3rd International Seminar on Spent Fuel Storage

IAEA
International Atomic Energy Agency

Spent Fuel Management of NPPs in Argentina: Conceptual Design of the future Atucha I Dry Storage

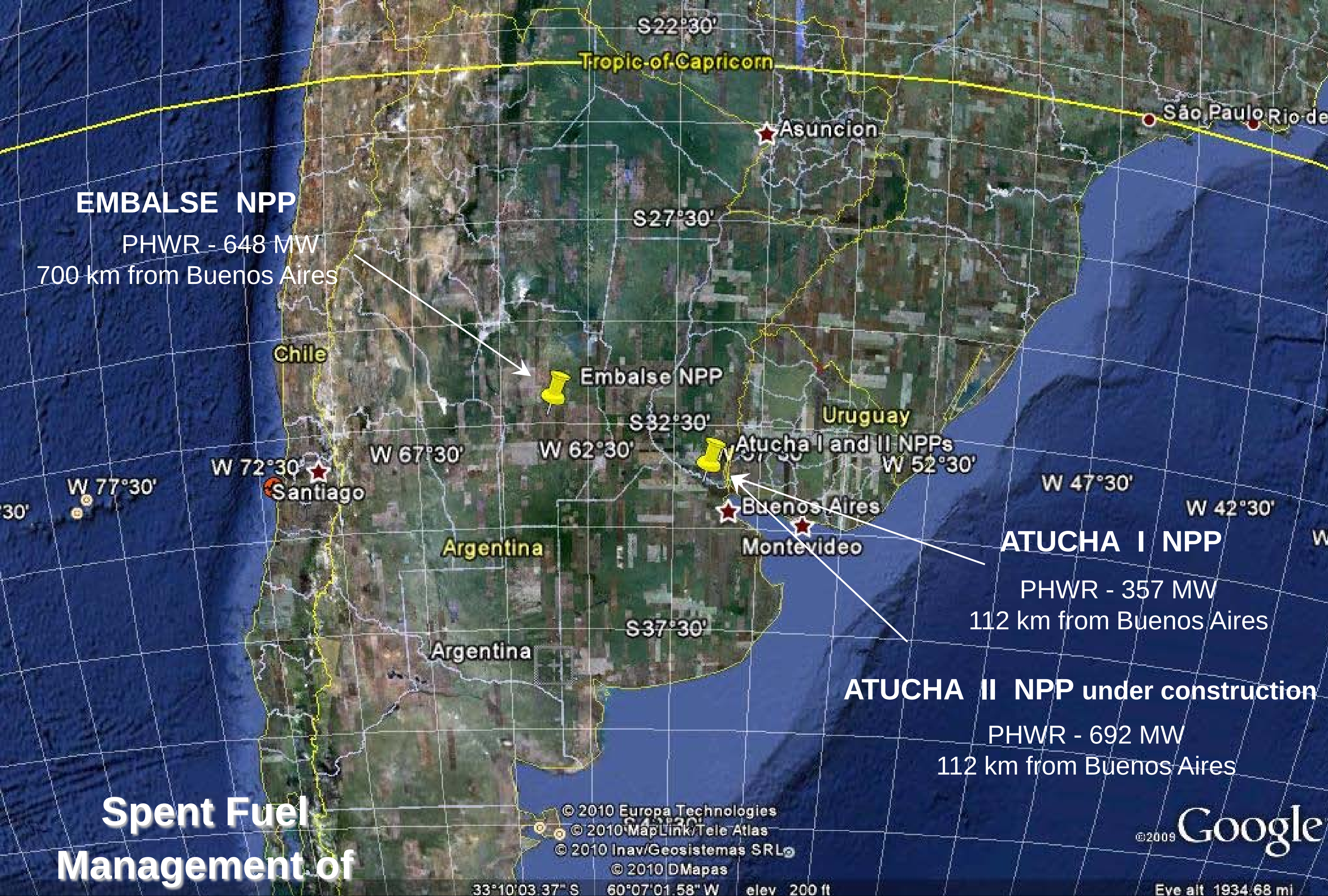
G. Moliterno, O. Beuter, J. M. Frediani, S. Zanni, J. P. Oyola

Oral presentation: P. Vizcaíno

CONICET

NUCLEOELECTRICA ARGENTINA S.A.

CNEA

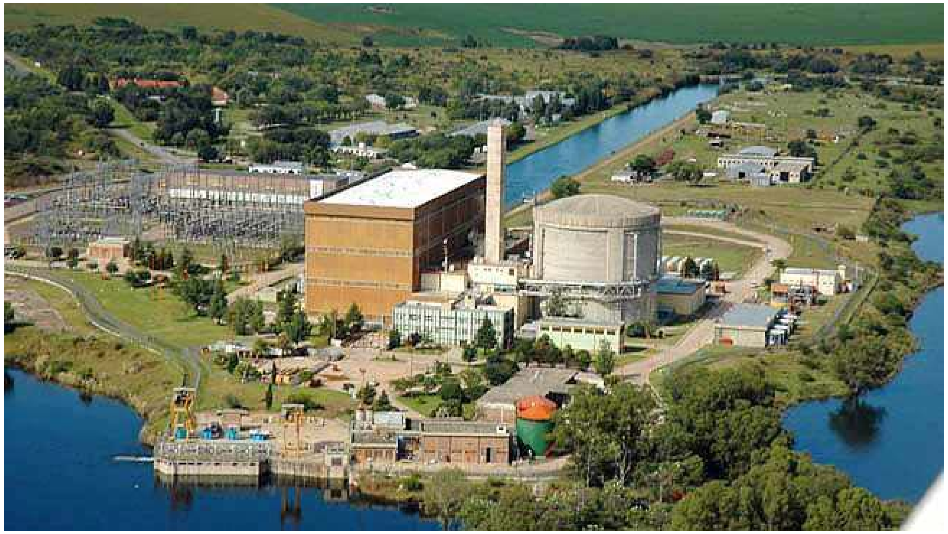


Spent Fuel Management of NPPs in Argentina

Geographical localization

Embalse NPP

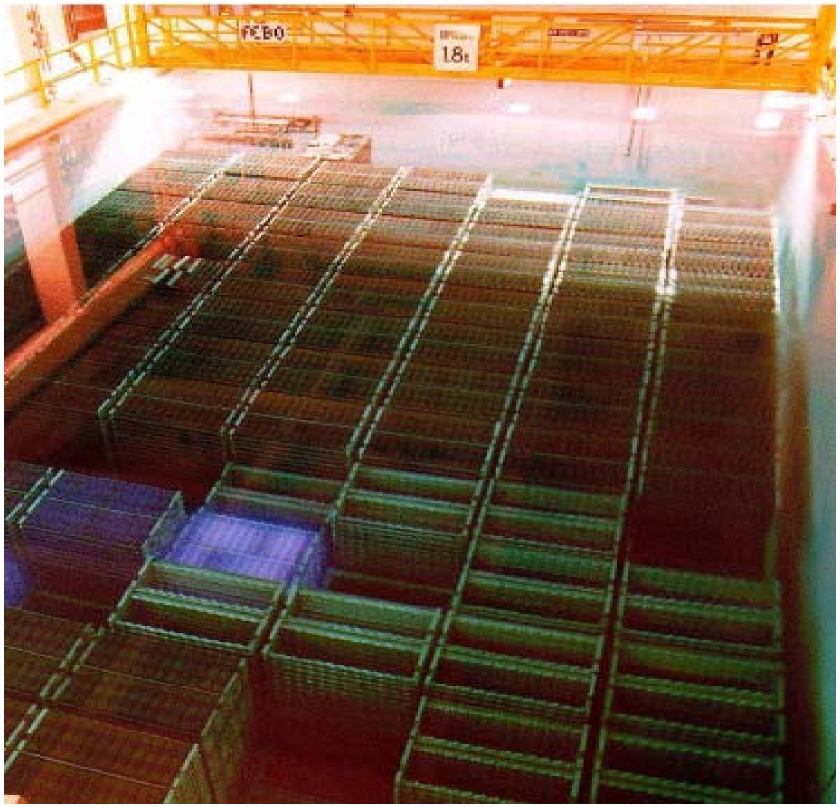
CNE reactor is a typical CANDU 6 (648 MWe) on load PHWR that is in operation in Argentina since 1984.



