

REPLACING NUCLEAR STAFF: THE PROACTIVELY WORK AT IPEN/CNEN-SP

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Abstract. The purpose of this paper was to bring the actual situation of Nuclear Education and Training in Brazil. Accordingly, this paper overviewed the situation of the educational matter on Latin America, especially in Brazil, in terms of efficiency and effectiveness of its superior education system. Mainly this paper pointed out for the replacing of nuclear staff and the proactive work of the Energy and Nuclear Research Institute (IPEN) of the Brazilian Nuclear Energy Commission (CNEN).

1. Introduction

The world expenditure of electric power will increase almost 60% until 2020, this information was reported by the Department of Energy of the United States (2000). The greatest part of the fuel used will still be coal, but there shall be a great expansion in the utilization of natural gas and, in the developing countries the utilization of Nuclear Energy will increase. Bearing this in mind, countries should be worried with some problems that affect nuclear area all around the world, such as: *the relative ageing and retiring of the human workforce; the ability to maintain the accumulated knowledge; the replacement of technical expertise; the nuclear education and training; the decreasing number and the dilution of nuclear programmes; the decreasing number of students taking nuclear subjects; the ageing research facilities, which are being closed and not replaced; the significant faction of nuclear graduates not entering the nuclear industry* [1].

In developing countries such as Brazil it is no longer different, in other words, the proportion of those problems become even bigger. The Brazilian Government decided to enter in the field of nuclear power generation in 1968. The purpose was to give to the electric sector an opportunity to become acquainted with this modern technology and to gain the necessary experience to cope with possible future needs. As, at the time, a thermal power complementation to supply electric energy in the Southeast Region of Brazil, at Rio de Janeiro area, it was decided that it should be based a nuclear power. Specifically, the Nuclear Power Station of Brazil, located at Itaorna Beach, in Angra dos Reis, State of Rio de Janeiro, because of several factors related to the characteristics of the nuclear generation system, such as abundance of cooling water and infrastructure concerning transporting and assembling of heavy equipment [2].

The Brazilian Nuclear Energy Commission (CNEN) was created in October 10 of 1956, reporting to the Ministry of Science and Technology (MCT). CNEN is the body entitled to establish standards and regulations on radiological protection, to issue licenses (permissions) and to survey and control the nuclear activities in Brazil. Besides licensing and controlling the operation of the Nuclear Power Station of Angra dos Reis, CNEN seeks to add to the quality of the nuclear generated electricity supply of the country. Therefore, the Commission develops theoretical and experimental studies aimed to support the power production planning as well as to increase the efficiency, reliability and operational safety of the plants. To execute its activities, CNEN counts on some units such as: *Headquarters of CNEN; [Institute of Nuclear Engineering \(IEN\)](#); [Institute of Radiological Protection and Dosimetry \(IRD\)](#); Energy and Nuclear Research Institute (IPEN); Center of Nuclear Technology Development (CDTN); two [Regional Centers of Nuclear Sciences, one located in Recife/PE \(CRCN-NE\)](#) and the other in Goiás/GO (CRCN-CO); [Central Plan District \(DIPLAN\)](#); “Caetité” District (DICAÉ) and “Fortaleza” District (DIFOR)* [3].

2. An Overview of Superior Education in Brazil

Brazil is the world's fifth largest country, occupying half of the South America Continent. It is a complex and full diversity country with a population of 160 million peoples, from which 70 million are economically active. Its territory is divided into 5 political regions, such as: *South: which comprises the states of Rio Grande do Sul (RS), Santa Catarina (SC) and Paraná (PR); Southeast: which encompass the states of São Paulo (SP), Minas Gerais (MG), Rio de Janeiro (RJ) and Espírito Santo (ES); Center-West: which encompass the states of Distrito Federal (DF), Goiás (GO), Mato Grosso do Sul (MS) and Mato Grosso (MT); North: that comprises the states of Tocantins (TO), Amazonas (AM), Pará (PA), Amapá (AP), Roraima (RR), Rondônia (RO) and Acre (AC); Northeast: which encompass the states of Bahia (BA), Sergipe (SE), Alagoas (AL), Pernambuco (PE), Paraíba (PB), RioGrande do Norte (RN), Ceará (CE), Piauí (PI) and Maranhão (MA).*

As shown in the Table I below comparing Brazil to other countries of Latin America, it is the first in terms of number of Doctorate Courses and the second in number of Institutions offering those courses

Table I – Countries from Latin-America and its Institutions offering Doctorate Courses [4].

