Human resources development: capabilities and experience of CNEA and its Institutes in Argentina

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Abstract. The aim of this presentation is to describe the current situation of nuclear education and key knowledge preservation in Argentina, particularly in the National Atomic Energy Commission (CNEA). It is also the purpose of this presentation to renew the offer of nuclear education possibilities and capabilities available in our country in the present times of nuclear renaissance and increasing demands of qualified manpower.

1. INTRODUCTION

Nuclear energy's history in the country is marked by some important achievements, including the early introduction of nuclear power generation, self-sufficiency in the fuel cycle, development of medical applications and exportation of nuclear technology.

Fulfillment of these goals has always been based on a long-standing active policy of human resources development, either through "on the job" training activities guided by experienced professionals and sustained on a fellowship programme, or via its own academic institutes for under and post graduate studies.

Nowadays, the perspective for nuclear energy is promising, but for many years nuclear activities had been loosing momentum worldwide. For more then ten years, starting in the ninenties, CNEA had difficulties in incorporating new personnel. Consequently, the institution faced problems related to an ageing staff, the most prominent of these being the peril of loosing key knowledge.

In 2006 the argentinean government re-launched nuclear energy programmes. Funds are being provided for finishing the construction of the third NPP, for a feasibility study of a fourth one, as well as for life extension of the Embalse NPP, and for various projects in the areas of small reactors and fuel cycle.

There is a need to accelerate the development of the nuclear workforce. New, young personnel is being trained and is joining the organization. The number of students and fellowships devoted to nuclear careers was increased; young engineers and technologists are receiving fellowships for training in specific areas, in turn related to the ongoing projects.

This turnover is promoting the introduction of new policies and methodologies of knowledge management and human resources development, including key knowledge identification, sharing and transfer, as well as institutional values and culture diffusion.

2. Nuclear activities in our country

The Argentinean Atomic Energy Commission (Comisión Nacional de Energía Atómica – CNEA) was created in 1950. Since the onset of these activities the country maintained a policy of technological autonomy search in the peaceful uses of nuclear energy.

From the very beginning the decision of introducing nuclear energy generation for the country was taken, and further steps were guided by the idea of using nuclear activities as a catalyst for general industrial development. All the technological decisions taken were merged in the idea of continuous and broad development of knowledge and human resources capacities.

Research reactors and nuclear power plants development and construction became driving forces. The experimental reactors RA-1 and RA-3 were the first "ability tests" for the whole system.

The first nuclear power plant feasibility studies were done locally and the decision was taken on using natural uranium – heavy water technology, in order to attain fuel cycle self sufficiency. Priority was given to participation of local industry, and this resulted in qualitative jump in general industrial procedures, introducing Quality Assurance concepts.

The idea of "technology packages (TP)" was introduced in the NPP construction, and a policy of developing local suppliers of technical goods and services was imposed to the bidders.

As a result, participation of the local industry in the first NPP -Atucha I, a Heavy Water Pressurized Power Reactor (HPWR) of Siemens design, connected to the grid in 1974- was 42%, including not only civil works but also many nuclear components.

This policy was maintained, and led to a local participation of more than 50% in the second NPP, an AECL Candu 600 connected to the grid in 1983. In this case, local participation included engineering as well.

The policy of technological autonomy and local suppliers' development, and the need to reach an operational flexibility unattainable within the public sector, resulted in the promotion by CNEA of the formation of different companies in the nuclear sector. Examples to be mentioned are the technology company INVAP (1976), the fuel elements fabrication society CONUAR (1982), the zircaloy and special alloys company FAESA (1986), ENSI (1989) for engineering services and operation of a heavy water production plant, and DIOXITEK (1997), mainly Uranium dioxide and Co60 supplier, among others.

The creation of these companies was an effective tool for knowledge transfer and for consolidation and preservation of capacities and skills.

They also increased the presence and weight of the nuclear sector in the national economy, giving challenging job opportunities to trained professionals, and opening new opportunities, including the possibility of nuclear exports, difficult task for a government organization.

After three decades of sustained growth, and in accordance with a trend that started in industrialized countries, in the mid 1980´s nuclear activities began to decline in Argentina, due, in this case, to a combination of financial and political reasons. Major projects, such as the construction of a third nuclear power plant (NPP) and a heavy water production plant, were delayed due to lack of funding and political support, and in the case of the third NPP, finally stopped.

In 1994 a new structure was imposed upon the nuclear sector. Two new organizations were created, taking over the operation of NPPs and Nuclear Regulatory activities from CNEA, which even retaining responsibilities on nuclear areas, became actually and for some time mainly a research and development organization.