Fuel bundles are composed by 37 bars of 495.3 mm length. Each Zircaloy-4 bar contains 38 UO_2 pellets of natural uranium. Fuel assembly has an external diameter of 102.74 mm and contains 22 Kg of UO_2.

“Calandria” (right) has 380 horizontal pressure tubes /channels with a capacity of 4560 fuel bundles (12 per channel)

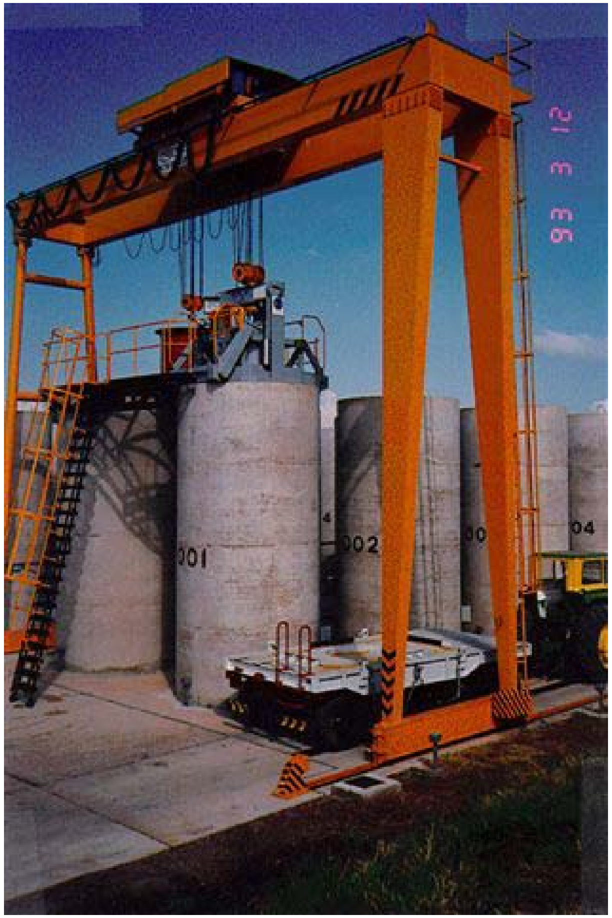
Refueling at full power is 15.2 fuel bundles per day, maximum burn up 7800 MWd/tU



The spent fuel bundle are transferred underwater to the reception bay (capacity: 4800 bundles).

They are disposed horizontally on trays of a double array of 12 bundles each one which are transferred to the storage bay and stocked in piles (capacity for 45144 spent fuel bundles, that is, 10 full power years -FPY-).

A dry storage (right) was implemented in 1993 to manage the spent fuel (SF) up to the end of life of CNE. SF bundles remain at least 6 years in the pool and then are transferred to the dry storage: concrete silos close to the CNE building.



Each full loaded silo (left) contains 9 steel sealed piled baskets, each one with 60 bundles.
They are 6.3 m high vertical cylinders and approx. 3 m external diameter. Cooled by natural convection, were designed to support some accidental events as earthquakes, floods, etc.,
No especial activities of maintenance are necessary when the silos are filled and sealed. At present, there are 152 full loaded silos from 216.

Atucha I NPP

➢ Atucha I is a PHWR (357 MWe) of German origin which is in operation since 1974.

➢ The fuel assembly of ANPP I have an active length of 5.3 [m] and a circular cross section of 0.10 [m] diameter, with 36 fuel rods plus one structural rod. Each Fuel Assembly (FA) is loaded with approximately 176 [kg] of UO_2.

➢ ANPP I was fuelled with natural uranium during the first 27 years of operation. The average burn up of the SF was approximately 6.000 [MWd/tU]. In Since 1995, the utility started a program to gradually convert the fuel to slightly enriched uranium (SEU) using an enrichment of 0.85% U-235.

➢ Since august of 2001 the whole core is fuelled with SEU and the average burn up of the spent fuel element is approximately 11.300 [MWd/tU]. This change produced an important saving in fuel consumption: from 395 [FA/FPY] to 210 [FA/FPY].

Prospective

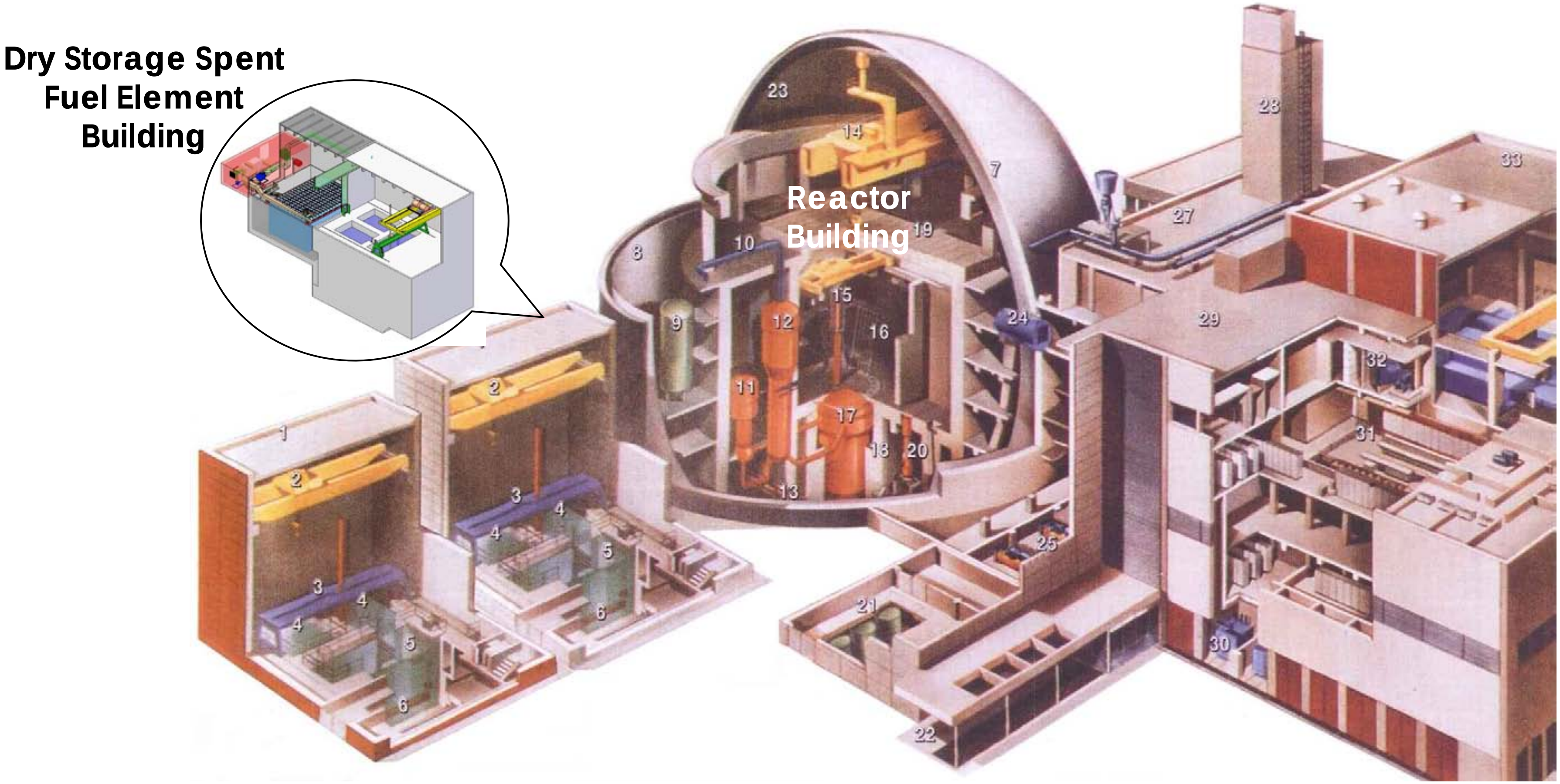
- The Fuel Elements (FE) Management Division of ANPP I determined that with the proposed system (2016 FE storage capacity) the plant end of life (PEL) would be exceeded in 5.27 FPY or 6.19 calendar years. **(This is assuming a 0.72 FE daily consumption, power factor of 85% and 250 reserves positions to empty the reactor core). With this FE storage capacity the station could run until February 2024, if a Life Extension is got, time enough to build a Dry Storage System compatible with ANPP I and ANPP II.**