Countries	Nº Courses	Nº of Superior Educational Institutions
Brazil	701	68
Cuba	203	15
México	380	90
Argentina	147	21
Venezuela	01	13
Chile	56	7
Peru	40	12
Colômbia	33	20
Costa Rica	13	7
Uruguai	0	1
Ecuador	3	1
Bolívia	2	2
Honduras	1	1
Panamá	1	1
TOTAL	1 963	269

Despite of the vast area and population, concerning nuclear education, Brazil has a few Colleges or Universities and Research Institute that offers Nuclear Education, more specifically on two regions of Brazil, southeast and northeast, whereas in fact northeast has only the state of Pernambuco acting on this field.

In the state of São Paulo, southeast region of Brazil, the University of São Paulo (USP), the largest institution of higher education and research and the third in size in Latin America is influential in the area of higher education in the South-America continent. USP has educated countless professors with masters' and doctors' degrees, now teaching at private colleges and universities in Brazil. With its numerous accomplishments throughout the years, USP continues to evolve in the areas of education, science, technology, and the arts. The university offers undergraduate courses in all areas of knowledge (*but nuclear*) and ten of its 23 national graduate programs were given the maximum grade attributed by the Higher Education Coordinating Office (called CAPES) of the Federal Ministry of Education. Table II shows data published by USP and CAPES (Post-Graduation Statistic Data/2003), the university

comparing to Brazil has post-graduated on 2002, for example, 22.735 thousand master's degrees and 6.843 doctor's degrees and USP is responsible for 14,47% and 30,25%, respectively, comparing to Brazil as whole [5].

Table II – Total of Post-graduated Students at USP comparing to Brazil. [4]

Year	Brazil		USP		Percentage	
	MSc	PhD	MSc	PhD	MSc	PhD
2000	17.692	5.335	2.733	1.627	15,45%	30,62%
2001	19.551	6.042	2.892	1.778	14,79%	29,46%
2002	22.735	6.843	3.289	2.070	14,47%	30,25%

The expectation of the Brazilian Government is to increase the number of doctor's degree to 10 thousand by the year of 2006. In 2003, the total of doctors was 8.094, 18,3 % more than the year before (as data published by CAPES¹). Figure 1 below shows the evolution of the number of doctor degrees awarded during the period of 1987 to 2003.

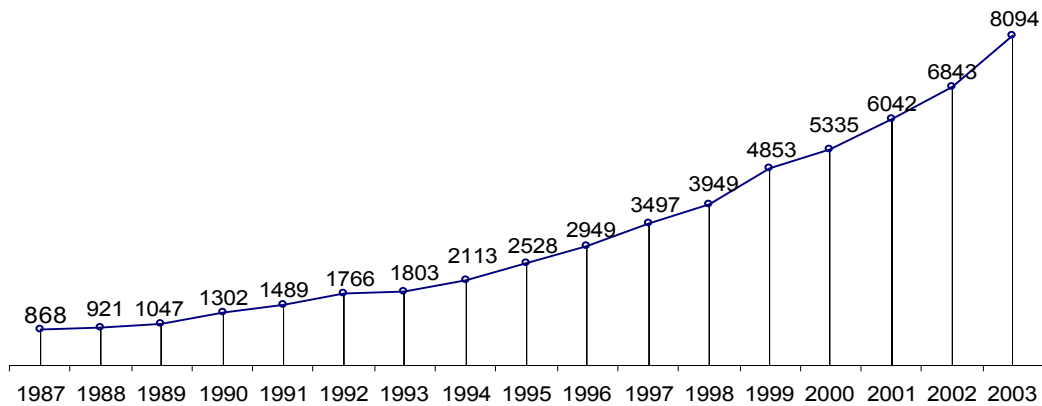


Figure 1: Number of doctor degrees awarded in Brazil [6].

