Spanish participation in the JHR project

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EXECUTIVE SUMMARY:

The Spanish consortium joined the JHR project in 2006.

In-kind contribution to the construction that includes:

- The 3 Primary Heat Exchangers,
- The development of a Experimental Loops Simulator (EXSIMU)
- CSN (+CIEMAT) Technical support
- CIEMAT support for these items and coordination (technical + management)

Exploitation of the facility for proprietary and Joint International projects

Participants:

CIEMAT, CSN,EA,ENSA,ENUSA,SOCOIN,TECNATOM

Framework:

- Bilateral agreement CEA- CIEMAT (Spanish Consortium) (Jul 2006)
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- Spanish Ministry ACI-PROMOCIONA JHR (Dec 2009)

Nuclear Power Plants and Fuel Cycle facilities

IN SPAIN IN 2011

Nuclear contribution to electricity production close to 20%,

1 BWR from 1971, all the others have their first operation after 1983. All plants passed the Stress tests after Fukushima.

8 NPP operating units
- 6 PWRs
- 2 BWRs

1 NPP (Vandellos I)
- In the phase 2 of decommissioning

1 NPP (José Cabrera)
- Stopped in April 2006

Juzbado
- Fuel fabrication plant

El Cabril
- Low and Intermediate level wastes repository

Main actors in Nuclear Energy at Spain - 2011

The 9 NPP

ENRESA: El Cabril, Interim Dry Centralized Storage Project, R&D on Geological Disposal and on Partitioning and Transmutation

ENUSA: Juzbado Fuel Fabrication plant, R&D on High burn-up fuel and Spent fuel Characterization and Safety aspects

CSN: The Nuclear Safety Council (Regulatory Body), R&D on Radiological Protection of Persons, Evaluation and Reduction of Radiological impact and Wastes, Management of Nuclear & Radiological emergencies.

Engineering: Several large companies: Tecnatom, Empresarios Agrupados, Socoin, Sener, Initec, Iberinco, Idom, Geocisa,…

ENSA: Heavy equipment supplier with large experience in the fabrication of primary components, spent fuel racks. It is fabricating the dry storage casks for the Trillo NPP on-site dry spent fuel storage.

Universities: Several Univ. with R&D on Nuclear Physics and Engineering

CIEMAT: The national research center on Energy, Environment and Technology, including a large Fusion laboratory with an Stellerator

Ministries of Science and Education and M. of Industry and the **CEIDEN Technological Platform**: Coordination of R&D&I in Nuclear Energy

CEIDEN: The Spanish Platform for R&D in Nuclear Energy:

Including all the main actors of the nuclear fuel cycle:

Utilities, ENUSA (Fuel Fabrication), ENRESA (Waste Management), Engineering Companies, Reactor equipments, CSN (Regulatory Body), Research Centers, Universities, Ministries

Council: Endesa, Union Fenosa, ENUSA, ENRESA, TECNATOM, ENSA, CIEMAT, UPM, CSN, Industry Ministry(IT&C)

Most active programs:

- Jules Horowitz Reactor (w. CIEMAT coordination)
- Zorita Structural Materials (w. CIEMAT contribution)
- Zorita non metallic Materials (w. CIEMAT contribution)
- Fuel for present reactors (w. CIEMAT contribution)
- Education and Training (w. CIEMAT co-coordination)

Origins and motivation of the Spanish participation at the JHR

- Proposed by CIEMAT and coordinated within CEIDEN (Spanish Nuclear Technology Platform)
- Granted access to one of the largest nuclear experimental facilities in Europe for the next decades, with preferencial conditions
- Participation in the construction of a large experimental nuclear facility
- Increasing the know-how on nuclear material and fuel testing and associated experimental techniques
- Qualification of our industries to new European codes and standards
- Follow-up of the experience of Halden HRP
- Low probability to built a comparable facility at Spain
- Main topics of interest
  - Materials and fuels issues related to the safety of present and Gen III reactors
  - Performance and possible upgrades of fuels for LWR
  - Materials and Fuels for nuclear waste transmutation
  - General knowledge of nuclear materials and fuels including new concepts as Gen IV