- According to the scenario projected by NASA, considering a power factor of 85% for ANPP I, the pool storage capacity will be exhausted in March 2015. PEL by design will be reach in December 2017.

- So, in order not to penalize plant operation, it is required to have at least 614 free positions in the pool before March 2015.

- To avoid interferences with the normal operation of the plant it was evaluated to make the installation of a temporary Dry Storage Fuel Elements as an extension of controlled area.

Atucha I: NPP Spent Fuel Dry Storage Conceptual Design



- Under the constrains of the daily operation, the project was focused on the Building Pool Nº1 enlargement, in order to built an underground Spent Fuel Element Dry Storage (SFEDS).

- This system ensures the operation of ANPP I to reach the design end of life and possibility a link with the ANPP II Dry Storage System.

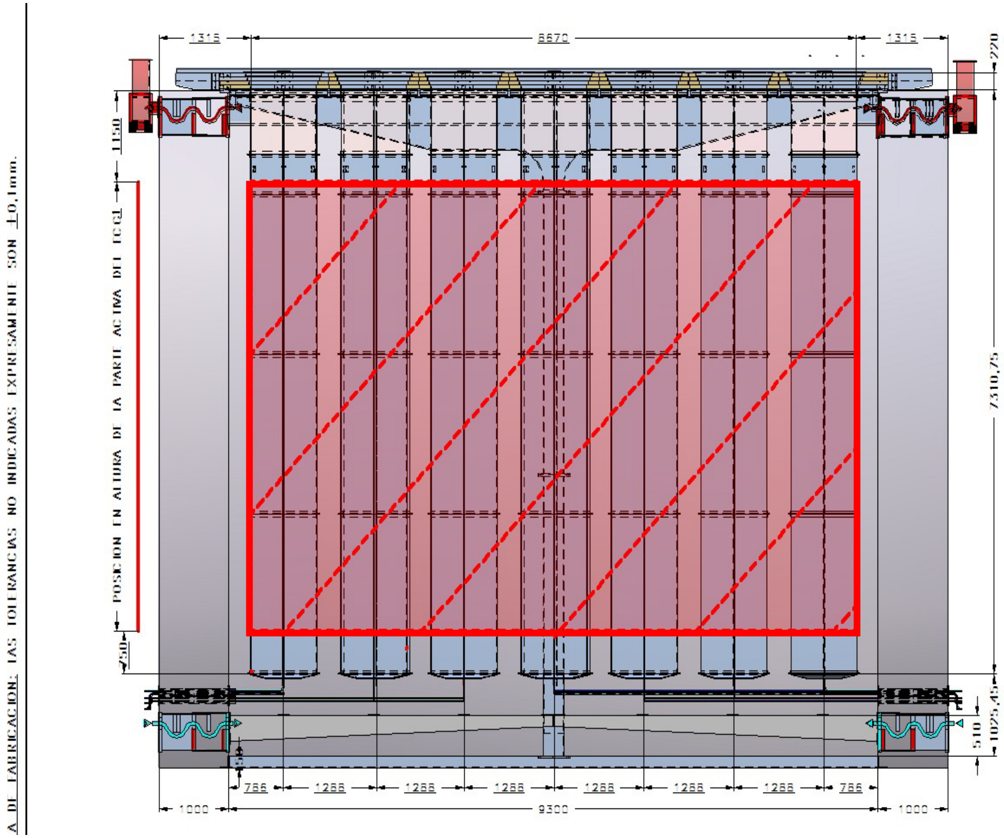
Fundamental Requirements to Dry Storage System

- Safe SFE confinement for a minimum of 50 years.
- Subcriticality: The storage configuration must be subcritical.
- Biological shield: The radiological limits should be respected.
- Heat balance: The FE temperature should never exceed, inside the silo, the maximum allowable by the FE sheath.
- System must be reversible, wet-dry-wet.
- Passive cooling methods ensuring maximum temperature not to be exceeded.
- Loading and unloading of the containers underwater.
- The loaded transport shield must not exceed the capacity of the existent crane.
- Possibility to isolate both buildings.
- To Include in the design the possible life extension of the ANPP I.
- Must to be constructed and licensed by 2013 to allow sufficient time for transfer SFE from pool I to SFEDS.
- The conceptual design includes containment barriers which increase the safety of the storage system.

Criticality of the configuration adopted

system criticality should be performed for different scenarios, both for normal operation and accidental situations during storage maneuvers.

Calculation based on the regulations NUREG-1536 *¨Standard Review Plan for Dry Cask Storage Systems¨* and NUREG-1617 *¨Standard Review Plan for Transportation packages for spent nuclear fuel¨*. These regulations establish criteria for acceptance a multiplication factor ***Keff ≤ 0.95***.



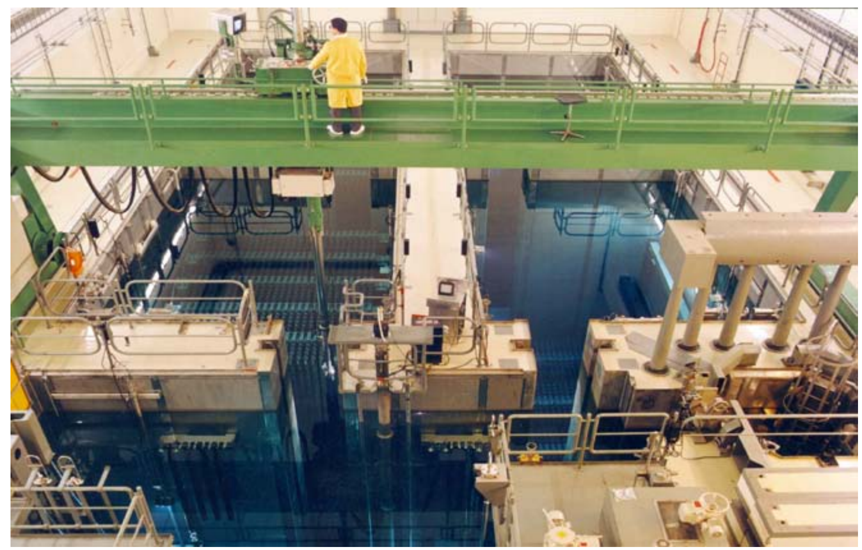
View storage silos. Area for criticality calculations in red.