This rearrangement made CNEA lose a significant amount of its staff and its knowledge, giving rise to a considerable weakening of some relevant areas. For more than a decade and in accordance with a general policy of reducing national government budgets, including wages expenses, CNEA had to cease hiring personnel. As a consequence, its staff became increasingly reduced and aged.

Recently, the whole world became conscious about the consequences of global warming on climate changes, as well as about the risks associated with the dependence of energy mainly on fossil fuels. Nuclear energy became a quite clear option worldwide, and Argentina was not an exception to that trend. The government authorities have recognized the importance of including the nuclear option in the energetic matrix for the country, and have given extra support to the nuclear sector.

The incorporation of new staff to CNEA was reassumed, and new projects were re-launched. In 2006, the federal government announced a new policy in the nuclear field, based on completion of the third NPP, life extension of the Embalse NPP, reopening and operation of an enrichment pilot plant, decision to construct a CAREM reactor, a small fourth generation NPP of local design, and starting the feasibility studies for a fourth NPP. In this context of high demand of qualified workforce, incorporation of new staff attained momentum.

CNEA and its related companies of the nuclear sector are presently active in several fields: operation of two nuclear power plants, construction of a third one, operation of several research reactors and critical facilities, production of Mo-99 from low enrichment targets (having world leadership in that field). Argentina has also exported, in the last twenty-five years, four research reactors (the last one, OPAL in Australia, attained criticality last year), and is active in the fuel cycle (having attained maturity in high-density and very high-density fuel for research reactors, among others), in radioisotope production and in nuclear medicine

In spite of the long-sustained weakening of the national nuclear sector, CNEA never ceased its activities in educational areas, aware of the considerable amount of time required to form a solid professional in the nuclear field, and driven by the conviction that nuclear energy would be essential for the prospective sustainable development of the country.

3. Nuclear education and training experience in CNEA

3.1 An account of Argentinean nuclear education expertise development

When Argentina began its activities on the peaceful uses of atomic energy in 1950, achieving technological autonomy became the strategic objective. This in turn demanded a solid programme of nuclear education for the generation of qualified and creative human resources in fields of little or no previous development in the national universities.

Even though disciplines such as Engineering (mainly civil) and Chemistry were rather strong in the country (the Argentinean Engineers Society – CAI - had been founded in 1895, and the Argentinean Chemical Association – AQA - in 1912), other areas relevant for nuclear activities either had little development in the universities, as was the case with Physics, or none at all, as was the case with Metallurgy.

In order to provide for these necessities, CNEA launched an active programme for human resources development. The key point to its conception, sustained through the years, was to form professionals with a strong scientific and technological background, and not just specialists in the nuclear techniques of the day.

This wise decision was based in the concept that the rapidly evolving field of nuclear technology demanded creative workers with problem-solving skills, backed by their solid formation, which would enable them to keep up with this high rate of changes.

The programme started in the early fifties with courses and schools on reactor physics, metallurgy, radioisotope applications and nuclear physics.

A major milestone was the creation in 1955 of the Physics Institute (nowadays Balseiro Institute, named after its creator and first Director), in a joint venture between CNEA and the National University of Cuyo. Located in Bariloche, in the South-West of the country, it exemplifies the interweavement between the development of and the education in nuclear activities. Not only does it share laboratories with an important CNEA Atomic Center and its faculty consists of active technologists and researchers, but it also supports its full-time students by means of CNEA fellowships.

Simultaneously, and in close contact with the Bariloche Physics Institute, a series of lectures by leading foreign experts at CNEA in 1955 set the foundations of the formation in Metallurgy. A formal framework for this activity was established in 1962, when the first of a series of ten annual Panamerican Courses on Metallurgy, sponsored by the Organization of American States, took place in CNEA at Buenos Aires.

In the mid 1970´s, with one NPP already operating and a second one under construction, the need for Nuclear Engineers began to be felt. A study was made of nuclear engineering careers in Europe and the US, and the School of Nuclear Engineering was created in 1977. Attached to the Balseiro Institute, it was managed jointly by CNEA and the National University of Cuyo under a similar regime of full-time students and fellowships. Once more to provide the students with a solid background was the main concern, coupled with the development of problem-solving skills.

Laboratories and a Research Reactor, RA-6, were built to support the experimental work, with financial assistance from the United Nations Development Program (UNDP). Furthermore, this support made it possible to hire internationally renowned professionals as teachers and,

almost equally important, to consolidate research and development groups which would become, in time, the basis of the School.

