Spent Fuel Management of NPPs in Argentina

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Presentado en: IAEA & OECD/NEA International Conference on Management of Spent Fuel from Nuclear Power Reactors.
Viena, Austria, 31 de mayo al 4 de junio de 2010

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Abstract

There are two Nuclear Power Plants in operation in Argentina: "Atucha I" (unique PHWR design) in operation since 1974, and "Embalse" (typical CANDU reactor) which started operation in 1984. Both NPPs are operated by "Nucleoeléctrica Argentina S.A" which is responsible for the management and interim storage of spent fuel till the end of the operative life of the plants. A third NPP, "Atucha II" is under construction, with a similar design of Atucha I. The legislative framework establishes that after final shutdown of a NPP the spent fuel will be transferred to the "National Atomic Energy Commission", which is also responsible for the decommissioning of the Plants. In Atucha I, the spent fuel is stored underwater, until another option is implemented meanwhile in Embalse the spent fuel is stored during six years in pools and then it is moved to a dry storage. A decision about the fuel cycle back-end strategy will be taken before year 2030.

1. Introduction

The uses and applications of nuclear energy have begun in Argentina in 1950, the year that the National Atomic Energy Commission (CNEA) has been created.

Since that time a very wide variety of activities were performed in the nuclear field by private and public entities. The radioactive waste generated is managed accordingly to the legal and national regulatory provisions in force, in agreement with the obligations derived from the "Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management".

The legal framework applicable to radioactive waste and spent fuel management, integrates with the provisions of the National Constitution and with the legislation adopted by the National Congress by Act Nº 24804 (1997) which regulates the Nuclear Activity and Act Nº 25018 (1998) which determines the Radioactive Waste Management Regime [1]. The National Act of Nuclear Activity assigns to CNEA the state ownership of spent fuel and the responsibility for the management of radioactive wastes, thus becoming the *Responsible Organization*. The same Act sets forth that CNEA shall take full responsibility for the decommissioning of nuclear power plants and any other significant facility.

In 1994 National Nuclear Regulator Body (ENREN) was created and in 1997, it was changed to Nuclear Regulatory Authority (ARN) by National Act 24804. ARN is empowered to regulate and supervise the nuclear activity in all matters related to radiological and nuclear safety, physical protection and safeguards. Likewise, it authorizes to ARN to supervise the use of nuclear materials, the licensing of persons and facilities and the verification of safeguards treated.

National Act Nº 25018 proposes the National Radioactive Waste Management Program (PNGRR) and CNEA as the responsible for the compliance with a specific *Strategic*

Plan for Radioactive Waste Management. This *Strategic Plan,* updated in 2006, outlines the commitments that the National Government must assume for the safety of Spent Fuel Management and Radioactive Waste Management, ensuring public health, the protection of the environment and the rights of future generations.

There are two Nuclear Power Plants in operation in Argentina, supplying about 8% of the national electricity production: "Atucha I" NPP (a unique PHWR design), and "Embalse" NPP (a typical CANDU 6). Both NPP are operated, since 1994, by Nucleoeléctrica Argentina S.A (NA-SA) which is the *Primary Responsible* for the management and interim storage of spent fuel till the end of the operative life of the plants. A third NPP "Atucha II", with a similar design of Atucha I, is under construction.

Government of Argentina exercises state ownership of special radioactive fission material contained in spent fuel from any origin: nuclear power plants and experimental, research and/or production reactors (Article 32, Act Nº 24804). Spent fuel is not considered radioactive waste and the resprocessing possibility remains open [1,2]. In that sense, according to the *Strategic Plan*, the decision for reprocessing spent fuel will be adopted before 2030. At such time the installation of an underground geological laboratory must have been started, which allows the design and construction of a deep geological repository, which must be operative by the year 2060. Meanwhile, the spent fuel generated by the two PHWR in Argentina is being stored in wet and dry interim storages. At the moment of decommissioning, an appropriate transfer of Responsible Entity will be needed and before that a decommissioning license should be required by CNEA.