3. Nuclear Educational Programmes in Brazil

In Brazil the challenge to provide basic and attractive nuclear educational programmes still needs necessary actions from government. As reported by OECD [1], "...failure to take appropriate steps now will seriously jeopardize the provision of adequate expertise tomorrow - we must act now". Taking in to account the focus of this paper, the first step is to present the current situation of nuclear-related education and training in Brazil, as following:

3.1. In the State of São Paulo/SP

The most developed state of Brazil, São Paulo, has more than 36 millions inhabitants even so there is only one Research Institution, in association with a University offering nuclear programme, i.e. IPEN.

3.1.1. Education and Training in Nuclear Technology Programme at the Energy and Nuclear Research Institute (IPEN)

¹ CAPES, does its evaluation three-annually on all Brazilian Post-graduate Courses. Their evaluations vary on a scale from 1 to 5. Universities are allowed to conduct their programme only with grade up to 3, if not the course is disregarded. The acquirement of evaluation up to 5, i.e. 6 and 7 is given only to programme that has high academic level recognized internationally for expertise

IPEN is located in the City of São Paulo at the campus of the University of São Paulo (commonly referred to as USP) and occupying an area of 500,000 m² of its campus. IPEN develops technologies of reactors and the fuel cycle; it carries out materials analyses, produces radioisotopes and radiopharmaceuticals, and mechanical and electronic equipments used in the nuclear area. In the library of this institute is available the biggest amount of scientific publications in the nuclear area of the country.

The Postgraduate Programme on Nuclear Technology at IPEN was established in 1976, since then, the Institute has been qualifying high level of specialists to Brazil and Latin America, on nuclear academic and professional fields. The IPEN Postgraduate Programme on Nuclear Technology, in association with the University of São Paulo, offers graduate-master and graduate-doctor courses that is organized in three areas of concentration:

- TNA – Nuclear Technology and its Applications;
- TNM – Nuclear Technology on Materials;
- TNR – Nuclear Technology for Reactors.

Its programme has acquired the grade 6 attributed by CAPES, for the three-annual 1999/2001, the progress report presented the following numbers, as shown on Table III.

Table III - IPEN Postgraduate Programme performance [7].

	Year	2000	2001	2002	2003
Students registered on Postgraduate Programme (MSc/PhD)		347		316	347
Staff of Thesis Advisor's		153	151	147	153
Disciplines offered		60	67	57	63
Thesis and Dissertation concluded		83	84	74	64
Postgraduate Scholarship (MSc/PhD)		91	84	160	138
Students in the Undergraduate Scholarship Program (PIBIC)		80	76	59	55
Applications for selection exams		180	197	257	420
Scholarship for trainees		500	550	377	352

Professional Master's Degree on Lasers in Dentistry: in august 1999, IPEN has started teaching, in partnership with in the Department of Dentistry of USP, in order to provide to the dentists theoretical and practical knowledge about lasers and their applications in dentistry, to prepare them to use the laser in their clinical treatments with the latest accepted laser technology. Table IV, presents the performance of the professional masters degree.

Table IV – Professional Master Degree at IPEN [7].

	Year	2000	2001	2002	2003	2004
Dissertations concluded		03	38	13	23	10
Students registered		24	16	22	15	X
Disciplines offered		08	08	08	08	X

IPEN has been planning, for the near future, to provide extension and training courses to meet the needs of the society using its major nuclear science and technology facilities. Having the mission to provide education and training in nuclear science and related areas and been aware

of the common sense concerned to the relative aging to the human workforce and the ability to maintain the accumulated knowledge, IPEN is working hard to replace technical expertise to keep alive the nuclear activities in the country.

