EMBALSE NUCLEAR POWER PLANT REFURBISHMENT

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NUCLEOELECTRICA ARGENTINA S.A.

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ATUCHA I NPP

Reactor: SIEMENS PHWR vessel.
Thermal/Elect. Power: 1,179 MWt/362 MWe
Moderator & Coolant: D20
Fuel: slightly enriched Uranium (0.85%)
Connected to gird: 1974

ATUCHA II NPP

Reactor: SIEMENS PHWR vessel.
Thermal/Elect. Power: 1,179 MWt/362 MWe
Moderator & Coolant: D20
Fuel: slightly enriched Uranium (0.85%)
Connected to gird: 1974

EMBALSE NPP

Reactor: CANDU 6 PHWR, pressure tubes.
Thermal/Elect. Power: 2,109 MWt/648 MWe
Moderator & Coolant: D20
Fuel: Natural Uranium (0.85%)
Connected to gird: 1983

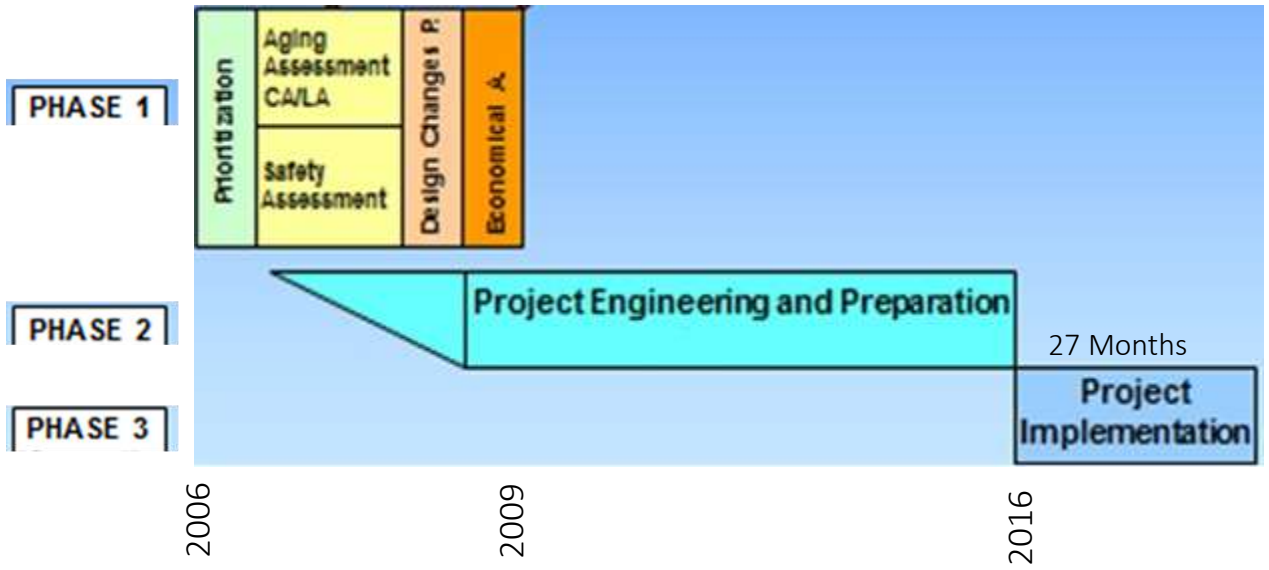
EMBALSE Refurbishment

Unlike pressure vessel reactors, Candu pressure tubes have a limiting life by design of 30 years, defined by the elongation of tubes due to creep.