Wet storage: Pools in ANPP I

The average discharge rate with natural uranium for this burn up is of 1.4 SF/day, but the use of SEU reduced the discharge to 0.7 SF/day. The arising SF were stored in the original decaying water pools.

Pool building 1, with two pools and Pool building 2, with four. The pools of the Pool building 1 were completely filled in 1982, containing 3151 spent fuels (pool I: 1637, Pool II: 1514). This year the pool building 2 started to storage spent fuels and this process continues up to the present.

Hanger loaded with fuels in the pool (upper level). Below the lower level (level 1)



Panoramic view of the four pools of the building 2, the monitoring pool (down) and the bridge. ANPP I.

Characteristics of the pools

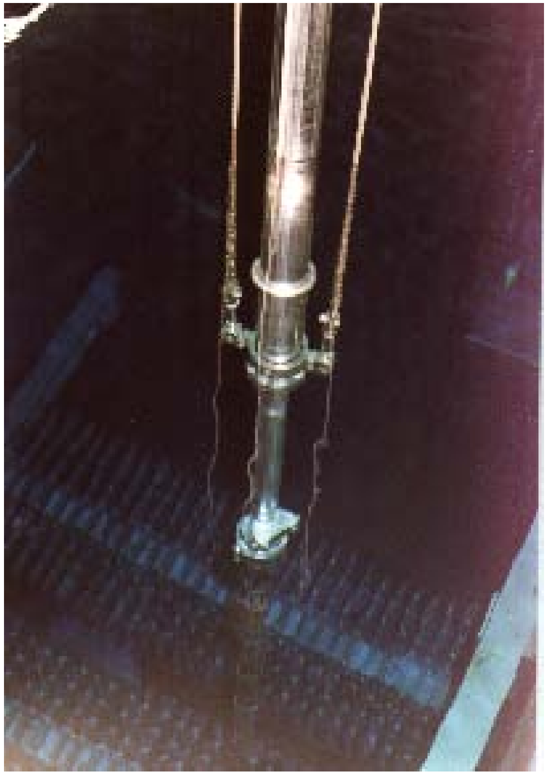
The dimensions of the pools are 5 m x 5 m x 17 m (deepness). These pools have two levels. The deeper level or level one is the first to be filled. For the building 1, both levels of the pools are fully occupied.

The SF are vertically suspended from a hanger. The present hangers are a modification respect to the original design, changed in 1982, when the pools of the building 2 began to operate. This improvement allowed to increase the pools storage capacity.

There are two types of hangers:

Singles: capacity for 168 SF.

Doubles: capacity for 280 SF.



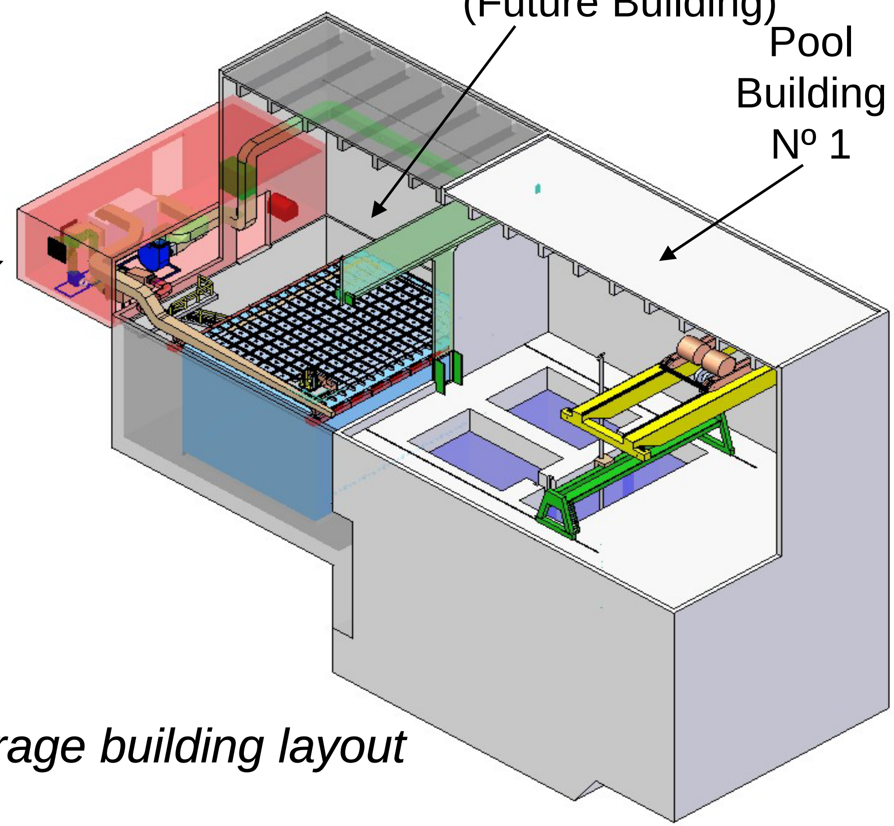
Tool used to place or remove the fuels from the hangers.

Dry Storage: installation overview

To avoid interferences with the plant normal operation, it is preferable to perform the Spent Fuel Elements Dry Storage in vertical silos in the Pool Building 1. The Spent Fuel Elements (SFE) of that pool are stored there since the plant start operation. The underground silos should be an extension of the existing building and with a load capacity of 1890 SFE (15 rows x 7 columns x 18 FE -2 basket of 9 FE -).

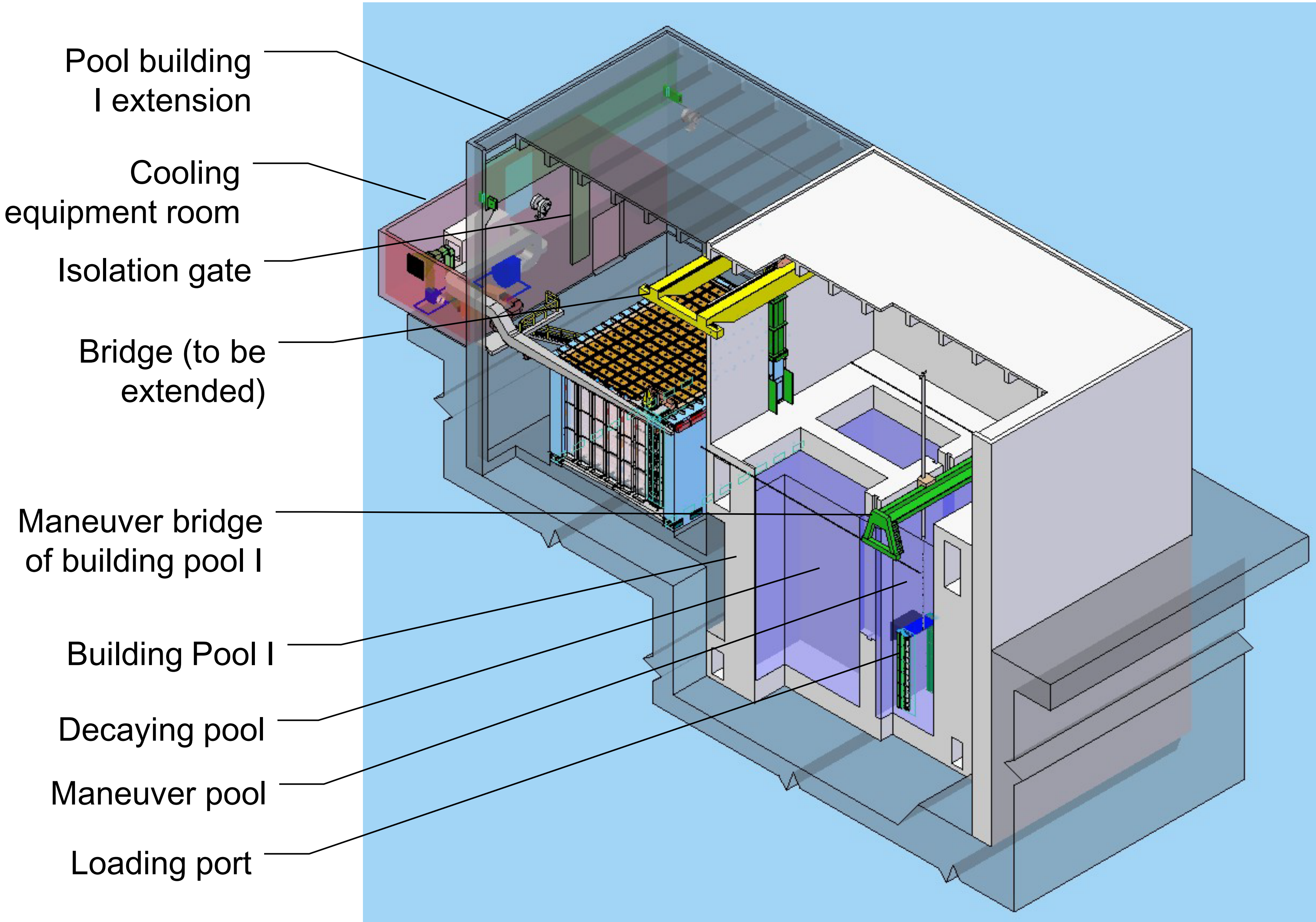
As explained before, the necessary time to transfer 1998 SFE (a complete pool capacity) to the Dry Storage place will take approximately one year.