Undergraduate disciplines: Recognized internationally for its high level of education provided IPEN has started, since the year 2000, teaching undergraduate disciplines for students from University of São Paulo. A number of 27 disciplines are part of an optional curricular and has been offered to almost 300 students, of different unit of USP undergraduate courses [7].

3.2. In the State of Rio de Janeiro/RJ

Located in southeast region of Brazil, Rio de Janeiro is the second most developed state. With a population of more than 14 millions inhabitants, corresponding to 8,47% of the national population. In the state of Rio de Janeiro there is more than one university that offers nuclear programmes, as presented below:

3.2.1. Professional Master Program at the Institute of Nuclear Engineering (IEN)

IEN is located in the University City, in Rio de Janeiro/RJ, being the pioneering center in the country in the research and development of fast reactors. It develops softwares to analyze problems related to engineering of reactors, produces radioisotopes used in nuclear medicine, equipments and systems, including for Angra I and II nuclear power plants. The IEN postgraduate program offers professional master level, on Nuclear Science and Technology. IEN offers in collaboration with: the Physics Institute and the Engineering School of the Federal University of Rio de Janeiro; the Military Engineering Institute; the Federal Center of Technological Education “Celso Suckow da Fonseca (CEFET-RJ) among others, undergraduation and postgraduation courses [8].

3.2.2. Graduate-Master Program at the Institute of Radiation Protection and Dosimetry (IRD)

IRD is the Institute responsible for developing procedures in order to assure the safety of the workers who deal with radiation, the population and the environment as well in this Institute courses are promoted, radiological equipment analyses are carried out and procedures to deal with radiological or nuclear emergencies are elaborated. The IRD postgraduate program started its activities in 2001 and since then they had registered, respectively: 13; 17; 20 and 10 students, and 12 of them had obtained their master degree. IRD also provide extension and training courses to meet the needs of the society using its major nuclear science and technology facilities [9].

3.2.3. Nuclear Education at the Coordination of Postgraduate Program in Engineering of the Federal University of Rio de Janeiro (COPPE/UFRJ)

COPPE/UFRJ is the first graduate school of engineering in Brazil. COPPE started its activities in 1963, serving as a model for many other initiatives in this area in other parts of the country, and it continues to distinguish itself as a source of state-of-the-art research, innovative teaching methods as well as highly qualified engineers at the service of the country. COPPE is one of four units that constitute up the Technology Center of the Federal University of Rio de Janeiro, the other three being the undergraduate School of Engineering, the School of Chemical Engineering and the Institute of Macromolecules. The Master's Program began in 1968, but the Doctor of Science's Program was launched only in 1979. COPPE offers also undergraduate activities through the Nuclear Engineering Department of the School of Engineering of the Federal University of Rio de Janeiro. Students from the Mechanical Engineering Department and from the Electrical Engineering Department can take elective courses in the Nuclear Engineering Department, as part of a curricular option called “Nuclear Emphasis”. All professors of the Program participate in this undergraduate effort. COPPE's basic academic units are twelve engineering departments: Biomedical, Chemical, Civil, Electrical, Energy Planning, Mechanical, Metallurgical and Materials, Nuclear, Ocean, Production, Systems & Computer, and Transport [10].

3.2.4. Undergraduate Nuclear Energy Emphasis at State University of Rio de Janeiro (UERJ)
UERJ offers undergraduate course as part of a curricular option called *Nuclear Energy Emphasis*. Since the nuclear industry seeks for multidisciplinary profile professional, the Nuclear Energy Emphasis aims to form qualified human resources, in area such as: Applied Nuclear Physician; Reactors Nuclear Physician and Reactors Nuclear Engineering [11].

3.2.5. Graduate-Master Program at the Military Engineering Institute (IME)

IME offers graduate-master program since 1969. The Postgraduate Program started its activities in fact on 1958, forming specialized human resources on nuclear engineering. Presently, the program has one areas of concentration with two lines of research: *Nuclear Installation* – Nuclear Reactors and Environmental Control [12].