As it was planed, Pan-American Courses of metallurgy were moved afterwards to Mexico. In 1974 CNEA organized the Courses on Materials Science and Technology, also opened to attendants from the region within the frame of OAS programmes. This activity, whose annual courses, seminars and colloquia were attended to by hundreds of Argentinean and foreign professionals, attained full university status when the Sabato Institute was founded in 1993, in a joint venture between CNEA and the National University of San Martín.

The formula of full-time students, fellowships, and technologists / researchers as teachers first implemented in the Physics Institute, was also applied This Institute offers undergraduate and graduate studies in Materials Science and Technology, leading to Master and PhD degrees.

Formation in Radiochemistry began in a similar way - with the establishment of some research groups and the first courses on the subject in 1952 -, and rapidly gained momentum: by August 1955, ten new radioisotopes, discovered using CNEA's sincro-ciclotron and identified by first-generation radiochemists, were presented at the first Geneva Conference.

Human resources development in this field continued by means of courses and alliances with different universities, until the recent creation, jointly with the National University of San Martín, of the Institute of Nuclear Studies "Dan Beninson". As well as formation in radiochemistry and nuclear applications, it offers graduate studies in nuclear reactors.

Regarding health applications, CNEA has promoted the activities since the late fifties, dictating courses on dosimetry and in radioisotope applications, that were attended by hundreds of professionals, mainly physicians.

In those years a close collaboration in the area of nuclear medicine began between CNEA and the University of Buenos Aires (UBA). Important centers fully equiped were created, to develop and apply methodologies of diagnosis and treatment: a Nuclear Medicine Center in the UBA's "Hospital de Clinicas" in 1967, and in 1969, an Oncological Center of Nuclear Medicine in the " Instituto de Oncología A.H. Roffo".

In 1991 CNEA, the National University of Cuyo (UNC), and the government of the province of Mendoza, established a school of Nuclear Medicine (FUESMEN), a modern center with the first PET equipment of the country, devoted to research and development in diagnosis and treatment using nuclear techniques.

It offers Post-Graduate studies for physicians on Nuclear Medicine and Radioisotopes, as well as master courses in Medical Physics for physicists and engineers, in collaboration with Balseiro Institute.

Presently, a new center created by CNEA and FUESMEN is about to be opened in Buenos Aires, to give high complexity assistance to oncological, cardiological and neurological cases and promote research and teaching.

3.2 Present capabilities

At present CNEA human assets development is based on:

- **Education in its three Institutes:**

CNEA has three main Institutes fo form physicists, engineers and material science specialists. The three of them were created and based taking into account that the rapidly evolving field of nuclear technology demands creative workers with problem-solving skills, backed by their solid formation.

The Institutes were created in alliance with national universities. It faculty members are CNEA researchers and technologists and the experimental facilities belong to CNEA laboratories and installations, having a remarcable amount of equipment, including research reactors.

Balseiro Institute: located in San Carlos de Bariloche, in the northern Patagonia, offers under and postgraduate studies in nuclear and mechanical engineering, and in various areas of physics, including medical physics, as well as training in technological applications of nuclear energy .

More than 270 nuclear engineers and 50 Ph.Ds. in nuclear engineering have graduated until today, together with an important number of physicists and almost 100 specialists in nuclear applications.

Sabato Institute: located in Buenos Aires, offers undergraduate and postgraduate studies in materials science and engineering, as well as a master degree in non destructive testing.

Around 200 professionals have graduated until now , including 20 Ph.Ds.

Dan Beninson Institute for Nuclear Studies is also located in Buenos Aires and offers one year postgraduate programmes in nuclear reactors and its fuel cycle, and in radiochemistry and nuclear applications. They are mainly aimed to people directly involved in the nuclear field.

The three Institutes also offer a number of courses on dosimetry, radioisotopes applications, radiochemistry, radiological protection, welding, non-destructive testing, etc, aimed to professionals and technicians working in different areas, as well as difusion activities for primary and secondary schools teachers and students.

- **Training on the job.**

The methodology followed by CNEA in order to attain technological autonomy depended both on a strong scientific and technological background and in “learning by doing”.

This last conception naturally gave rise since the early sixties to a fellowship programme to train technicians and undergraduate, doctoral and post-doctoral students by working in CNEA laboratories, under the guidance of a fellowship director.

Fellowships are offered in working areas selected taking into account the relevance of the subject to the main projects, and the availability of adequate direction and facilities. The need of knowledge transfer from experts retiring in the near future is also considered.