Objective

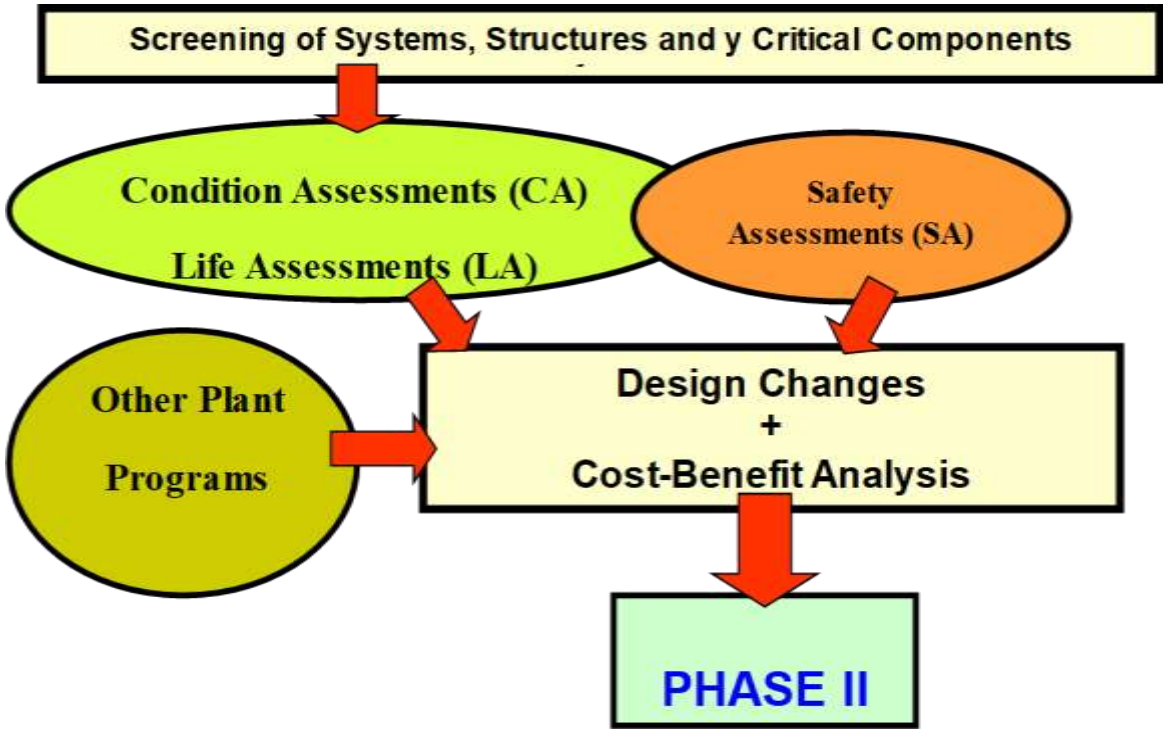
- **Saving cots:** The LEP represented 30% of cost and time compared with the construction of a new plant and it was not required to face any dismantling cost.
- **Energy diversification:** ENPP-LEP was important to keep a diversified energetic matrix.
- **Keeping the knowledge:** The reactor retubing and Safety Systems improvement/modernization was done under NASA responsibility with own personnel, and technical assistance from the designer.
- **Keeping safe:** Focus on "one-time activities"
- **Technology transfer and local contractors qualification**
- **Keeping control:** of work knowledge & quality, budget and critical path schedule of main activities, instead of a Turn-key project

EMBALSE Refurbishment : Main Features



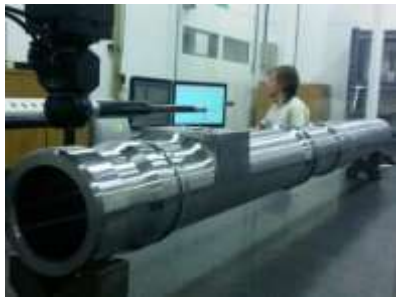
EMBALSE Refurbishment : PHASE I

- **Project organization**
  - Staff hiring and training
  - Procedures development for engineering assessment
  - Life & Aging Assessment of Systems Structures and Component LA/AA SEC (Division of responsibilities and evaluations scope)
  - Walkdowns and special inspections implemented during the last maintenance outages of first life cycle, with NASA personnel and advisors.



EMBALSE Refurbishment : PHASE II

- **Technical specifications development, component manufacturing and construction contract**
  - ASME III, Class I components manufacturing contracts (95 % of reactor components locally supplied)
  - **Local suppliers qualification**.
    - International Accreditation (ASME, TSSA)
    - Pre-Production QualificationS
  - New components manufacturing and acceptance test at the manufacturer warehouse.
  - Strategies and contract development for the site installation
  - Site installation procedures
  - Personnel training and qualification – Site facilities construction
  - Integrated schedule for refurbishment outage development



EMBALSE Refurbishment : PHASE III

Main activities of the Refurbishment Outage

Preparatory activities
Reactor Fuel Channel and Feeder Pipes Replacement
Steam Generator Replacement
Moderator System Components Replacement (heat exchangers and valves)
System Improvements (mechanical, electrical and Instrumentation and Control)
Uprating of the Reactor, Turbogenerator and Balance of the Plant
Systems fill-up, construction tests and commissioning

Type of LEP Resource	
NASA personnel	186
NASA temporary contract	252
Trades under NASA direction	1,590
Contractors	2,064
TOTAL	4,092

Plant staff supported the Project with Operational assistance, Engineering Review, Maintenance and Radioprotection

EMBALSE Refurbishment : PHASE III

Fuel Channel Replacement

Reactor FC replacement Scope: fuel channel replacement including Calandria tubes and feeders replacement up to header connection.