3.3. In the State of Minas Gerais

Minas Gerais, the third state politically developed in Brazil, has a total of more than 17 millions inhabitants and Belo Horizonte is the capital of the state.

3.3.1. Graduate-Master Program at the Center of Nuclear Technology Development (CDTN)

CDTN is located in the campus of the Federal University of Minas Gerais, Belo Horizonte. It develops materials and equipments for the nuclear sector; and through hydrological evaluations and environmental monitoring, carries out nuclear techniques, and studies on food irradiation. The CDTN postgraduate program on Science and Technology of Radiations, Minerals and Materials, recommended by CAPES on July/2002 and on february/2003 they started its activities. CDTN also provide extension and training courses to meet the needs of the society using its major nuclear science and technology facilities [13].

3.3.2. Graduate-Master Program at the University of Minas Gerais (UFMG)

UFMG offers a graduate-master course on Science and Nuclear Techniques that is organized in three areas of concentration: Nuclear Engineering; Energy Engineering and Radioprotection, Radiation and its Application and Nuclear Instrumentation [14].

3.4. In the State of Pernambuco

The State of Pernambuco is one of the most important states of the northeast region of Brazil. It has the total population estimated in more than 7 millions inhabitants and Recife is the capital of the state.

Located in Recife, the [Regional Center of Nuclear Sciences \(CRCN\) of the CNEN](#) is being constructed in the campus of the Federal University of Pernambuco. The CRCN is a center directed to the development of research and training of professionals who will act to guarantee the safe use of the ionizing radiation. The Center has units of radiological safety metrology of the ionizing radiation, logistic support and training [15].

3.4.1. Postgraduate Program at the Federal University of Pernambuco (UFPE).

The UFPE Postgraduate Program on Energetic and Nuclear Technology was established in 1977, this program offers graduate-master and graduate-doctor which are organized in four areas of concentration: Dosimetry and Instrumentation; Radioisotopes and its Applications; Engineering Reactors and Renewable Energy Sources. Its programme has acquired the grade 5 attributed by CAPES, for the three-annual 1999/2001 [16]. Table V summarizes the nuclear postgraduate programmes in all Brazilian Institutions, within their evaluation level attributed by CAPES² [17].

² CAPES had evaluated the IPEN postgraduate program awarding them with the best grades and ranking, among the best postgraduate courses in the country.

Table V – Post-Graduation Programmes on Nuclear Field In Brazil (Data 2003)

Institutions	City/State/Region	Programme	Level	CAPES Evaluation
IPEN/USP	São Paulo/SP/ Southeast	Nuclear Technology	Master and Doctorate	6
IEN	Rio de Janeiro/RJ/Southeast	Nuclear Engineering	Professional Master	3
IRD	Rio de Janeiro/RJ/Southeast	Radiation Protection and Dosimetry	Master	3
IME	Rio de Janeiro/RJ/Southeast	Nuclear Engineering	Master	3
UFRJ/COPPE	Rio de Janeiro/RJ/Southeast	Nuclear Engineering	Master and Doctorate	6
CDTN	Belo Horizonte/MG/Southeast	Radiation Technology Science	Master	3
UFMG	Belo Horizonte/MG/Southeast	Science and Nuclear Techniques	Master	4
UFPE	Recife/PE/Northeast	Energetic and Nuclear Technology	Master and Doctorate	5

4. Nuclear Training Courses in Brazil

In Brazil, as in other member countries, the value of training is highly regarded. There are not many companies in Brazil that offers training for both new graduates and experienced staff with the aim of increasing the competence of the trainees in their specific function within the organization. For the purpose of this paper let's consider two examples. The first one shows how industries may provide highly qualified employees to meet its specific needs on nuclear area and the second example is based on the recommendation on how the Government should provide support to develop "educational networks or bridges" (as reported by OECD) between universities, industry and research institutes [1].

