NUCLEAR FUEL SUPPLY VIEW IN ARGENTINA

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ABSTRAC

The Argentine Atomic Energy Commission promoted and participated in a unique achievement in the R & D system in Argentina: the integration of science technology and production based on a central core of knowledge for the control and management of the nuclear fuel cycle technology.

CONUAR SA, as a fuel manufacturer, FAE SA, the manufacturer of Zircaloy tubes, CNEA and now DIOXITEC SA producer of Uranium Dioxide, have been supply, in the last ten years, the amount of products required for about 1300 Tn of equivalent U content in fuels.

The most promising changes for the fuel cycle economy is the Slight Enriched Uranium project which begun in Atucha I reactor. In 1997 seventy five fuel assemblies, equivalent to 900 Candu fuel bundles, will complete its irradiation.

1.THE NUCLEAR FUEL CYCLE INDUSTRY IN ARGENTINA

The decision for the erection of Atucha I, the first Nuclear Power Plant in Argentina, a 340 MWe Siemens PHWR, in 1967, generate the born of a nuclear industry in Argentina. It grows slowly with the construction of Embalse CANDU-600 and consolidated with the government decision, in 1979, for the construction of 4 PHWR of 600 MWe before the end of the century.

Two facts has to be mentioned as a result of the establishment of a nuclear industry in Argentina. The metal-mechanical industry did a qualitative jump in production quality and introduced new technologies by own development or by transfer from abroad. This facts support at the beginning of 90's the projection of the Argentine Manufacturers to the international market with high quality conventional products.

The core of the nuclear fuel cycle industry in Argentina was the Atomic Energy Commission (CNEA) which played a main roll as a promotion agency and as a main participant in Engineering, Process developments and manufacturing, within a scheme and policy that give as a results a unique achievement in the R & D system in Argentina: the integration of science-technology and production based on a central core of knowledge for the control and management of the nuclear technology.

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The Atomic Energy Commission assumed the commitment for the production and self sufficiency, by it self or by associated enterprise, of the goods and services of the nuclear fuel cycle. The production and sales of radioisotopes for medicine and industry were also one of it most important achievement. At the same time CNEAs promote the transfer of technology toward private enterprise in Argentina for intermediate and main components for NPP. The investment was timely made and was moderated according to the steps the country did.

This plan failed because the endless process of construction of Atucha II (Siemens PHWR), the first unit of the series, the lack of decision for the fourth NPP, a growing and spurious antinuclear feeling, never well dimensioned and the new electric regulatory market introduced in 1990.

A Nuclear Technology Company, INVAP SE was born in 1976, as a joint venture between CNEA and the Provincial Government of Rio Negro.

INVAP SE was responsible for the development of the Uranium Enrichment Technology and Zirconium Sponge. Participate actively in the domestic development of Zircaloy tubes Technology and Candu Fuel Technology developments and construction of production machinery. These projects are examples of own developments that went to production scale. Several machines developed by INVAP SE for this industry were later exported.

A main achievement of INVAP, was the export projects. Out of them are remarkable the NUR Reactor built in Algeria for research purposes and the MPR a Radioisotope Production Reactor of 22 MWth, close to be commissioned, build in El Cairo, Egypt for the AEA. Also, as a main contractor of CNEA, this Nuclear Technology Company developed an inherent safe small power reactor named CAREM. A prototype of 25 MWe will be install in the country starting its construction next year.

INVAP SE developed and installed the facilities for the dry storage of irradiated CANDU fuel in the NPP located at Embalse, Córdoba Province.

Two additional companies of this type were establish:

• Nuclear Mendoza SE, belonging to CNEA and the Government of Mendoza Province. The aim of this company was the Engineering and eventual operation of Chemical plants for Uranium refining and conversion. Due to business policy this company is near its extinction.

• Engineering and Services Neuquen Company (ENSI SE), a joint company between CNEA and the Government of Neuquen Province, were build for the engineering and operation of the Heavy Water Industrial Plant (PIAP). The final installation of this Plant of 200 TN per year of production, the commissioning and the initial operation until the production of the first 50 TN of Heavy Water was the main achievement of the Company. At the present time a contract for the replacement of 600 TN of heavy water rented to Canada for Embalse NPP is underway.

A fuel manufacturing company, CONUAR SA, was founded in 1981. This stock company belongs 67 % to private capital (Pecom Nuclear SA) and 33 % to CNEA.