Definition and build-up of the Spanish consortium

- Initial interest from research, regulation and fuel manufacturing
- Early identification of the need of participation from industrial partners as the end-users (utilities, service providers and manufacturing companies)
- CEIDEN coordination resulted in Utilities possibly represented by associated engineering companies
- Issues to enable wide industrial participation:
  - Large fraction of the participation as In-Kind contribution
    - Indeed the agreement from Spain to JHR is 100% in-kind
    - The internal contribution from most of the industrial partners is 100% in-kind
    - Financial flux from institutional partners to industrial partners
    - Using the experience of the industrial partners
  - Very detailed definition of responsibilities within the Spanish consortium
  - Detailed definition of scope and deliverables, with revisions if needed
  - Confidentiality between partners inside the Spanish consortium
  - Management of the consortium by a Consortium Board chaired by CIEMAT, representation of all partners and reporting to CEIDEN.

Members of the Spanish consortium

- CIEMAT: Spanish Research national organization for energy and environment, including several divisions and units related to nuclear energy.
- CSN: Spanish Nuclear regulatory body, including a large technical division.
- ENUSA: Enusa Industrias Avanzadas, S.A. focuses on the design, manufacture and supply of fuel to Spanish and international power plants. It is involved in everything from the supply of raw materials and their processing up to obtainment of the end product, which is placed inside the core of nuclear reactors, and it provides engineering and fuel services to the plants.
- ENSA: Ensa is a worldwide leader supplying manufactured equipment and services for the civil nuclear industry particularly, large components for nuclear power plants.
- EA, SOCOIN & TECNATOM: are 3 independent engineering companies. They are architect-engineering organizations of international standing and diversified activity in several areas including nuclear energy. The three are partially owned or have dependencies from several utilities operating at Spain.
- Additional support from Science and Innovation Ministry and from Waste management public enterprise.

Financial resources for the In-Kind contribution

- The project started with the resources of the participating institutions:
  - CIEMAT: Financial contribution + in-kind technical and management
  - CSN, ENUSA : Financial contribution + in-kind technical
  - ENSA, EA, SOCOIN, TECNATOM: only in-kind technical
- Additional resources for the In-Kind contribution
  - Grants from Science and Innovation Ministry to CIEMAT
    - Participation to the ESFRI infrastructures (JHR is ESFRI)
    - Facilitating internationalization of research and innovation
    - This participation will allow the Spanish Universities to have some access to JHR via CIEMAT
    - Access to remote experimental facilities of reference
    - Exchange of scientists between Spain-France (Bilateral national agreements) (Being explored for the future)
  - Collaboration of waste management companies with CIEMAT
- Additional resources for participation beyond the In-Kind contribution
  - EU projects: JHR-CP, MTR-I3

Building the Legal framework

- Bilateral agreement CEA- CIEMAT (Spanish Consortium) (Jul 2006)
- Mandate from CEIDEN to establish a Spanish Consortium (Dec 2006)
- International Consortium Agreement (March 2007)
- Spanish Consortium Agreement (Jul 2007)
- Side letters to Bilateral agreement CEA- CIEMAT (Nov 2007)
- Technical annex for the Spanish consortium agreement and (Jun 2008)
- JHR-CP (Jan 2009)
- Spanish Ministry ACI-PROMOCIONA JHR (Dec 2009)
- Still some details to be clarified
- Still alive process
  - Review of the Bilateral Agreement side letters (2011-2012)
  - Review of the Spanish consortium agreement and technical annex (2011-2012)
  - Formalization of support to CIEMAT from Spanish institutions (2011)
  - Looking for additional support from Ministries (2011-…)
  - Looking for additional support from EU (2012-…)

Identification of the In-Kind contribution

It took nearly 1 year of discussions and negotiation to identify the agreed Spanish In-kind contribution.