Training: all staff including supervision, quality, safety, radio protection and trades were trained and qualified for each Series. Over 4000 qualification records were issued. In order to have fresh knowledge the training was implemented in parallel with the site execution.

Site Facilities: to meet the requirements for training, tool storage, commissioning and repair, reactor waste storage, decontamination

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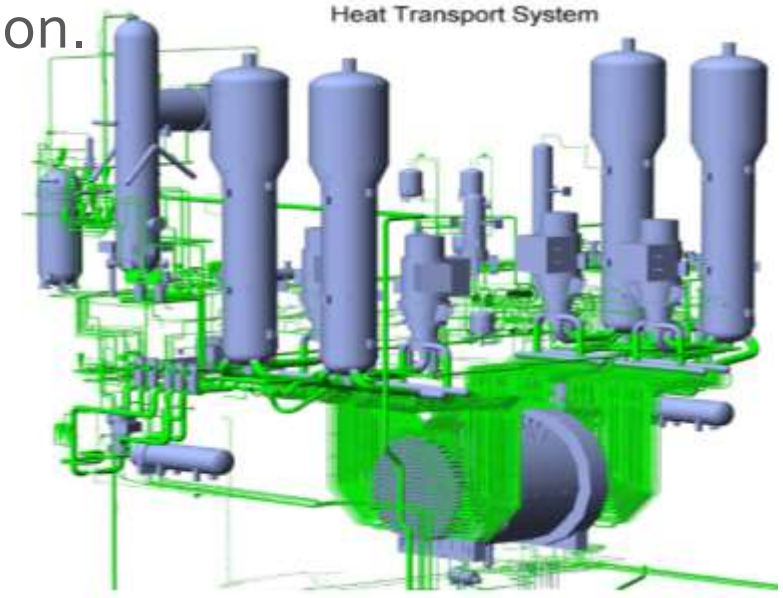


EMBALSE Refurbishment : PHASE III

Fuel Channel Replacement

Retube execution: was divided in series that can be grouped on:

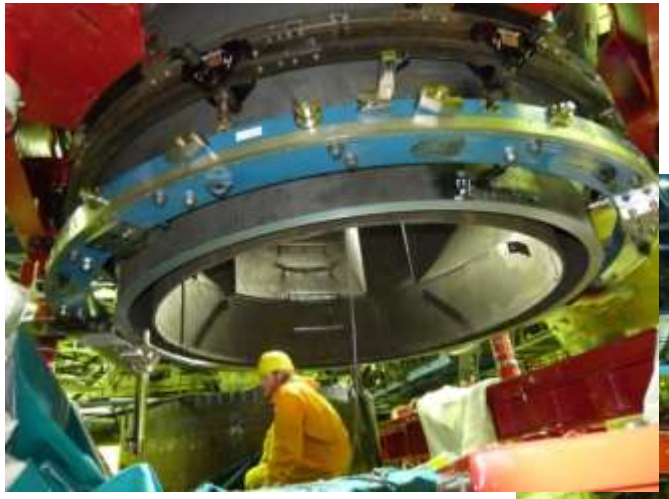
REMOVAL -- INSPECTION -- REINSTALLATION.

- 24 hs/day, 7 days/week, 365 days/y
- Key aspect, “keep going”
- Total dose half of the estimated (last years at low power condition).
- No events of alfa contamination

EMBALSE Refurbishment : PHASE III

Other activities

Steam Generator Replacement:
First of the kind replacemente



Moderator Syst. Component Replacement :
Heat exchanger, main valves, pumps impellers