2. Atucha I Nuclear Power Plant

Atucha I NPP (CNA I) is a 357 MWe PHWR of German origin which is in operation since 1974. It has started to operate with natural uranium fuel but from 1995 to 2000 the fresh fuel in the core was gradually modified from natural to slightly enriched uranium (0.85 % nominal). This modification allows to increase the average burn up almost in a factor of 2 (11300 MWd/tU) [4], reducing the frequency of refueling at full power from 1.29 to 0.72 fuel element per day and, subsequently, reducing significantly the number of spent fuel assemblies generated by year.

Atucha I fuel element (fig. 1) is composed by 36 bars (plus a structural bar) with an active length of 5323 mm and a total length of 5566.4 mm. Each bar contains about 400 UO_2 pellets cladding in a zircaloy-4 alloy tube with an external diameter of 13.82 mm and 0.5 mm thick. The fuel assembly (153.5 kg of U) is very slender, with a total length of 6028.5 mm, an external diameter of 107.8 mm and a weight of approximately 200 kg. The total number of fuel elements in the reactor core is 252.

The data of each fuel element are introduced in an online computational program which allows to know the history and location of each fuel element from the fresh fuel storage to its disposal location in the pool. The same software also calculates the burn up, the production and isotopic composition of U and the fission product inventory, based on the time of residence, the position of the fuel assembly inside the reactor core and the cooling time. This program is used as well for safeguards purposes, inter alias to obtain the mapping of the pools and to generate the itemized list of the spent fuel elements, which includes, for each fuel assembly, its uranium and plutonium masses.

The average nuclear production is 0.51 kg of Pu per spent fuel assembly in the case of natural uranium fresh fuel and 0.70 kg of Pu per spent fuel assembly in the case of 0.85% uranium fresh fuel. The inventory to the end of 2007 was about 8000 spent fuel assemblies for them with natural uranium and 1500 spent fuel for slightly enriched uranium, it means approximately 5 tons of Pu [1].

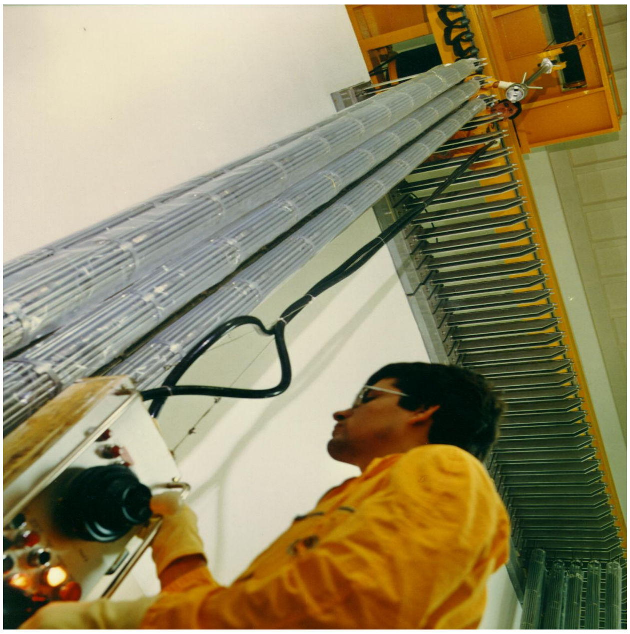

fig.1

Spent fuel is stored temporarily under water. The Plant has two Pool Buildings, House I with two decay pools, and House II, with four decay pools, where the spent fuel is stored underwater hanging vertically in stainless steel racks, in a double layer arrangement. There is only one transfer channel between the reactor building and the maneuvering pools of the two houses. The pools are 17 m deep and the walls are made of concrete with 2 mm thick stainless steel lining meanwhile the floor, also made of concrete, has a 3 mm thick stainless steel lining.