More than 200 fellows are yearly being trained in CNEA laboratories, under supervision of staff members. Their main areas of working are: nuclear energy, (which include experimental reactors) in its main areas of neutronics, safety, termahidraulics, instrumentation and control; nuclear fuel development and production ; spent fuel treatment, radioactive wastes, environment; nuclear applications of radiations and radioisotopes, targets and radioisotopes production; uranium prospecting, alternative energy sources mainly solar panels, fuel cells and hydrogen as energy vector, as well as some basic physics, chemistry and biology.

Some of the fellows continue afterwards their career in CNEA and its related companies of the nuclear sector, and others become engaged by the national industry or other research, development and innovation national or international institutions.

4. A wide human resources plan to face the present challenge

The re-launching of a nuclear energy programme in Argentina elicited the planning and implementacion of strategies for human resource development. The need of such strategies is an internationally well known problem affecting the nuclear industry, which has been analyzed in many publications [1-7].

In the face of the current situation, it is on CNEA's advantage the fact of having preserved its human resources development activities during the "grey years".

As in many other countries, the main concerns regarding nuclear human resources are:

- Loss of critical knowledge peril.
- Need to identify key experts and present-future knowledge gaps.
- Capture of knowledge from leaving professionals, in particular from "critical experts" that are about to retire
- Share and transfer of relevant knowledge.
- Rescue of organizational culture and values, and institutional history.

In view of the facts, a concentrated effort of human assets development is under way, to sustain the nuclear workforce for existing and future installations and for developing new designs, based on:

- Review of the present situation regarding available human resources, their fields of expertise and their retirement plans.
- Identification of key knowledge areas, at present times and in the mid term, in face of the main programmes and projects.
- Identification of both active and retired people that could help in transferring the accumulated knowledge to the newcomers.
- Identification of knowledge gaps or bottlenecks, also in the frame of the new projects.
- Study of an incentives plan for people willing to move to main nuclear programmes and projects

Actual actions under way are:

Via the institutes:

1. The number of students and fellowships in nuclear engineering, nuclear reactors and radiochemistry is being doubled
2. e-learning has started with a long distance course for improving college knowledge in physics, calculus and chemistry of candidates to the Balseiro Institute coming from different universities
3. An Argentinean network on nuclear education (RAEN) is being developed, connecting the Balseiro, Sabato and Beninson Institutes, and the Mendoza School of Nuclear Medicine, to coordinate its activities and get the most efficient results

At the labs:

1. The number of fellowships for "training on the job" activities is being increased in critical areas,
2. Priority is assigned to critical knowledge maintenance, both for recruiting new staff and for fellowships working subjects.
3. Review of the general situation regarding critical knowledge and human resources needs is underway, developing the data bases required for a complete analysis.
4. Preparation of contents for a "general formation" course for recently engaged young professionals and fellows is under way, covering mainly radiological and nuclear safety basic knowledge and general institutional knowledge (organization, procedures, main projects, main achievements, etc.)
5. Reports describing the history of selected technological achivements are being prepared, in connection with proffesional historians and social scientists.

To reinforce this program, some other actions aimed at capturing and transferring the mentiond critical knowledge are under study:

- Grupal tutorship system, with critical experts becoming tutors of the new staff, coordinating the training and transferring their knowledge and lessons learned.
- Review reports on relevant subjects, covering the international knowledge, CNEA experience, lessons learned and recommendations not only on what to do and why, but also on "what not to do, and why" prepared by recognized national experts retired or close to the retirement.

5. International projection of CNEA human resources development activities: experience and the future

Since its very beginning, CNEA´s efforts in education have been opened to nationals from other countries, mainly from the Latin American region.

About 60 foreign students have graduated from CNEA Institutes, while hundreds have assisted to topical courses, seminars and training on the job stays, using CNEA's financial support, or aided by bilateral agreements or by International Agencies, as the OAS or United Nations via UNDP. As an example, in the period 1999-2006 the country has received more than 280 foreign fellows and scientific visitors under IAEA Technical Cooperation programmes, almost 130 of them in CNEA working groups .

A particular case worthwhile to be mentioned has been the training of staff related to exports of nuclear technology as research reactors, radioisotopes production plants, fuel fabrication plants, etc. to Peru, Algeria, Egypt, Australia, etc., where, through "learning by doing" stays of dozens of professionals from those countries at CNEA laboratories.

International opening of CNEA capabilities in the field of nuclear education has contributed to sharing and transferring nuclear knowledge; lessons learned from the experience, if shared, may contribute to formulate international strategies for human resource development for the nuclear industry.

At present, Argentina has significant means to provide the qualified personnel necessary for the growth of nuclear activities in the country, with capacities and equipment that can be offered to international projects on nuclear education. Based on its 50-year experience on international cooperation in this field, CNEA is willing to contribute to the worldwide effort in developing human resources for the nuclear future.

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