DE LA RECHERCHE À L'INDUSTRIE

CEA R&D STRATEGY

THE ESSENTIAL TOOLS TO SUPPORT THE PRESENT AND PREPARE THE FUTURE OF NUCLEAR ENERGY

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CEA, FRANCE

OUTLINE

1. French Nuclear Energy Policy
2. CEA and the nuclear energy division (DEN).
3. The main missions of DEN and its tools.
4. JHR and ASTRID : international cooperation examples
5. Other important facilities, existing and in project.
6. An idea of the investment needed.

FRENCH ENERGY POLICY IS LINKED TO EUROPEAN ONE

France keeps heading fixed by the European Climate-Energy Package in 2020

Reduction by 20% of the consumption of primary energy

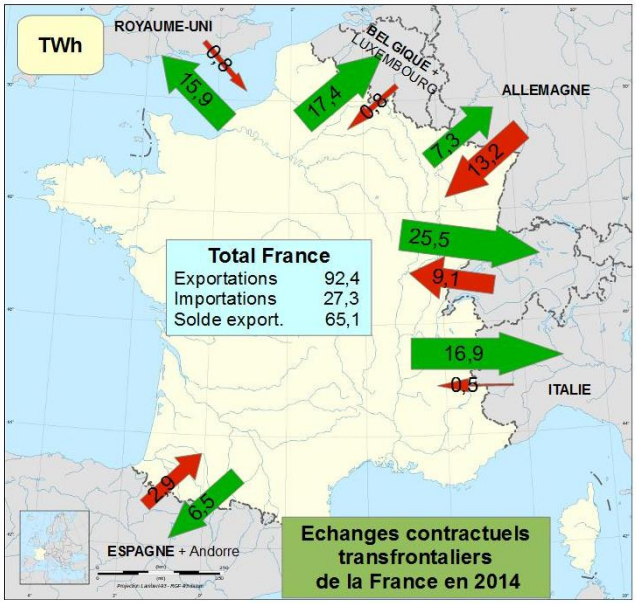
Reduction by 20% of GHG emissions (compared to 1990)

With a 20% share of renewable energy in the energy mix

Nuclear and Renewable :

- **Renewable: intermittent supply**
- **Nuclear energy: base-load supply**

France is integrated in the European grid : net exporter of electricity (65 TWh in 2014).



FRENCH TRANSITION ENERGY BILL : KEY-POINTS

- Reduction by 2030 of the use of fossil resources by 30% and of GHG by 40%, and halve the overall energy consumption in 2050 compared to 2012 level.
- Capping the installed nuclear capacity to the current level (63 GWe), and decrease the share of nuclear electricity from 75% to 50% by 2025.
- Establishment of a Multi Annual Energy Plan (MEP), revised every 5 years, that sets the evolution of Energy mix.
- Additionally : EPR in Flamanville will be achieved, closed MOX fuel cycle is confirmed, CIGEO (deep geological repository) is confirmed.