Its main objective is the supply of nuclear fuel for the Argentine NPPs. It is located in Ezeiza, Buenos Aires Province and up to date has produce 4000 Fuel Assemblies of 6 meters long for Atucha I PHWR and more than 35.000 bundles for Embalse NPP. The production line for Atucha II Fuel is also ready for the contract of the first core. Provisions are in progress for the production of CAREM slight enriched PWR fuel. Additionally it have participated in services for the NPPs.

A company named FAE SA (Especial Alloys Manufacturing) was establish in 1985 between CONUAR SA (68 %) and CNEA (32 %) for the production of Zircaloy. FAE SA has already manufactured more than 2500 kilometers of tubes for the argentine's NPPs and is able to manufacture Zircaloy tubes for PWRs, titanium tubes for condensers and stainless steel tubes for the conventional industry.

At the end of 1994 an important change has occurred in the organization of nuclear energy in Argentina. The previous and new organizations are shown in Figure 1 and 2. The government made the decision to privatize the construction and operation of NPPs, and as a results of the reorganization of the Atomic Energy Commission (CNEA) also the front end of the nuclear fuel cycle.

A new company called Nucleoelectrica SA (NA SA), belonging 100 % to the Economic Ministry - which will be privatized in the near future - taken over the responsibilities for the finishing of Atucha II NPP, which is at 85 % of stage of construction, and the operation of Atucha I, a Pressure Vessel Natural Uranium-Heavy Water Reactor of 340 MWe in operation since 1974 and Embalse NPP, a CANDU-600 Reactor in operation since 1984.

The regulatory activities were transferred to a new governmental Regulatory Organization, called Ente Nacional Regulador Nuclear (ENREN) - now ARN (Autoridad Regulatoria Nuclear) - while CNEA remain as responsible for the Research and Development and waste management.

At the beginning of 1997 a new Company named DIOXITEC SA was created for the production of Uranium Dioxide at the present in the Plant of CNEA located in Córdoba City. This Company belongs 99 % to CNEA and 1 % to Nuclear Mendoza SE. It will be privatize in the near future.

A law No.24804, named Ley Nacional de la Actividad Nuclear (National Law for the Nuclear Activities), was approved in April this year, which regulate de Atomic Energy Commission (CNEA) activities and the one reserved for the Nuclear Regulatory Authority (ARN).

2. DOMESTIC PHWR FUEL SUPPLY AND PERFORMANCE

The amount and performance of domestic manufactured and foreign supplied fuel is shown in Table 1 and 2.

The impact on mass production of domestic developed manufacturing technology for CANDU fuel [1] and production learning factor of the company, which taken over the production line without any external assistance, explain the difference in the failure rate compared to Canadian manufactured fuel. However, the failure rates of domestic manufactured fuel are quite similar to the figures of fuel supplied in Canada in the intermediate stage of the technology.

A long term contract between CONUAR SA and Nucleoeléctrica Argentina SA support the continuity of the local fuel production and focused the activities of fuel manufacturer. However, the future competitiveness of nuclear power plant, required a strong effort in reducing fuel prices and increasing its operational flexibility and reliability.

In a similar situation is placed DIOXITEC SA which have to face a resiting of the plant because the urban location of the present Plant, an optimization of the final price of U/UO_2 and a possible change of the method of production

To this end we are facing a review of the fuel design, a renewal of production lines introducing updated production technology and we made an important organizational re-engineering including administrative services and procurement.

Fifteen years of production and domestic fuel performance experience allow us to review the design of fuel and manufacturing processes and equipment, in order to improve reactor operational flexibility, fuel cycle economy and fuel reliability.

The most promising changes for the fuel cycle economy is the Slight Enriched Uranium (SEU) project which begun in our Atucha I reactor in January 1995 [2] [4]. To day more than 15 fuel assemblies out of 253 in the core were discharge with an excellent performance [3]. During 1997, 60 fuel assembly , equivalent to 720 Candu fuel bundles, will be irradiated.

The SEU fuel with an enrichment of .85 % in U-235 will reach a burnup of 11.5 Mwd/kg U with maximum linear power ranging the 500 W/cm. The main advantages from the use of SEU in Atucha I core are the extension of fuel discharge burnup, reduction of the spent fuel volume, reduction in the total fuel cost and reduction in the frequency of on power refuelling [5].

The benefit of this programme for Embalse (CANDU-600) NPP is under evaluation.

3. RESEARCH AND DEVELOPMENT ACTIVITIES

Basically CNEA has developed the tools for design analysis and a data bank throughout its own fuel performance evaluation and experimental irradiations.

