

# Brazilian Graduate Studies in Nuclear Engineering : A Brief Review

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## A Short History of the Brazilian NPPs

In the 1960s, electricity consumption by industries and domestic consumers in Brazil increased and the military government decided to seek bids for hydro electrical plants and for an initial nuclear plant.

Westinghouse was in charge of the turnkey contract for Angra 1, the first Brazilian nuclear power plant. Construction started in 1971 at a coastal site located in Brazilian southeast;



Angra dos Reis Bay, Brazil



NPP Angra 1 and 2, Brazil

Angra dos Reis was selected because of its proximity to the most demanding power consuming centers in the country i.e. Rio de Janeiro, São Paulo and Minas Gerais, supported for considerable economy reasons, beyond the fact of the southeast region was furnished with the largest and most efficient transmission network at that time.



In the late 1970s, Brazil signed an agreement with West Germany for supply of eight 1300 MWe nuclear units over the following 15 years. Two would be built immediately, with equipment from Siemens-KWU.

The rest would be assembled having 90% Brazilian content obtained through a technology transfer agreement. The state-owned company Empresas Nucleares Brasileiras (Nuclebras) was set up with a number of subsidiaries focused on particular aspects of engineering and the nuclear fuel cycle.

Economic problems delayed the construction of the Brazilian-German reactors, and the whole program was reorganized once again at the end of the 1980s. Only one reactor Angra 2 was settled up.

### Operating Brazilian power reactors

<i>Reactors</i>	<i>Model</i>	<i>Net MWe August, 2004</i>	<i>First year of production</i>
Angra 1	PWR	626	1982
Angra 2	PWR	1270	2000
<b>Total Net MWe</b>		1896	

### Power (GWh)

<b>Year</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>
Total	308508	322899	296237
Angra 1&2	3977	6046	14352
% nuclear	1.3	1.9	4.8

New NPP Angra 3 is planned itself to supply about 10 TWh year

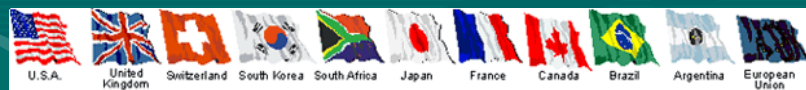
President Luis Inácio Lula da Silva (2006) has repeatedly stated his intention to build Angra 3 and complete the project.

According to the 10-year Expansion Plan of the Electrical Sector (2002-2011), Angra 3 connection to the grid is foreseen to take place in 2009.

The restart of its construction depends upon the final decision of the National Energy Policy Council that could authorize Eletronuclear to proceed with the environmental licensing.

Brazil has also been involved

in the Generation IV International Forum, and in the IAEA INPRO program, both developing new-generation reactor designs and systems.



Furthermore, the country has developed technology based on nuclear research reactors.

At IPEN, São Paulo, there are two research reactors - one a 5 MW pool type - and a cyclotron, with radioisotope production.

At IEN, Rio de Janeiro, there is an Argonaut research reactor.

At CDTN, Belo Horizonte, there is fruitful Triga Mark research reactor involved in Neutron Activation Analysis.

At CTSMP - the Navy Technology Centre at São Paulo, a prototype reactor for naval propulsion was being developed, but this program was redirected into possible applications for small power plants in the northeast of the country.

## Why Graduate Studies?

In Brazil, there is no Undergraduate Program in the Nuclear Field (2006), but...

The Brazilian scientific research generally growth by 19% in 2005, and by about 50% in the past five years.

Measured by the number of publications indexed in the Thomsom-ISI database, the Brazilian scientific production in 2005 represented 1.8% of the world production and ranks 17th in the list of countries.

Following this tendency, the Nuclear Research is blooming and evolving in Brazil.

In the last three years, three new Nuclear Graduate Programs have been established:

two Master Degrees

and one Doctorate.

CAPES is the regulatory commission from the Brazilian Ministry of Education in charge of the evaluation of graduate programs.