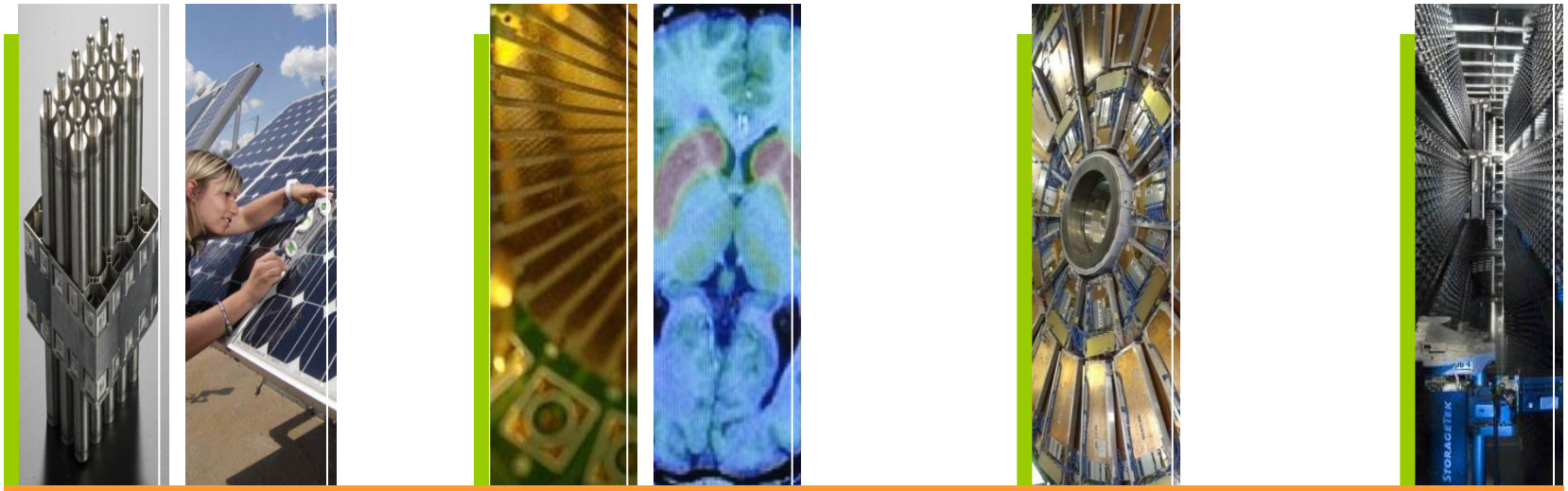
THE CEA MAIN MISSIONS

Low-Carbon Energies

Information and Health Technologies

Very Large Scale Facilities

Defence and Global Security



Basic Research
≃ 30% of the subsidies

Training and dissemination of knowledge

Technology development and transfer

THE CEA NUCLEAR ENERGY DIVISION

Nuclear Energy

- Support current nuclear energy industry
- Take part in the development of future industrial nuclear systems

Dismantling/Decommissioning

- Clean-up and dismantling nuclear facilities at the end of their life cycle

Valorization

- Provide to non nuclear industry or the other CEA divisions our skills and our tools

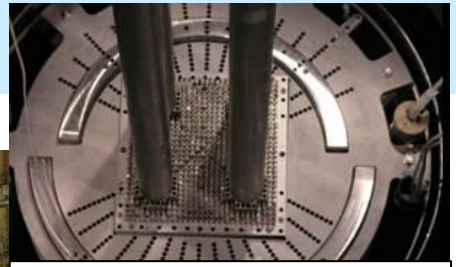
Training

- Make up skills in the nuclear energy field

SUSTAINABLE DEVELOPMENT OF NUCLEAR: KEY R&D ISSUES

Reactors

- Extending the operating lifetime of nuclear power plants
- Improving their performance levels (availability, etc.)
- Increasing their nuclear safety levels

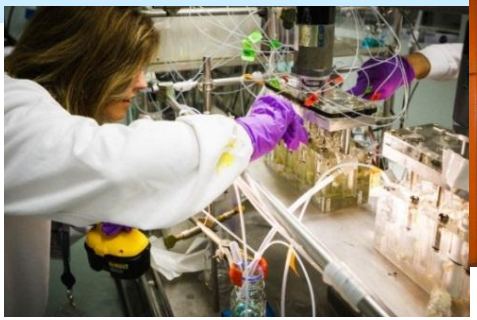


Studying the fluence absorbed by the 1300 MWe reactor vessels in EOLE

Investigation of irradiated materials and fuels at the Saclay centre

Cycle

- Meeting industry needs in a highly competitive market
- Supporting the recycling industry (La Hague & Melox), radwaste producers and Andra
- Preparing efficient new processes
- Promoting CEA developments in the international arena

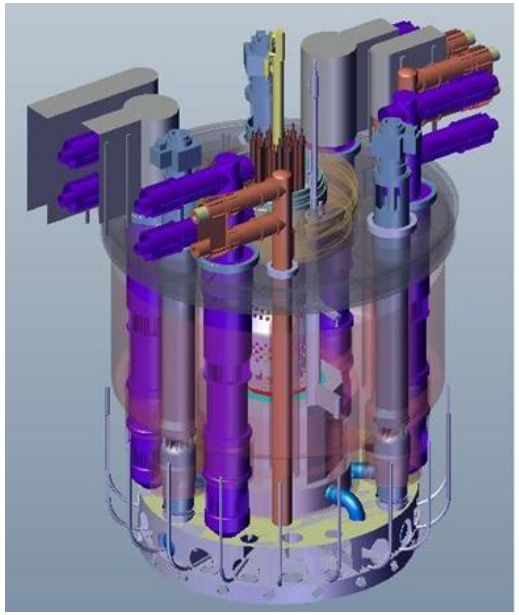


Platform of mixers and settlers to validate the performance of the selective uranium extraction process on a laboratory scale