An additional line (7 x 18) for 126 FE will be used to accommodate discarded fuel (cooling) channels



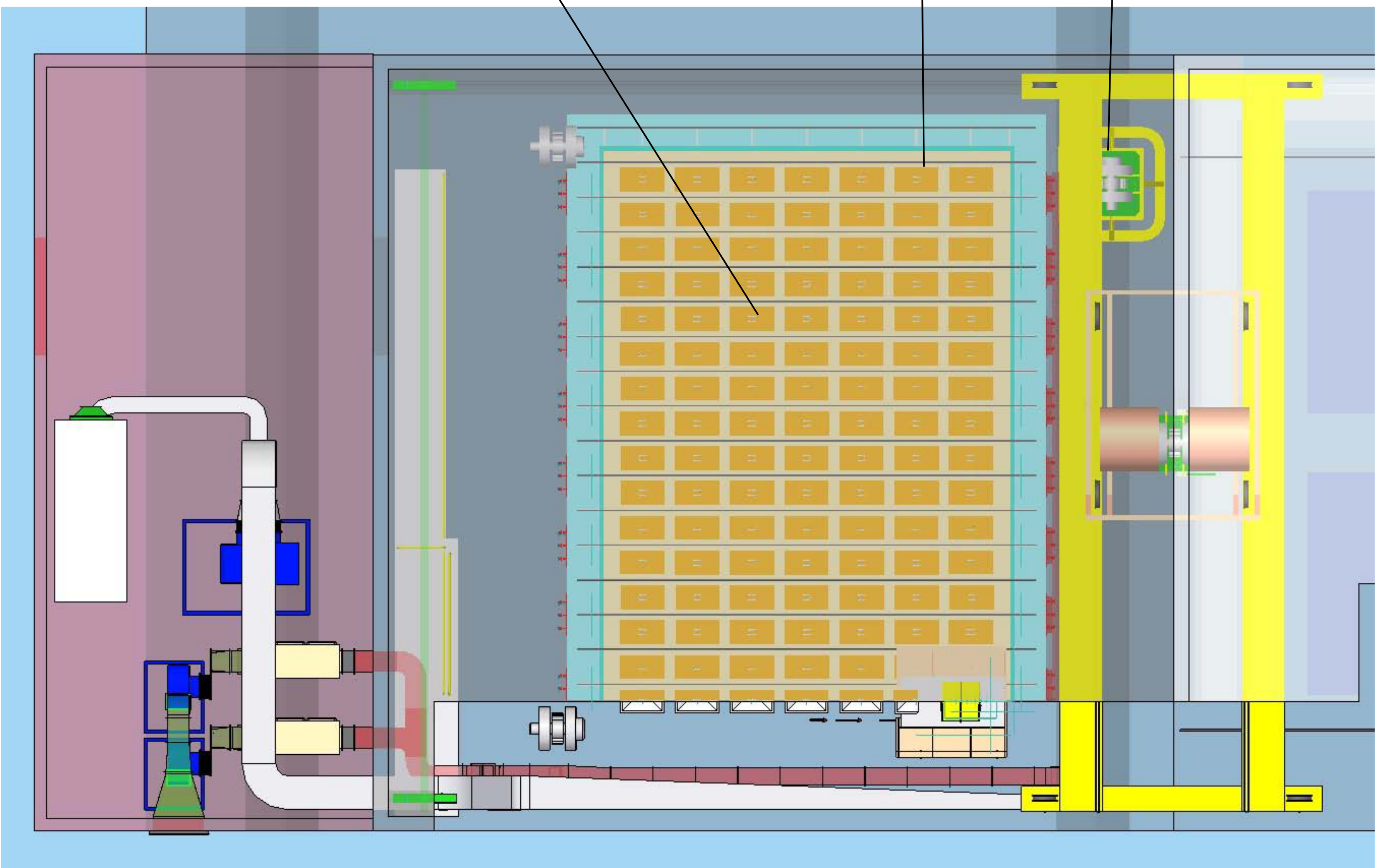
SFE Storage building layout

Installation overview…



Installation overview…

Silos: 15 rows x 7 columns containing two basket with 9 FE each one = 1890 FE

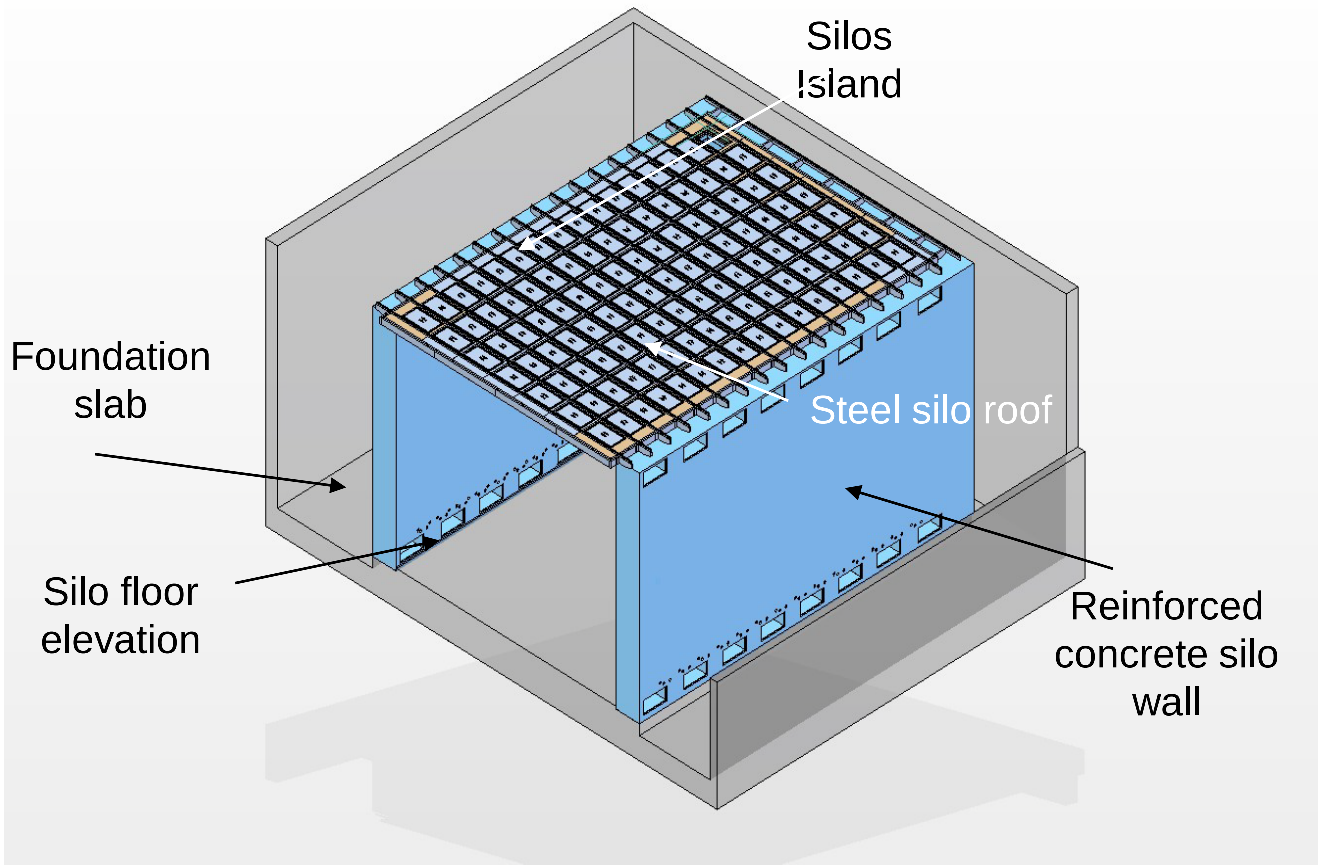


Silos Building

The installation provides for the enlargement of SFE Building I, towards the west side, a building which will contain two underground silos with 2016 SFE capacity, including internal components of the reactor, now deposited in SFE Building I and II (Cooling Channels, Control Rod Guide Tubes, Control Rods, etc).