The Pool Building with two storage pools is completed full with 3240 fuel elements. The initial capacity of the other Building (fig. 2) was 6944 positions but a re-racking program was performed for a more compact arrangement between fuel assemblies in the pools [4], increasing the storing capacity of fuel elements to 8304 positions. This task implied some changes in the storage bracket-suspension beam and the relocation of about 5000 spent fuel elements

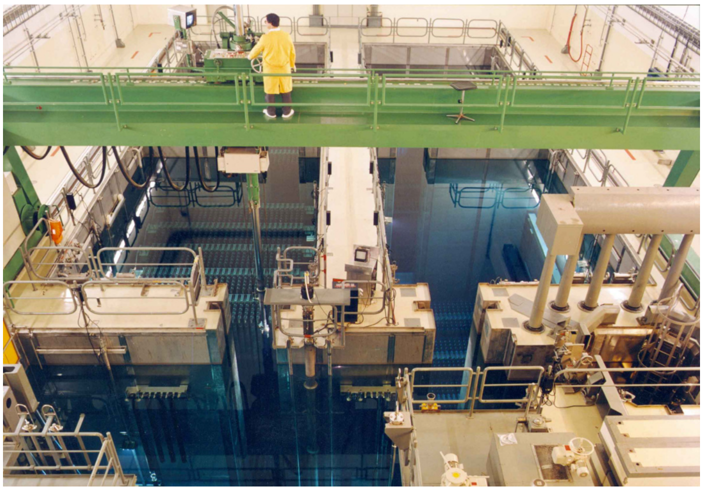

fig. 2

Considering a load factor of 85%, the arrangement will satisfy the storage demand up to 2015 but the end of the operative life of the Plant would be reached in 2017. It means that the storage capacity should be increased at least in about 600 positions to cover the demand. From then on everything indicates that the implementation of a dry storage seems to be the best solution to create additional capacity for storing the spent fuel either in the case of extension of life or to transfer all the spent fuel out of the NPP in the case of decommission [3,5]. In the meantime, according to the short time available, a simplified dry storage conceptual design is being considered. It consists of underground vertical silos placed in a new building annexed to House I building, where the oldest fuel elements would be moved from the Pools. This design guarantees that the fuel elements do not need to be moved out of the controlled area and it would allow the operation at least until the end of life time of the Plant [6].

In the case of **Atucha II Nuclear Power Plant (CNA II),** with a similar design of CNA I (692 MWe), which is planning to start to operate during next year, the spent fuel will be transfer to pools (fig. 3), with a storing capacity equivalent to ten years of normal operation, till a dry storage alternative will be defined.

fig. 3

3. Embalse Nuclear Power Plant

The Reactor of Embalse NPP (CNE) is a typical CANDU 6 (648 MWe) on load PHWR that is in operation in Argentina since 1984. The fuel bundles (fig. 4) are composed by 37 bars of 495.3 mm length. Each bar, containing 38 UO_2 pellets (natural uranium), is cladding in a zircaloy-4 alloy tube with an external diameter of 13.08 mm and 0.419 mm thick. The fuel assembly has an external diameter of 102.74 mm and the weight of the UO_2 contained is about 21.5 kg. The reactor core or “calandria” has 380 horizontal pressure channels with a capacity of 4560 fuel bundles (12 per channel).

fig. 4

The frequency of refueling at full power is 15.2 fuel bundles per day and the maximum burn up is 7800 MWd/tU. The nuclear production is approximately 68 grams of Pu per spent fuel bundle. The inventory (wet and dry storage) at the end of 2007 was about 112000 spent fuel bundles containing approximately 7.6 tons of Pu [1].

After leaving the core, the spent fuel bundles are transferred underwater to the reception bay with capacity for 4800 bundles. They are disposed horizontally on trays of a double array of 12 bundles each one. The trays are later transfer to the storage bay (fig. 5) and stocked in piles with up to 19 trays. There is a third little bay for defective fuels, with a storage capacity of 300 bundles. All the pools are made of concrete with epoxy resin lining. The main bay has capacity to store 45144 spent fuel bundles, equivalent approximately to the quantity generated during 10 years at maximum power.