General view of the evolving vitrification prototype equipped with a cold crucible melter adapted for nuclear environments at Marcoule

GEN IV NUCLEAR SYSTEMS: ASTRID PROJECT

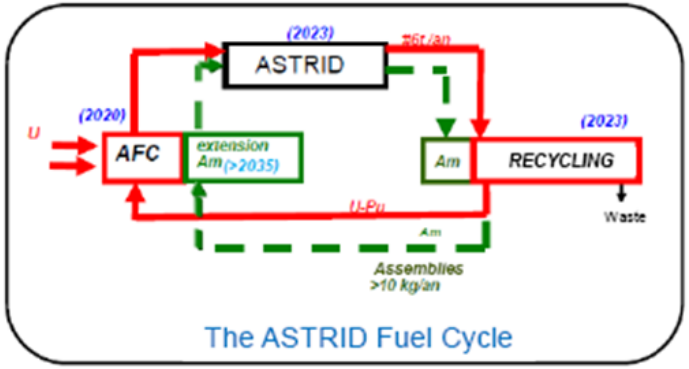
ASTRID - PRELIMINARY DESIGN CHOICES



Main features

- 1500 thMW - ~600 eMW
- Pool type reactor
- With an intermediate sodium circuit
- High level expectations in terms of safety demonstration
- Preliminary strategy for severe accidents (core catcher…)
- Diversified decay heat removal systems
- Oxide fuel UO2-PuO2 for starting cores
- Transmutation capability
- Fuel handling in sodium

ASTRID FUEL CYCLE DEVELOPMENT



ASTRID FUEL Fabrication Facilities

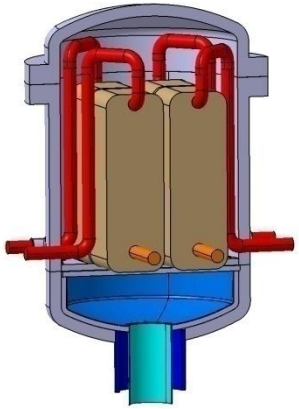
AFC Project (# 10 t/y), several scenarios under assessment

SFR closed cycle demonstration (U and Pu multi-recycling):

ATC, a Specific Engineering Scale Facility, or adaptation of the La Hague Head End (shearing and dissolution)

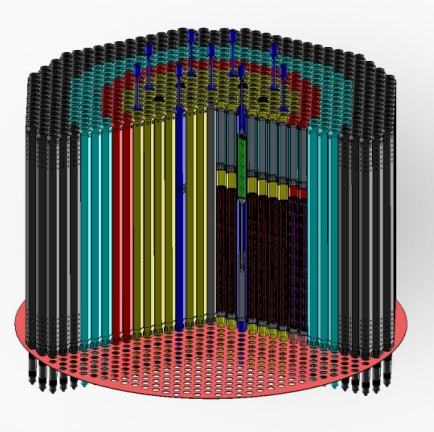
M.A. transmutation demonstration: Extension of the AFC

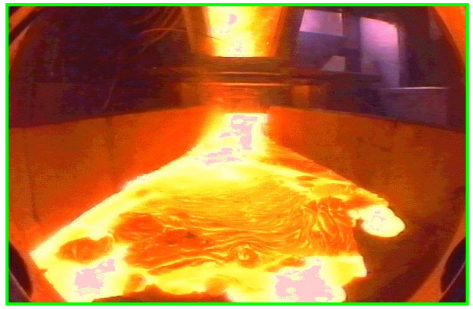
ASTRID MAIN INNOVATIVE CONCEPTS



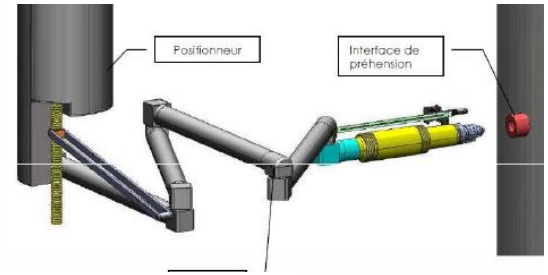
Nitrogen tertiary loop to eliminate sodium/water interaction