The new building should have the services of the present SFE Building to be able to carry out the correct transfer, maintenance and complete control of the system.

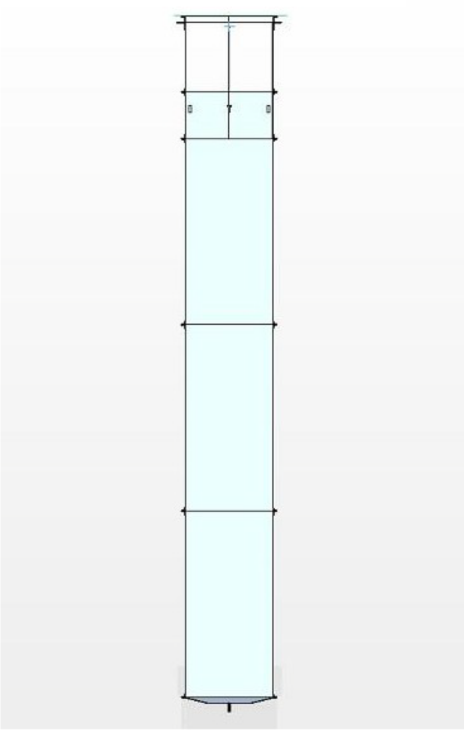
- Water
- Compressed air
- Ventilation
- Electric power
- Radiation monitoring systems
- Enlargement of the crane bridge rails



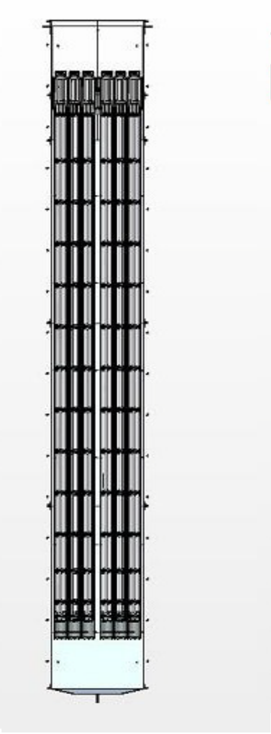
Silos

➢Silo's capacity: two baskets with 9 SFE each, with stainless steel wall, drying piping and silo monitoring.

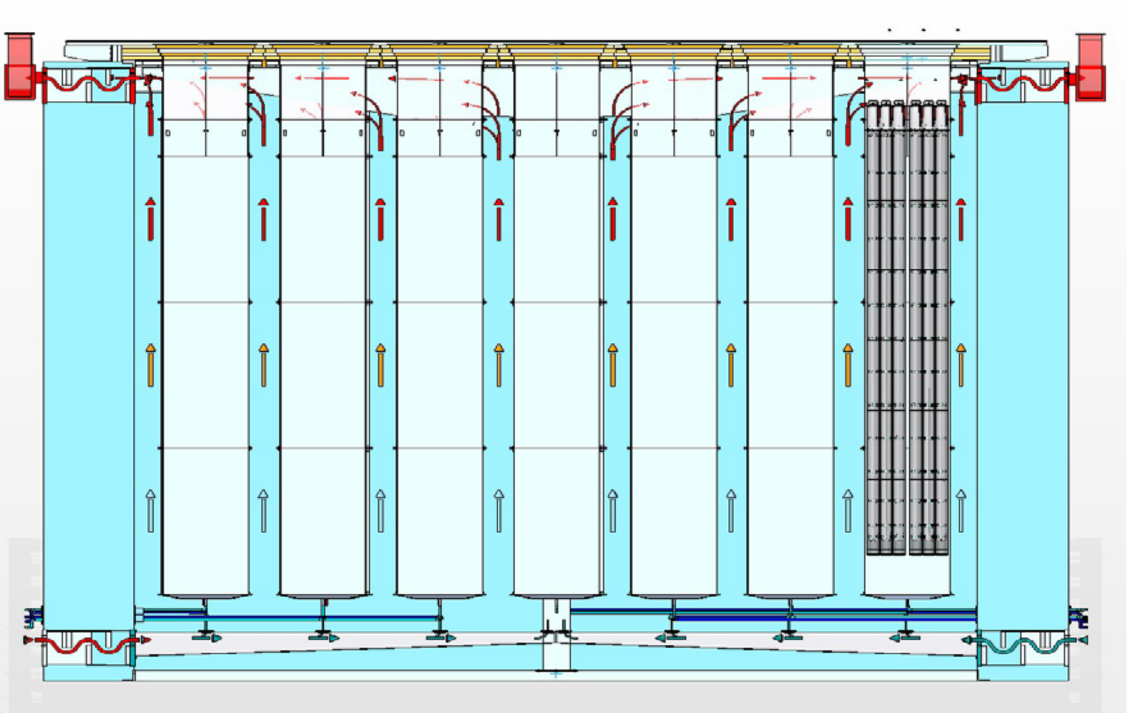
➢Heat dissipation of SFE: using natural thermal convection inside the closed silo. Instrumentation: provided to allow getting information of the equilibrium temperature and radiological status.



