2

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

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

required technology to design and build further nuclear power plants.

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

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

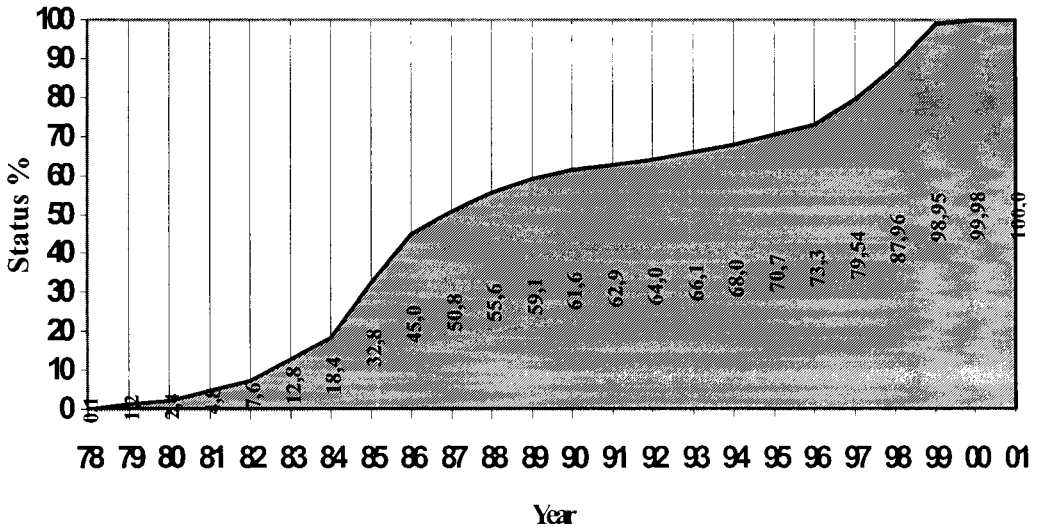

Fig. 2 – Angra 2 Construction Progress

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

The commissioning phase was a very successful one. No major equipment

problems occurred in spite of the very long storage time (~20 years), indicating the high quality of the component conservation programme.

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

Table 2 – Angra 2 Commissioning Milestones

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

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

2.1.2.1 Safety status of Angra 2

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

Angra 2 status is the one of a modern NPP, as a result of a consistent programme of upgrading that has been carried on along the construction years, with implementation of all safety related modifications added to the German reference

plant Grafenrheinfeld, as well as most improvements built in the newest German KONVOI plant series. Comprehensive testing carried out along the commissioning phase has allowed to adjust and confirm the design basis of the safety related equipment as well as of the operational equipment.

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

2.1.3 Angra 3

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

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

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

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

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

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

initial operation. The preservation measures including the 24 months inspection programme continue to be applied for the Angra 3 components stored at the site.

Table 3 – Angra 3 Current Status

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

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

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

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

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

Chapter 3. LEGISLATION AND REGULATION

3.1. Article 7. Legislative and regulatory framework

Brazil has established and maintained the necessary legislative and regulatory framework to ensure the safety of its nuclear installations. The Federal Constitution of 1988 specifies the distribution of responsibilities among the Federal Union, the States and the Municipalities with respect to the protection of the public