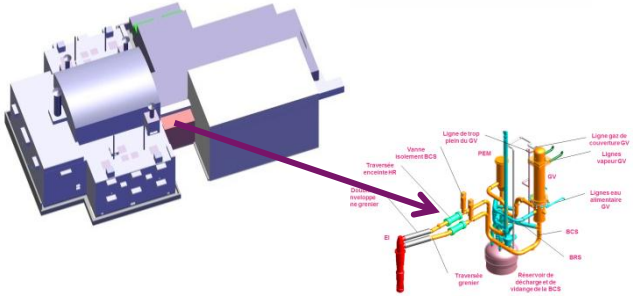
Improved safety core (« CFV »), patented by CEA-AREVA-EDF





In Service Inspection and Repair (ISIR) designed by conception





No early or major releases in case of severe accidents

Reinforce the containment

International cooperation on ASTRID

R&D COOPERATION	INDUSTRIAL COOPERATION
AREVA - FRANCE	AREVA NP - FRANCE
EDF - FRANCE	ALSTOM - FRANCE
ROSATOM - RUSSIA	COMEX NUCLEAIRE - FRANCE
DOE – UNITED STATES	EDF SEPTEN - FRANCE
JAEA - JAPAN	BOUYGUES - FRANCE
CAEA - CHINA	TOSHIBA – JAPAN
IGCAR - INDIA	ROLLS ROYCE - UNITED KINGDOM
KIT – GERMANY	ALCEN – FRANCE
NNL - UNITED KINGDOM	ASTRIUM - FRANCE
BRITISH UNIVERSITIES – UNITED KINGDO	JACOBS - FRANCE
JRC – EUROPEAN UNION	

MAIN COUNTRIES INVOLVED
RUSSIA
UNITED STATES
JAPAN
CHINA
INDIA
GERMANY
UNITED KINGDOM
EUROPEAN UNION

TOMORROW : JHR Reactor

A high performance material testing reactor under construction

JHR : an original international user facility model

- **Participation to funding through right of access to experimental capacity during the reactor lifetime**
- **20% of right of access so acquired by foreign organizations**
- **In consideration for an extend of the model to a use by hot laboratories**

Objective of JHR

- **Offering capacity of experimental irradiation.** *(Study of materials and fuel behavior under irradiation)*
- **Produce radioelement for medical use** (25% - 50 % of European needs)
- Meet the needs of 2nd and 3rd generations and partly of the 4th generation of reactors, especially the **innovation of materials and fuels required by the various concepts of generation 4**

JHR consortium members	participation
EDF (France)	20%
AREVA (France)	10%
EURATOM/JRC (EU)	6%
SCK/CEN (Belgium)	2%
NRI (Szech Republic)	2%
CIEMAT (Spain)	2%
VTT (Finland)	2%
Vattenfall (Sweden)	2%
DAE (India)	3%
IAEC (Israel)	2%
NNL (UK)	2%
CEA(France)	balance

NUCLEAR FISSION RESEARCH INFRASTRUCTURE ACCESS SCHEMES

JHR International Community example

- Yearly seminar,
- 3 working groups:
  - Fuel R&D issues,
  - Material R&D issues,
  - Technology issues for experimental devices),
- Secondee program.

JHR an International User Facility

- A key issue for future R&D in nuclear energy,
- Strong CEA intention to welcome Scientists, Engineers for a limiter period of time within JHR team for various topics (Secondee),
- Linked to Joint Programs in JHR.