Silo without SFE



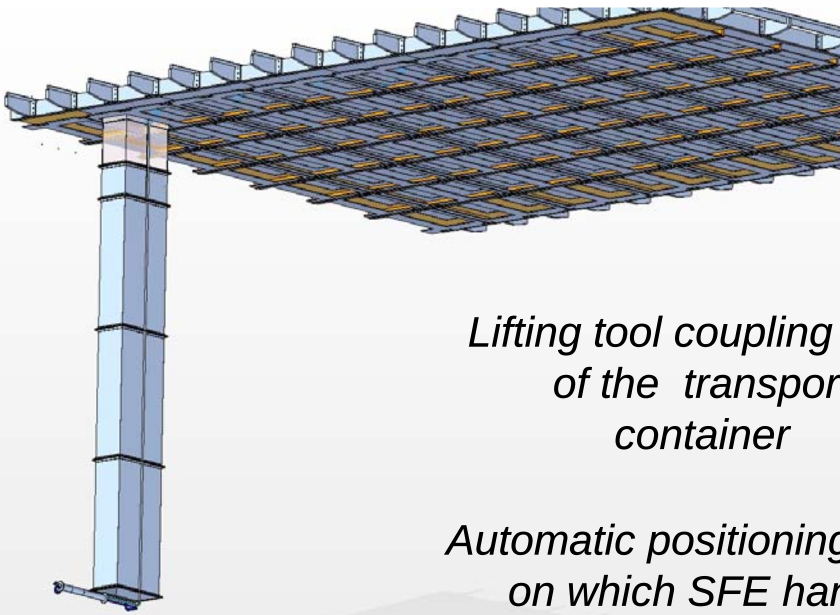
Silo with SFE



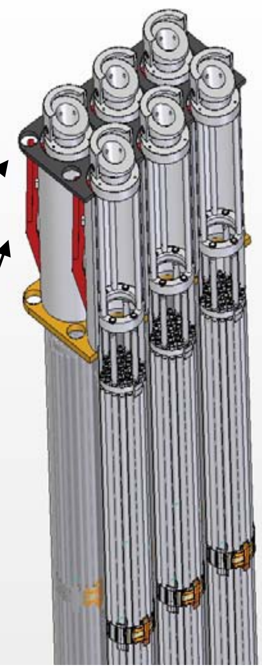
Sectional view of the support greed

Storage Unit (Basket)

The SFE will be stored in steel rectangular baskets, with 9 units capacity each. They have a support system on top which allows locking with the lifting tool.

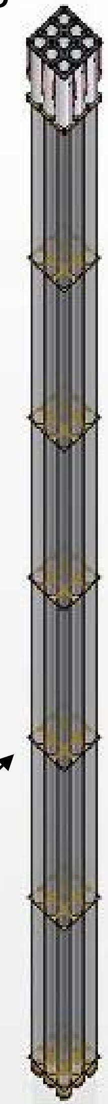


Support grid



Lifting tool coupling plate of the transport container

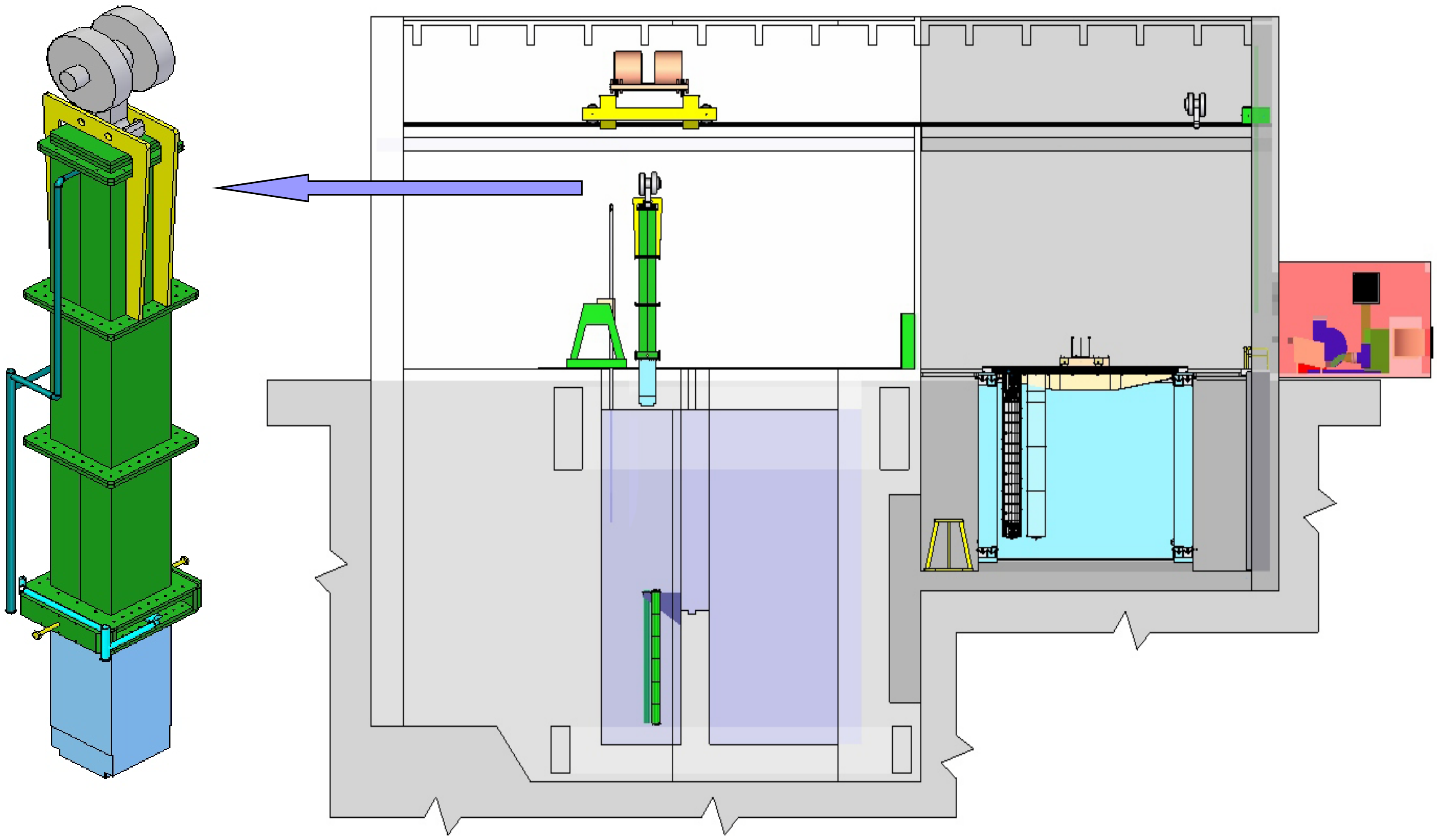
Automatic positioning lock on which SFE hang



Protection Plate against impact and SFE spacing

Shielding for lifting and transportation

To remove the baskets with the SFE inside them, the facility has a structure with two functions: store the baskets inside them and provide adequate shielding level for the workers.