4.1. NUCLEP Training Center

The NUCLEP industry was founded in December 1975 with the purpose to design and fabricate heavy components to primary circuit of nuclear power plants. It was a strategic decision because Brazil, at the time, had not any company able to perform the task or to act in that advanced industrial sector. NUCLEP's personnel are highly qualified. In order to maintain that high quality level, employees attend specific training programs and permanently upgrade their skills. These factors, combined with on-the-job experience, keep NUCLEP prepared to develop the technical solutions needed to operate at the sophisticated technological level required in both nuclear and conventional components fabrication. This policy resulted in the creation of NUCLEP'S training center in 1980. The center was a pioneer in the qualification of welders, according to international standards, nondestructive test inspectors, levels 1 and 2, for ultrasonic, x-ray, magnetic particles and liquid penetrating. Its training center provides elementary and basic mechanical schooling for apprentices chosen through a selection process opened to the general public. The students become eligible for employment in the factory after successfully completing theoretical and practical disciplines. The two-year course is comprised of social and mechanical disciplines and is approved by the Department of Education of the State of Rio de Janeiro [18].

4.2. Federal Center of Technological Education, in Minas Gerais (CEFET/MG)

CEFET is supported by the Brazilian Government to provide education in different levels, such as: under graduation; technician; post-graduation and extension courses. In the State of Minas Gerais, the CEFET offers professional training course that attracts positive attention of the nuclear industries, providing opportunities for specialists in this area. The professional of technology in radiobiology is an undergraduate specialist who acquire, during the course, knowledge and skills to operate ionizing radiation equipments and to work with diagnosis by images, applied in Radiobiology field of Health, Industries and correlated areas. This specialist may work under supervision and cooperation of professional of engineering, physician or medicine workers [19].

5. The Proactive Work at IPEN-CNEN/SP

The Nuclear Energy Agency (NEA) of the Organization for Economic Co-Operation and Development (OECD) published a complete review on nuclear engineering education in 1999 that covered 16 member countries. In sum the OECD reported that: “In most countries there are now fewer comprehensive, high-quality nuclear technology programmes at universities than before. The ability of universities to attract top-quality students, meet future staffing requirements of the nuclear industry, and conduct needed leading-edge research is becoming seriously compromised”. In other words, the replacement of nuclear staff with high qualification of scientists, engineers and technicians of many disciplines, happens to be on those days, a hard work, but we have to increase understanding of this emerging problem [1].

IPEN started to work proactively aware that it would have to be creative to find ways to encourage young generation to enter nuclear area. Twenty eight years after the inauguration of the postgraduate programme, IPEN conquered a high level standard on education field. In 1998, IPEN had registered the following numbers concerning undergraduate scholarship students, so called in Brazil as “*Iniciação Científica (IC)*”: 224 undergraduate students got government scholarships from the Programme for Undergraduate Students (PIBIC) allocated at IPEN; 45 out of them entered the IPEN postgraduate programme; 17 was awarded with master degrees and 2 with doctor degree. The thesis number one thousand, in 2003, was one of a student from PIBIC. Although this may appears incipient it represents adherence to the nuclear program. Another example of this adherence is the following: the National Award granted by the National Council for Scientific and Technological Development (CNPq) called “Young Scientist”, last year, the second and third places was conquered by two IPEN students, that had developed their researches at the Chemical and Environmental Technology Center of the institute. In 2001, IPEN in accordance with USP, started to offer undergraduate optional disciplines to students interested on nuclear field. A total of 25 disciplines were approved by both Institutions and more than 350 students had attempted classes since then. In 2003, in collaboration with the USP Physics Institute, IPEN started the negotiation to hold a project called: *Programme of Undergraduate Course on Nuclear Science*, willing to form human resources for nuclear sector. IPEN’s expectation is to strengthen nuclear education networks with the Physics Institute of USP, since both institutes have high professional qualification, that could increase emphasis on nuclear and applied physics courses; integrate undergraduate students to several activities between faculty, research and academic topics on nuclear or correlated area. To meet the needs of the Brazilian society IPEN started to provide extension and training courses “*Lato sensu*” using its major nuclear science and technology facilities and expertise. An example of the proactive work using IPEN expertise was the 30 hours training course given to a group of managers and high school pedagogic teachers, in order to supply them with qualified information about nuclear radiological safety.