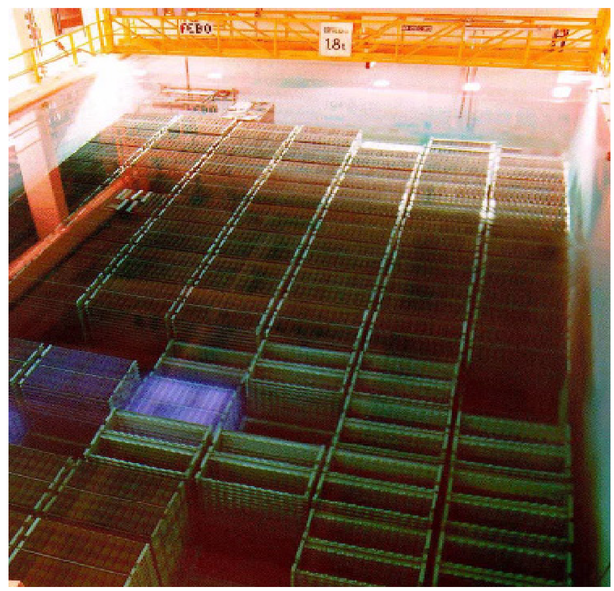

fig.5

A dry storage alternative was implemented in 1993 to cope with the spent fuel storage demand up to the end of the operative life of CNE. The spent fuel bundles must remain at least 6 years in the wet storage for thermal cooling and radioactive decay after being transfer to the dry storage.

The dry storage is a modular array of concrete “silos” (fig. 6), also called “canisters”, arranged in a yard at the power station site. Inside each full loaded canister nine steel sealed baskets are piled, each one with 60 bundles. The baskets are loaded under water and then removed from the pool inside a shielded transfer cask. After living the pool, the cask is drained and introduced in the operational cell where it is sealed by welding [7,8].

fig. 6

A second cask named the “transfer shielding” is used to transfer the sealed basket from the operational cell to the canisters. The canisters yard is inside the double fence which surrounded the NPP for security protection.

The canisters are 6.3 m high vertical cylinders, with approximately 3 m of external diameter [8]. They are cooled by natural convection and were designed to support some accidental events as earthquakes, floods, tornadoes and the risk of explosions. The system provides three barriers of protection to avoid the release of radioactive material to the environment (fuel rod shield, steel basket and the canister). It is completely independent of the power station systems and not requires especial activities of maintenance when the canisters are filled and sealed. At present there are 216 silos in CNE and 152 of them are full loaded.

CNE was designed with a 30 years nominal life at an average Load Factor (LF) of 80%. Due to its very good performance (LF=88% in the last 10 years), the end of the Plant operative life will be reached before the 30 years design life and it is estimated to be in 2011. A project for a refurbishment (life extension) is under development. This does not represent a problem regarding the spent fuel storage capacity because the modular design of the dry storage allows to be enlarged, with no fulfillment of special requirements, by the construction of a new battery of canisters when needed.

4. Conclusions

A decision about the fuel cycle back-end strategy will be taken before 2030. Meanwhile, the spent fuel in each Nuclear Plant is temporarily storage on site. In Atucha I, the spent fuel is being storage in pools but a dry storage design is under development. Embalse counts with a dry storage since 1993; the spent fuel, after certain period of time kept in wet storage, is transferred to dry storage silos. Enlargement of the spent fuel interim storage capacity at CNE is made easily through the construction of new modules of dry storage silos. The management of the spent fuel is a responsibility of the operator (NA-SA) during the operation life of the Plants. At the time of decommissioning, the responsibility will be of the Responsible Organization (CNEA). A reasonable time before that moment both Entities must come to make the appropriate transfer agreements as well as CNEA should start the decommissioning license procedure.

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