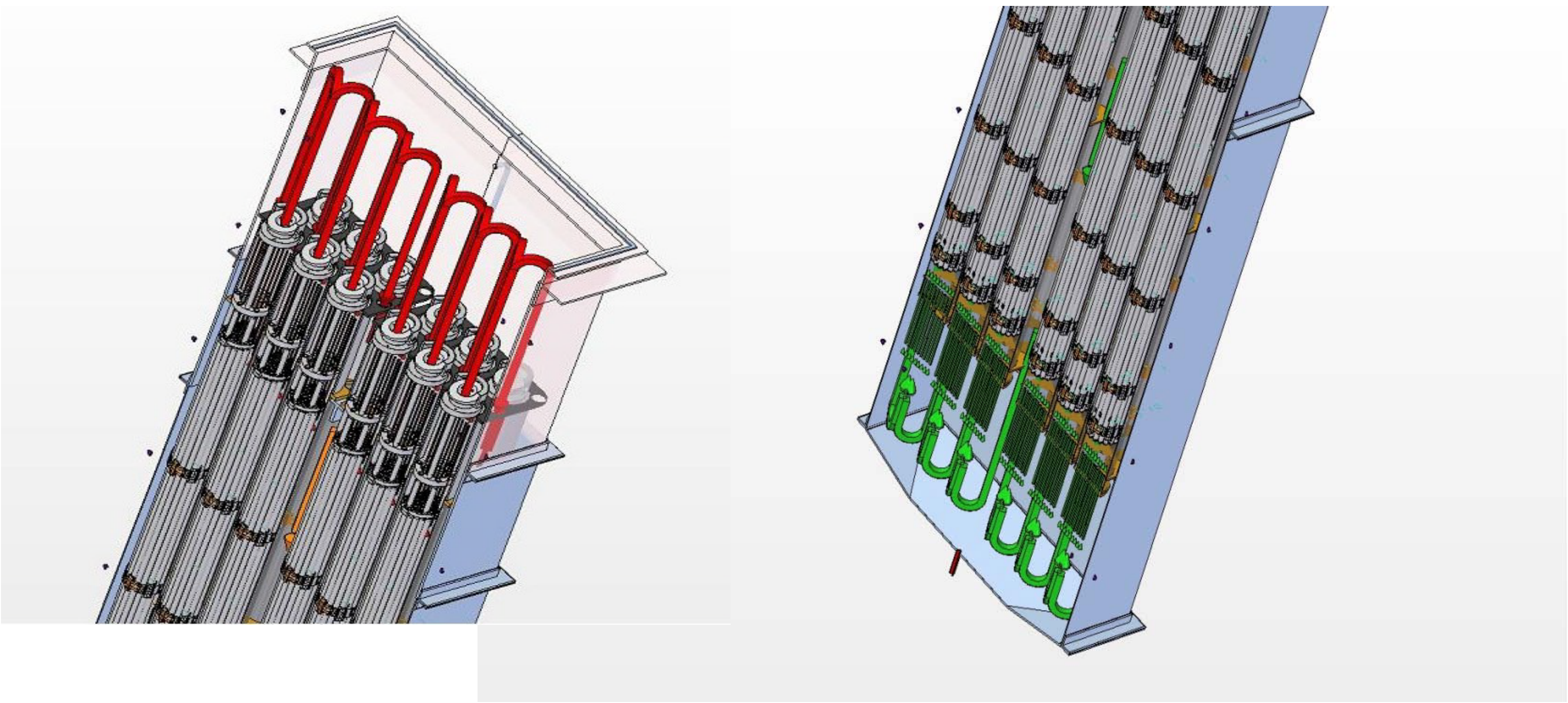


Shielding for lifting and transportation

Cooling

Natural convection internal cooling

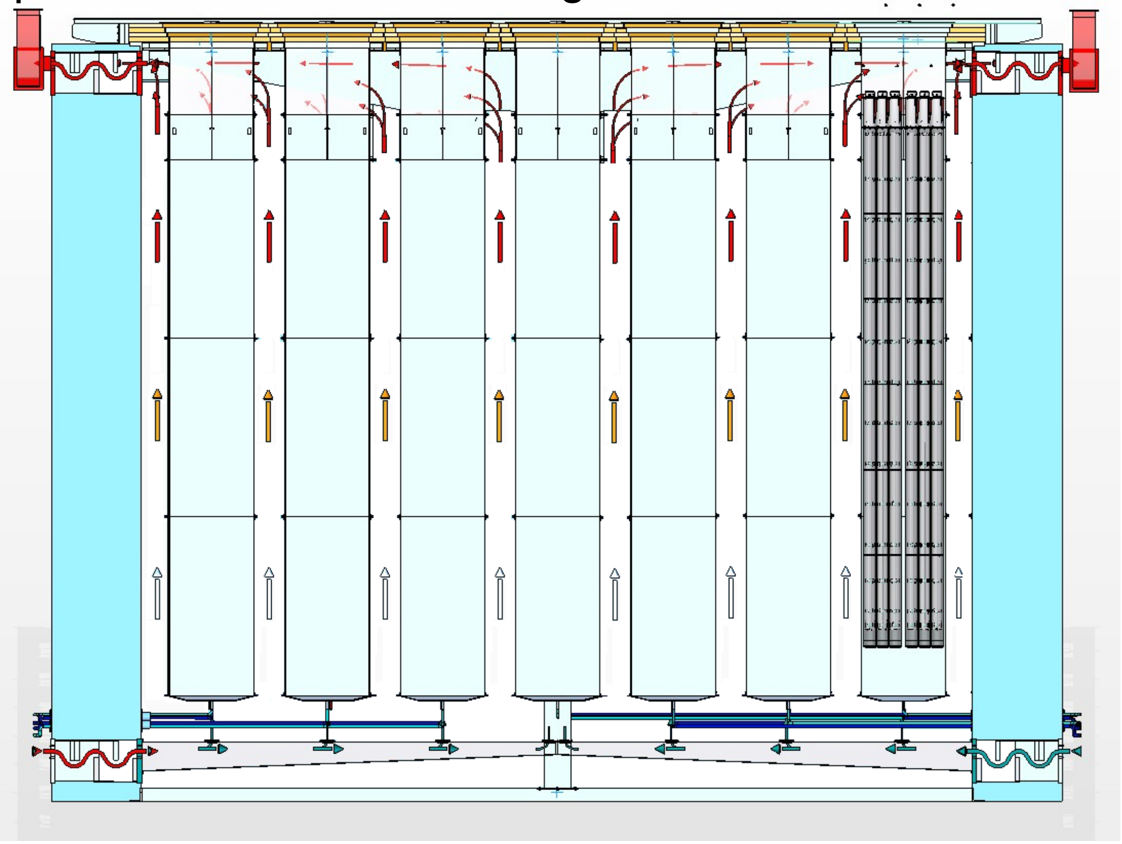
The gas inside the silo (not defined yet) will flow from bottom to the top by natural thermal convection, and will transmit the accumulated heat on top by conduction through the walls to the silo building.



Bottom and Top of the Silo. Gas circulation by means of natural convection.

External cooling by means of forced convection and conduction through the silo wall.

Silos cooling are made by forced convection air circulation through the ventilation system, which extracts the heat produced in the silo by conduction. The heat is transmitted by conduction through the concrete silo wall. The atmosphere between silos is under depression related to building environment.



Sectional view of silo unit. Air distribution among silos trough the air injection duct at the bottom. Air extraction is trough the upper area.

Conclusions:

Temporary Dry Storage in an enlargement of Pool Building I is shown as the most economical and simplest alternative from the licensing point of view as SFE are not removed from the controlled zone, allowing the operation of ANPP I until the Dry Storage System for ANPP II is put into service.

➢ ***Construction details will be analyzed at the detail engineering stage, which should be done parallel to the licensing stage.***

With this system:

➢ SFE will not leave the Controlled Zone (which means, lower demands for licensing) and allows additional containment barriers (Silo, Silo Structure and Reinforced Concrete Wall of the Silo) which decrease potential radiological impact on the Environment.

➢ SFE can shift from wet storage to Dry Storage, and eventually go back to wet storage, according to CNEA's decision after discontinuing its operation in 2017.

It allows to store irradiated internal components of the Reactor (Channels, Control Rod Guide Tubes), which now are taking place in the decay pools.

➢ Decrease investment regarding other proposed systems.

It allows normal operation of ANPP I until reaching the end of its life according to design and considers a possible life extension, enough to connect to the future CNA II Dry Storage System.