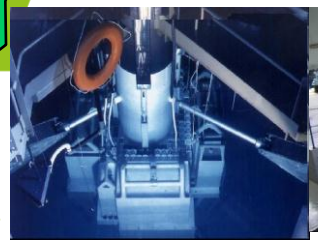
Long term relationship to learn best practices in Material and Fuel Sciences, Nuclear Safety Reactor Operation, Nuclear Technologies, …

TODAY : CEA offer within IAEA/ICERR centered on futur JHR and its ancillary facilities

LECI : Hot Lab on Materials

- Hands-On Training (Equipments)
- R&D Projects

ISIS: Education &Training



EOLE/MINERVE /(Zephyr)

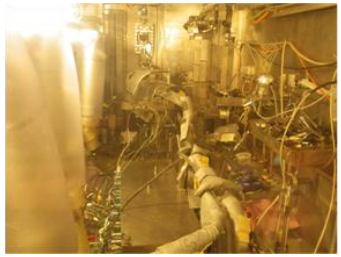
- Education &Training
- Hands-On Training
- R&D Projects

OSIRIS / (JHR)

- Hands-OnTraining
- R&D Projects

LECA : Mosaïc

- R&D Projects
- Hands-On Training (Equipments)



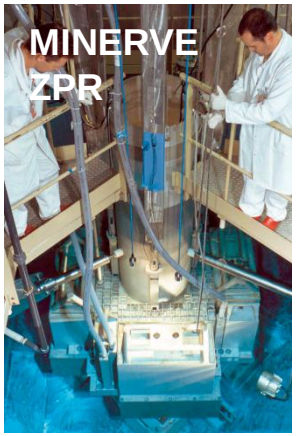
LARGE MULTIPURPOSE INFRASTRUCTURES FOR NUCLEAR DEVELOPMENT

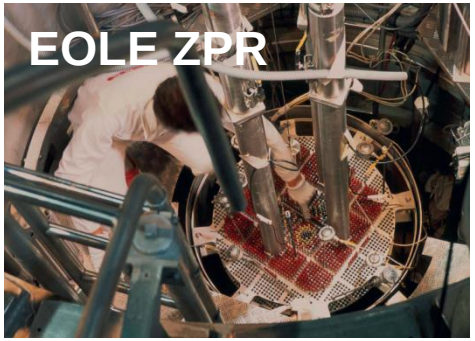
Operate large infrastructure for R&D activities

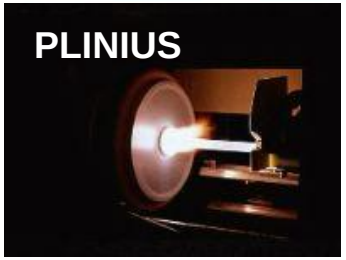
- Reactors
- Laboratories
- Experimental platforms

Renew the infrastructures to conduct the programs

- Satisfy administrative and legal constraints
- Keep the highest level of safety







NUCLEAR FISSION RESEARCH INFRASTRUCTURE NEEDS

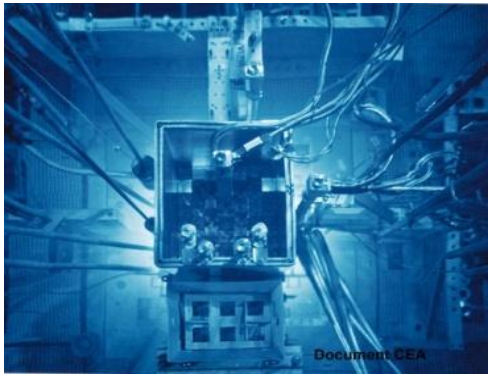
In terms of Infrastructures in France

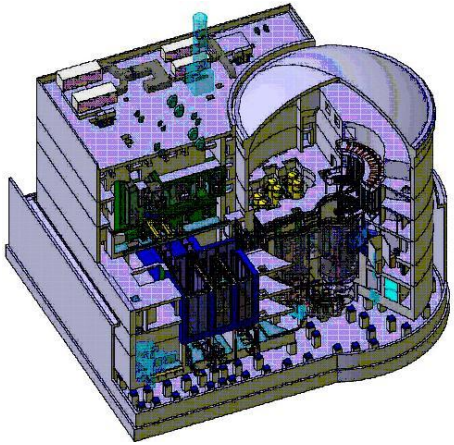
- Those different functions are realized by:
  - Material Testing Reactors (OSIRIS, then JHR), CABRI reactor (safety studies), irradiation means (JANNUS),
  - Hot laboratories LECI (materials) and LECA (fuels) then MOSAIC,
  - Back End Cycle studies hot laboratory (ATALANTE)
  - Zero Power critical mock-up (LWR : EOLE and MINERVE, then ZEPHYR / SFR : MASURCA)
  - Technological platforms :
    - Thermohydraulics (OMEGA)
    - Hydro-mechanics (HERMES for Fluid Induced Vibrations),
    - Mechanics (shaking tables for seism – TAMARIS, components – RESEDA),
    - Materials
    - Corrosion
    - Severe accidents (MISTRA – Hydrogen risk / PLINIUS – corium studies)