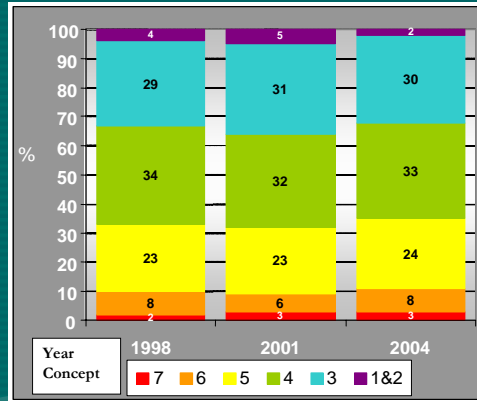
Its assessment of graduate education is based on the principle of peer review, i.e., visits by committees of specialists from Universities outside of the Graduate Program to be evaluated.

They evaluate all aspects concerning graduate studies, including *physical facilities, libraries, instruments and supplies, qualifications and performance of teaching staffs and students, and the quality and the number of their publications.*

This system enjoys great credibility in the academic community and the score is used to distribute the budget of Capes and CNPq – Agency of the Ministry of Science and Technology.

Evaluators (Ad-hoc) score Graduate Programs  
as we could freely classified :

- 7-Distinguished
- 6-Very Strong
- 5-Strong
- 4-Good
- 3-Adequate
- 2-Marginal
- 1-Inadequate



Overall evolution of the rating of all Brazilian Graduate Programs in the three last censuses



CRCN-UFPE

UFMG and CDTN

UFRJ, IEN, IME,  
ANGRA 1,2

IPEN-USP

<i>Institute, City, Region</i>	<i>Attached to CNEN</i>	<i>Degree</i>	<i>Starting year</i>	<i>Current Concept (Min 1, Max 7)</i>
DEN-UFMG, Belo Horizonte SE	<sup>1</sup> No	MSc	1968	4 <sup>a</sup>
		DSc	2005	4 <sup>b</sup>
COOPE-UFRJ, Rio de Janeiro, SE	<sup>1</sup> No	MSc	1968	6 <sup>a</sup>
		DSc	1979	6 <sup>a</sup>
IME, Rio de Janeiro, SE	<sup>1</sup> No	MSc	1969	3 <sup>a</sup>
IPEN-USP, São Paulo, SE	Yes	DSc	1976	6 <sup>a</sup>
		MSc	1976	6 <sup>a</sup>
CRCN- UFPE, Recife, NE	Yes	MSc	1977	5 <sup>a</sup>
		DSc	1997	5 <sup>a</sup>
CDTN, Belo Horizonte, SE	Yes	MSc	2003	3 <sup>b</sup>
IEN, Rio de Janeiro, SE	Yes	<sup>2</sup> MSc	2004	3 <sup>b</sup>

<sup>1</sup>Program partially supported by CNEN via undergraduate or/and graduate scholarships.  
<sup>2</sup>Professional Master of Science (emphasis on reactor operation)  
<sup>a</sup>Last evaluation released in 2004 by CAPES (Brazilian Ministry of Education), concerning activities in the period 2001-2003.  
<sup>b</sup>Convention from CAPES: new program starts with a given concept: 3 MSc and 4 DSc.

The building of scientific capacity needed has enlarged and improved the supply of proper personnel who is expected to operate the current infrastructure and other to be settled in the near future. Both the level of research funding and the number of graduate students involved in Nuclear Engineering (including applications in medical, agricultural and ecological) engaged in graduate programs have grown significantly in recent years, especially in Brazilian Southeast, the most industrialized and populated region of Brazil.

**From now on:**

In the XXI Century has come the time of international networks and initiatives. There is considerable potential benefit from information sharing under national and international cooperation to improve the Nuclear Engineering Education.

As described in the IAEA Summary Meeting Report of Senior Officials on Managing Nuclear Knowledge in 2002, two of the priority activities necessary for succession planning to ensure the preservation of viable nuclear education and training are:

- Promote networking of institutions for nuclear education and training in Member States in coordination with existing activities.
- Facilitate the development of curricula for internationally accepted higher university degrees on “nuclear technology”, by networking universities. Mutual recognition of disciplines among institutes should be stimulated.

Main References:

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