Some of the elements for the decision were:

- Experience from the partners of the Spanish Consortium
- Possibility to provide complete packages
- Needs from JHR identified by CEA (list of packages and components):
  - Heat exchanges of the primary circuit: design and fabrication
  - Safety related issues for JHR: A regulatory body point of view.
- Useful services for JHR project identified by Spanish Consortium
  - Experimental loop simulator
- High added value components
- Qualification of our industrial partners in French/European Codes and Standards (RCC-MX – Heat Exchangers)

Technical Challenges

- Adapting to French/European Codes and Standards
  - Whereas the Spanish manufacturing and engineering companies use mainly ASME codes the JHR uses French/European Codes
    - RCC-MX Ed.2008: French Rules for conception and construction materials on experimental reactors (France).
    - ESPN: additional French nuclear classification on PED Directive (97/23/CE)
  - This is particularly critical for the heat exchanges as they are part of the primary system
- Adapting to work for a large experimental facility
    - Live project specifications
    - Working in collaboration vs. working under contract (Sharing decisions and responsibilities)
- Working as Fabricant (because the ESPN norm vs. working for a system integrator)
- Defining the consortium and learning to adapt it to the Spanish regulation

PRESENT STATUS

- The objectives and scope of the experimental loop simulator
- Development complete ready for acceptance test

- The objectives and scope of the heat exchangers
- Design and validation to norms completed
- Fabrication starting

EXperiment SIMUlator (EXSIMU)

INITIAL SCOPE: R&D development of a simulator with 1-2 loops: **ADELINE** (MADISON)

EXSIMU GOALS

- **Assessing** the loops operation + additional design tasks
- **Training** experimentalists and operators
- Tool to **design and validate** loop operating procedures (**design of loop control system**)
- **Pre-design and assessment** of experiments.

INITIAL MODELLING SCOPE

- Experimental loops **Thermal hydraulic** modeling
- **Neutronic** Modeling of Experimental Device
- **Auxiliary Systems**: Chemical conditioning, Cooler secondary side, Pressurizer secondary side, Aerial lines and Fission products Lab., Other systems (Emergency cooling)
- All systems with generic and specific **malfunctions**.

MODELLING EXTENDED SCOPE

- **State-Chart Calculation: Irradiation Boundary Condition from JHR core**
- **Gamma-Heating Model**
- **Evaluation of reference data, definition of Acceptance Tests Procedures and System Test Units**

OTHER FEATURES

- WINDOWS O.S.
- **Graphical Human Machine Interphase (HMI)**.
- Simulation control functions included: Freeze, Reset, Backtrack, Snapshot,….