CNEA has developed the BACO code for the simulation of a fuel rod behavior under irradiation [6]. The domain of use is for PHWR, but may be extended for particular applications due to its flexibility. It has been used for simulating PWR, CANDU, and experimental fuel rods. The new version was developed in connection with the IAEA's Coordinate Research Project FUMEX (Fuel Modeling at Extended Burnup). A blind-test consisting of a set of experiments in order to compare fuel performance with code predictions included PIE analysis. The final burnup reached for the fuels were intermediate (25 MWd/kgU) and high (50 MWd/kgU). BACO code obtain a reasonable good performance with the FUMEX exercises, specially at intermediate burnup and low power.

Irradiation of fuel rods manufactured in Argentina begun in 1974 in the MzfR Reactor of Karlsruhe, Germany, a prototype for the Atucha I NPP.

Following this two fuel assemblies of Atucha I was irradiated in the Power Reactor.

A series of Candu elements were irradiated in the NRU in 1980. In 1984 more than 2000 bundles were irradiated for qualification in the Embalse Reactor before the massive production in CONUAR begun.

In 1986 Argentine MOX fuel started its irradiation in Petten Reactor. Six pins were manufactured in a Pu facility at CNEA. Those rods has been used for destructive pre irradiation analysis, as a pathfinder to adjust systems in the experimental Reactor and two rods include iodine doped pellets, to simulate a burnup of 15000 MWd/ton(M). The power histories were defined with the BACO code [7].

All this irradiations were followed by extensive post irradiation examinations or under water examinations.

The follow up of the irradiations parameters in power reactors and fuel performance evaluation as well as hot cell inspection are the support of the advance fuel program we are facing for the present two power stations in operation and the third in construction [8].

The main effort on advance conceptual re-design of fuel for Argentine's Reactors is the CARA Project which basically evaluated the impact on the reactor economy and fuel reliability of a 61 fuel rod assembly. In a first stage an homogeneous SEU enrichment, low linear power rating, advanced pellet design, similar hydraulic pressure drop and better Critical Heat Flux are the conditions for a low cost-high reliability fuel assembly. The main goal of this project is to keep the cost of fuel cycle, mainly for Atucha I and II NPP, as lower as possible in relation to the gas fueled Power Station, with a common production line for all NPP's fuel.

A moderate effort is been foreseen in relation with advance reactors fuel.

Low Void Coefficient Fuel is under evaluation in connection with the SEU fuel Project [9], using an appropriated combination of enrichment and absorber in the cell.

We have also begun a Project on actinides transmutation.

4. CONCLUSIONS

The new organization of the nuclear activities in Argentina impose a challenging effort in the particular responsibilities of the participants. A reduction in operation and maintenance cost of NPP, a reduction in fuel prices and increased fuel reliability for the fuel suppliers and a set of creative projects for the improvement of the present technologies and the development of the basis for the future reactor generation for CNEA.

Fuel performance of domestic supplied fuel in Argentina is aceptable for PHWR international level and is been improved throughout the introduction of updated manufacturing technology and control.

Today most important Project for the Argentine PHWR is the Slightly Enriched Uranium (SEU) Fuel Project in progress in the Atucha I Reactor.

A moderated effort is foreseen in advance reactors fuel. Mainly in CARA fuel to compete with gas fueled PP, in low void coefficient fuel and in actinides transmutation fuel.

5.REFERENCES

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C N E A

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Figure 1. Organization of Nuclear Asctivities in Argentina until the end of 1994.