We cover the full scope

Infrastructures evolution in France

- Some infrastructures need to be replaced (safety requirements):
  - Material Testing Reactors: OSIRIS -> JHR (2019),
  - Hot laboratories LECA (fuels) -> MOSAIC (2024),
  - Severe accidents: PLINIUS -> PLINIUS 2,
  - ZPR : EOLE/MINERVE -> ZEPHYR (2024).



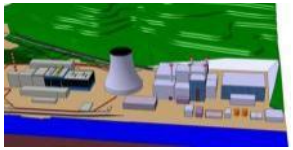


CEA EXPERIMENTAL PLATFORMS

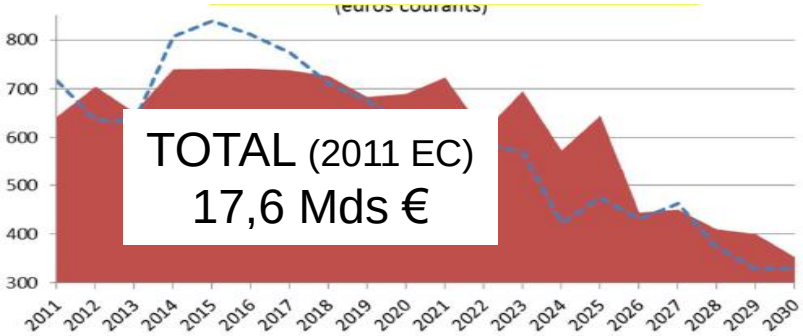
Needs	CEA Platform
Analytical water tests, TH code validation (gas entrainment, hot pool flows), Component qualification (ISIR)	**GISEH** : acronym for “Group Installations in Surrogate coolant for Hydraulics, thermal-hydraulics, mechanics, fluid-structure interaction” **Under construction**
Small Na loop (<3 m^3 Na) TH code validation and Component and technological qualification (under Na viewing)	**PAPIRUS** : acronym for “Parc of small Installation of R&d for Utilization of sodium Corrosion test, heat exchanger test, instrumentation… **90 % achieved**
Large Na loop (<100 m^3 Na) Component qualification (close to scale 1 prototypes)	**CHEOPS** : acronym for “Circuits et Hall d’Essais des grOs comPosants en Sodium” →Sodium-gas heat exchanger, S/A thermal-hydraulics, Control rods, passive shutdown system qualification, sodium handling, … **2019 : first test**
Severe Accidents corium behavior, Qualification of mitigation device (core catcher…)	**PLINIUS-2 :** experimental studies of corium-sodium-interaction and core catcher (100-300 kg of UO2), analytical test **2019 : first test**

FINANCIAL KEY POINTS OF THE NUCLEAR ENERGY DIVISION

- NUCLEAR ENERGY : 1390 M €
  - ✓ FUTURE INDUSTRIAL NUCLEAR SYSTEMS
    - – French state : 70%
    - – Nuclear Companies : 30%
  - ✓ OPTIMISATION OF CURRENT NUCLEAR SYSTEMS
    - – French state : 10%
    - – Nuclear Companies : 90%
  - ✓ LARGE MULTIPURPOSE INFRASTRUCTURES
    - – French state : 20%
    - – Nuclear Companies : 80%



- DISMANTLING AND DECOMMISSIONING
  - ✓ Dedicated funds : 90 %
  - ✓ Nuclear companies : 6%
  - ✓ Government: 4%



THANK YOU FOR ATTENTION