EXSIMU Project Status

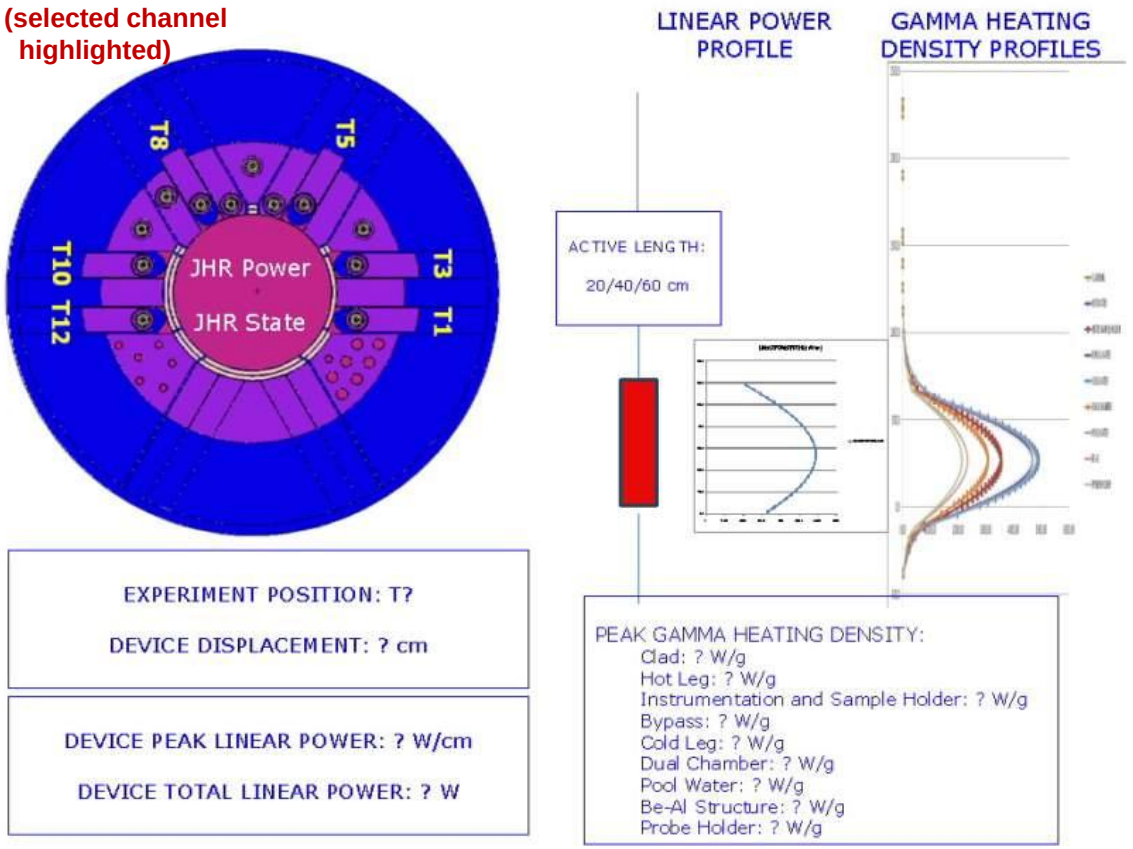
Thermalhydraulics Model

- Data Package Completed
- Final Design Specification
- HMI Design Completed, Interface mapping defined with Simulation Executive
- Ongoing Integration Phase

HMI Modules

- Pre-processing module
  - Selecting configurations and experiments
- Running the tests
  - Main page
  - Device page
  - Loop page
- Post-processing modules
  - Access to more (all) variables
  - Single variable plots
  - Xvs Y
  - Analysis tools