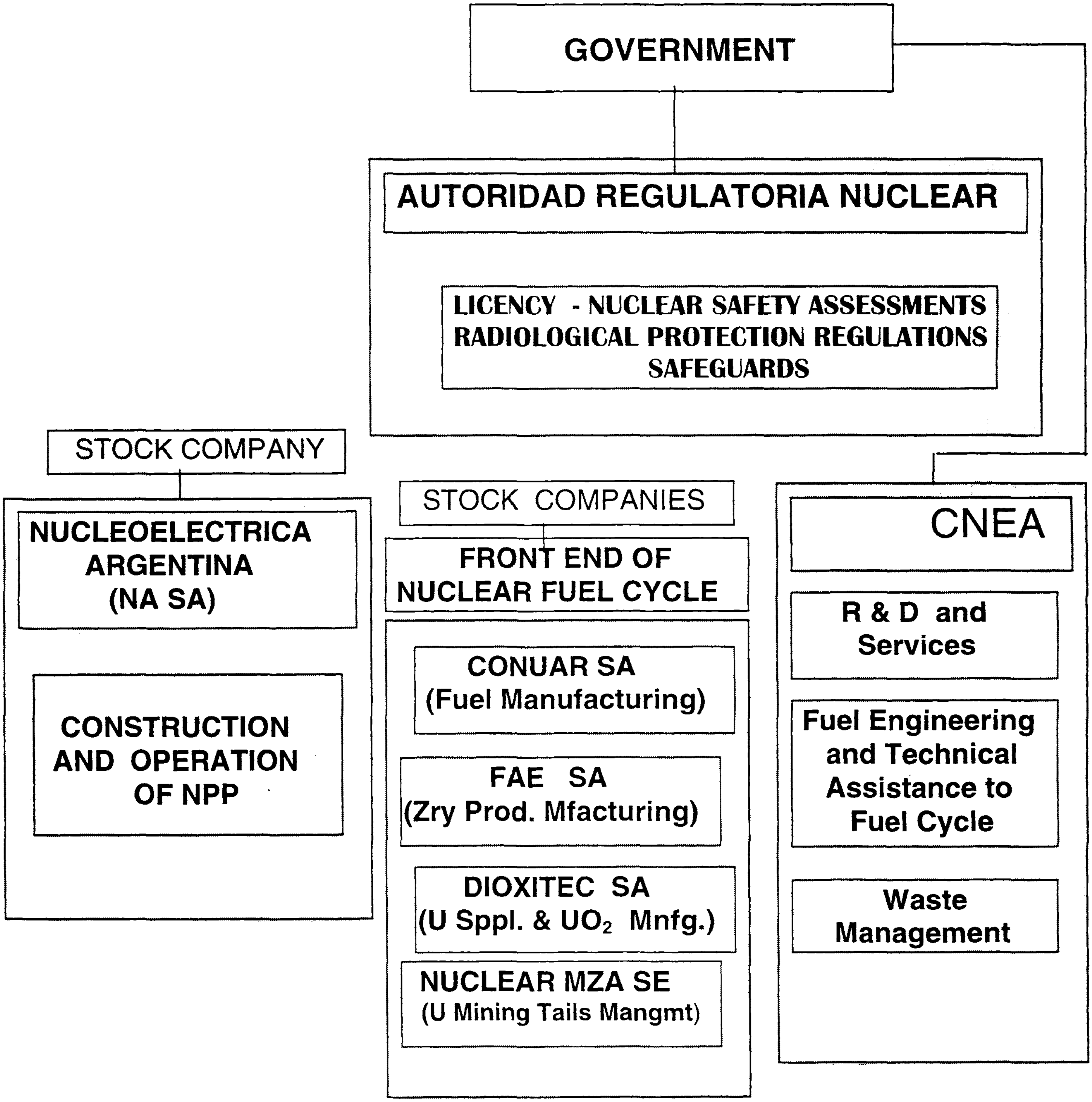

Figure 2. Organization of Nuclear Activities in Argentina since 1995.

SUPPLIER	RBU SIEMENS 1974 1983		C N E A 1978 1981		C ONU AR SA 1982 1996		TOT AL	
	QTY	%	QTY	%	QTY	%	QTY	%
IRRADIATED FUEL ASSEMBLIES	3314	45.4	240	3.3	3755	51.3	7309	100
MANUFACTURED FAILURES FUEL ASSEMBLIES	(1) 19	0.57	(2) 2	0.83	(3) 20	0.53	41	0.56

Main Cause s of Failures: (1) Hydriding, cladding flaws
(2) Unknown (pilot domestic manufacturing)
(3) Cladding, flaws, hydriding, poor endcap welding

Tabla 1. Amount of fuel supplied and fuel performance in Atucha I PHWR

SUPPLIER	CANADIAN SUPPLIERS 1984 1996		C N E A 1986 1988		CON UAR 1988 1996		TOT AL	
	QTY	%	QTY	%	QTY	%	QTY	%
IRRADIATED FUEL BUNDLES	16650	32.6	2100	4.1	32317	63.3	51067	100
MANUFACTURING FAILURES FUEL BUNDLES	(1) 15	.09	(2) 55	2.6	(3) 60	.18	75	.14

Main Cause s of Failures:
(1) Cladding flaws, poor endcap welding
(2) Poor endcap welding, hydriding (Pilot domestic manufacturing)
(3) Endcap porosity, hydriding, poor endcap welding

TABLA 2. Amount of fuel supplied and performance in Embalse HWR