The role of CNEN for the nuclear education and training are the following: 20 scholarships to be distributed between CNEN Research Institutes for their Programme of Postgraduate Students; 30 scholarships for the Institutional Programme of Undergraduate Students

(PROBIC) in counterpart of the Governmental Programme of Undergraduate Students (PIBIC) that allocates 59 scholarships for its CNEN Research Institutes. CNEN is aware to the importance to foster more and more financial support for its area in order to capture and retain human resources for nuclear sector and, specifically, to replace the ageing and retiring nuclear staff.

The National Council for Scientific and Technological Development (CNPq), foundation linked to the Ministry of Science and Technology (MCT) that supports Brazilian Researches Institutes, allocated for the period of 2004/2006 the total amount of 636 thousands for the Institution Programme of Cooperation, for the development of human resource for its CNEN Institutes, this amount represents the total of 26 scholarships. CNPq also supports the IPEN Postgraduate Programme on Nuclear Technology with the total of 21 scholarships for graduate-master and 36 for graduate-doctor. CAPES, supports Brazilian Research Institutes, allocating for IPEN the total of 32 scholarships, 15 for graduate-master and 17 for graduate-doctor. The State of São Paulo Research Foundation (FAPESP) is one of the main agencies to foster scientific and technological research in the country and it is linked to the Secretariat for Science, Technology, Economic Development and Tourism. Since 1962, FAPESP grants research and fellowship in all areas of knowledge and for IPEN Nuclear Technology Postgraduate Programme in 2003, it was given 24 scholarships, respectively, 06 for master and 18 for graduate-doctors. In summary, IPEN has the total of 42 graduate-master and 71 graduate-doctors scholarships being received by Brazilian and or State Government, but this is not enough since the number of the current demand is far from being attempted. Consequently, students hesitate to enter the nuclear field. Considering the population of Brazil and its complexity and since that in medium and long-term the energy options will be based on nuclear power plants, the strategic role of government is incipient. It should be more concerned in defining technology policy and financial supports in order to reducing the impact in the national and international nuclear scientific community and to enhance technology competitiveness in this area.

6. Conclusion

Those efforts corroborate the need of a co-ordinate work between research institutes and universities to encourage and reduce the negative perception of the younger generation to nuclear area. Those initiatives are still incipient, since weak government support for scholarship, fellowship and traineeships are not enough to signalize for this young generation the future needs in this area. With insufficient budget from government the impact and deterioration of nuclear education in Brazil will be still widespread. The work to be done is to bring the attention of Brazilian Politicians to the importance of the government orientation to long- term future nuclear issues.

In medium and long-term the energy options will be based on nuclear power plants, the strategic role of the government will have to be more effective. It should be more concerned in defining technology policy and financial supports in order to reduce the impact in the national and international nuclear scientific community and to enhance technology competitiveness in this area. Presently, Nuclear Energy in Brazil is responsible for 3% of all power generated by nuclear plants. For the southeast of Brazil this percentage may seems small, but it is important to supply energy for this region with high density population. Nuclear generation will increase its share in the energy matrix, once the Angra II (after 20 years in tests) and Angra III (probably in 2006) power plants start operating, obtaining a share of around 3% of the total [20].

The replacement of nuclear personnel is shrinking is a fact and this problem requires immediate attention of the entire nuclear community (academic communities, government and industry). Considering the jobless problem, the vast area of the country and the population

demand for education, the Brazilian government should implement an integrated nuclear program to form human resources, attract and retain students in nuclear engineering and related specialized fields. Last but not least should be the establishment of a cooperation management between IAEA and CNEN in order to support scholarship for young scientists with a potential to further develop nuclear sciences in Brazil.

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