EMBALSE Refurbishment : PHASE III

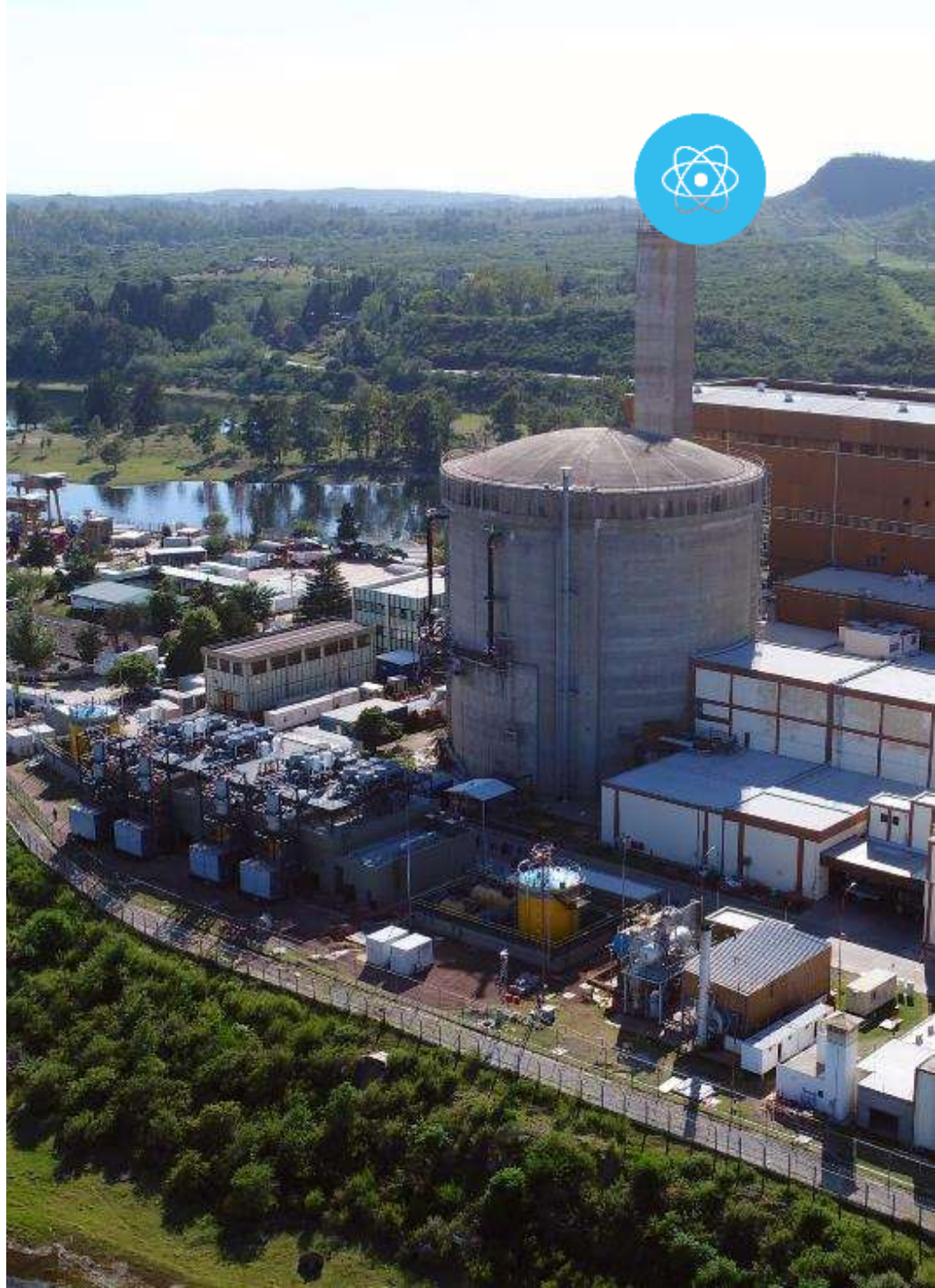
Other activities

Safety System Improvements and Modernization

- Reactor Trip Coverage of the Shut Down Systems Nº1 and Nº2.
- Reliability of the Emergency Core Cooling System (ECCS)
- Plant robustness against a seismic event, severe accidents, and a loss of Class IV / service water.
- Installation of an Hydrogen Control System in the reactor building.
- Installation of a new Emergency Power Supply System.
- Installation of a new Emergency Water Supply System.
- Installation of a new Filter Containment Venting System.
- Installation of new Standby Diesel Generators (Class III).

Conclusions

- The Embalse LEP was the most extensive of a CANDU6 up to date. Only one modification was added due to Fukushima accident.
- The Retubing was implemented under NASA direction, Candu Energy supplied the required tooling and technical advisors.
- A First-of-the-Kind Steam Generator Replacement was successfully implemented.
- The total dose was lower than the estimated.
- Big Project are always about people.



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