EXSIMU main page during operation



EXSIMU Project Status

- Experiment control

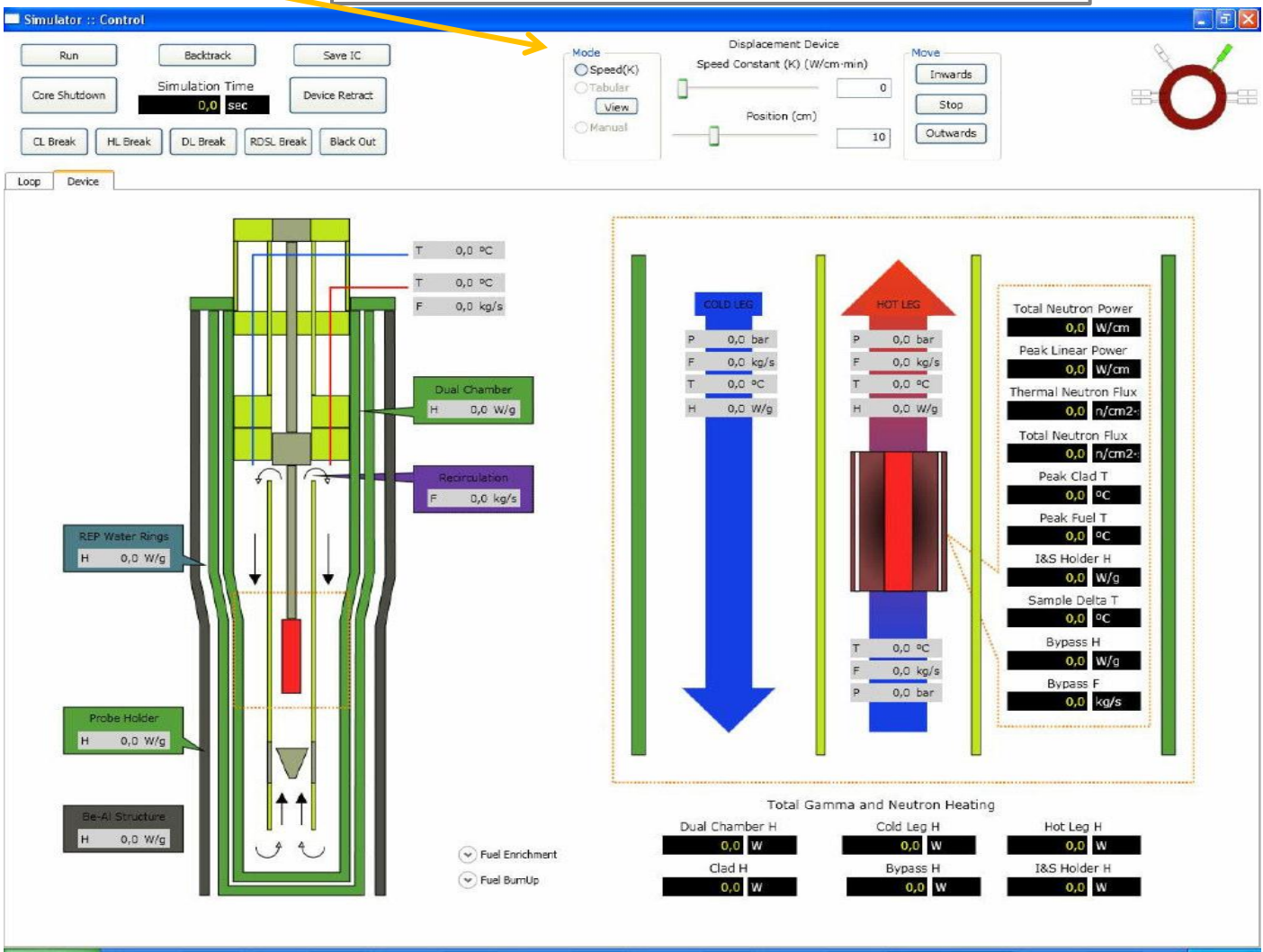
- Program control
- Reactor control
  - Core Shutdown
  - Device Retraction
- Malfunctions
  - Black out
  - Breaking of lines,...

Quasi-online display:
Temperature,
Pressure, Flow,
Power, n-flux,
Gamma & n heating

Peak, average and total values

Fuel enrichment & Burnup

EXSIMU DEVICE page during operation



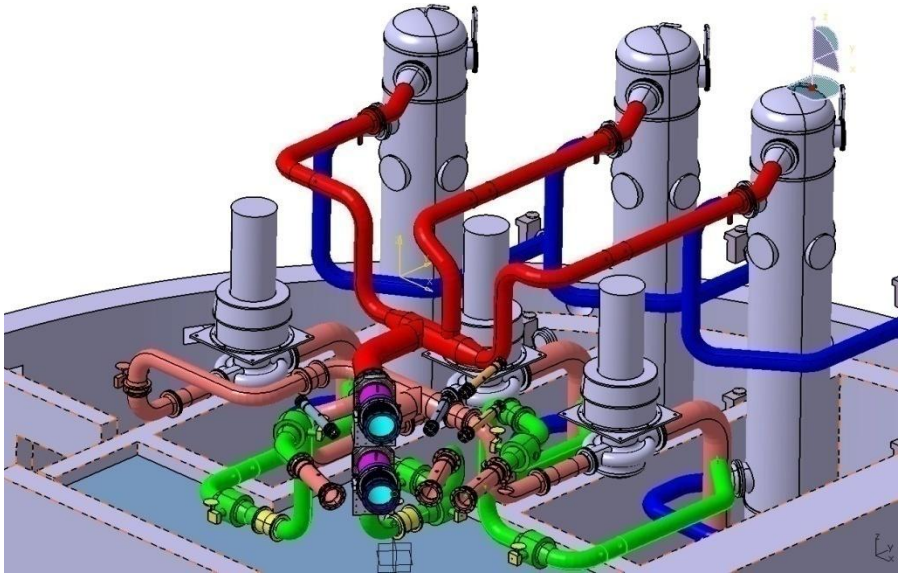
Heat Exchangers CONCEPT

Initial Scope:

- Design, manufacturing and supply of Three (3) Heat Exchangers for Primary Circuit
- Factory Test
- Transport to Cadarach

Additional scope :

- Role of “fabricant”
- Multiple mods of specifications
- Installation (Tools + Design and execution)
- Participation in onsite test



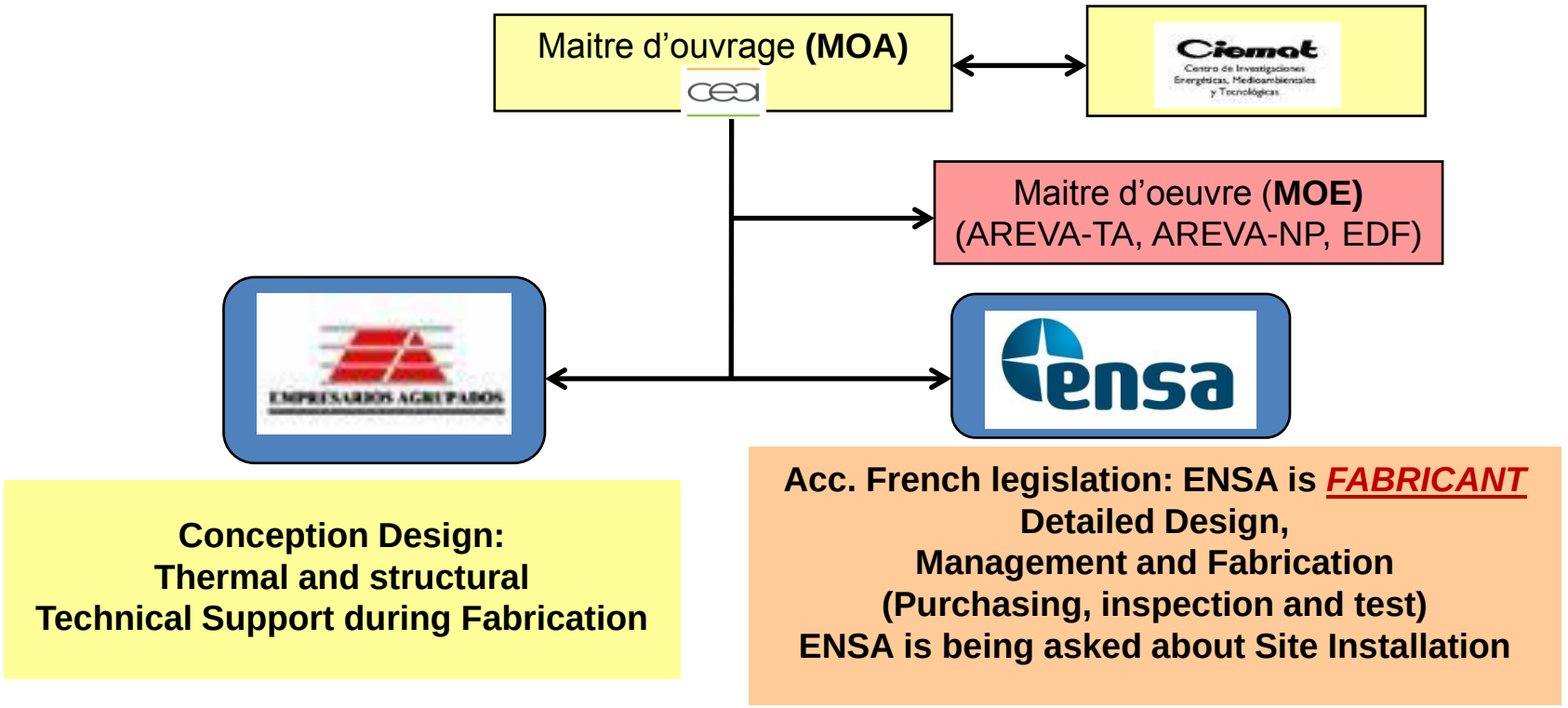
General view of complete RPP

OBJETIVES:

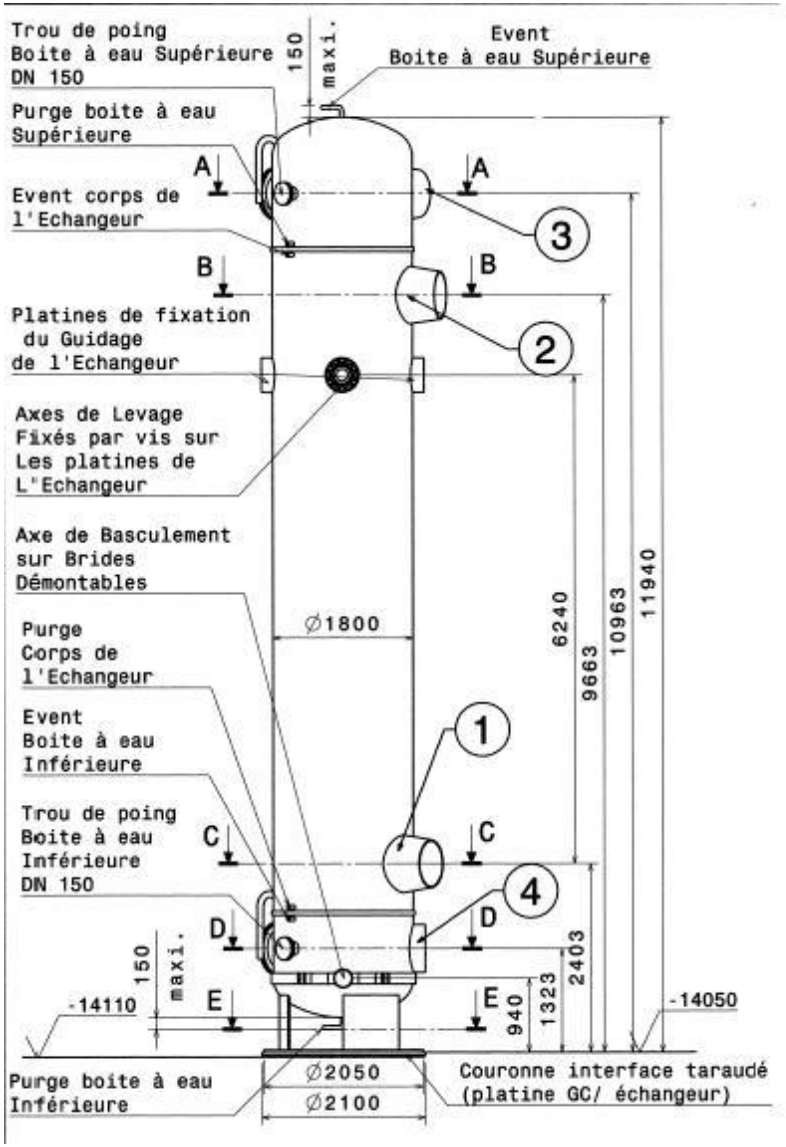
1. To guarantee a thermal power of 110MWt (36,67 MW) under normal conditions of primary and secondary circuit
2. To act like secondary barrel of primary fluids

Heat Exchangers

Organization Chart



Heat Exchangers



TECHNICAL CHARACT.

- **Material:** Stainless Steel. Controlled Cobalt Content.
  acc/ RCC MX: Class 1: Co<0.20%
- **Power:** 110MW_t (37 MW)
- **Flow:** 2600 m3/h
- ≈5800 expanded and tightening welded tubes
- T_{inlet}: 41º C / T_{outlet} : 29ºC
- **Design life :** >50 years
- Weight (empty): 33 ton

STANDARDS AND CODES

- **RCC-MX Ed.2008**: French Rules for conception and construction materials on experimental reactors (France).
- **ESPN**: additional French nuclear classification on PED Directive (97/23/CE)

  ➔ **Level 2 Category II** **QA Module: G**
- Several French articles and decrees

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