CEA R&D STRATEGY

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

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NUCLEAR ENERGY DIVISION
CEA, FRANCE

www.cea.fr
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.
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).
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
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
Reactors

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

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

Investigation of irradiated materials and fuels at the Saclay centre

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

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

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

Nitrogen tertiary loop to eliminate sodium/water interaction

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

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<tr>
<th>R&amp;D COOPERATION</th>
<th>INDUSTRIAL COOPERATION</th>
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<tbody>
<tr>
<td>AREVA - FRANCE</td>
<td>AREVA NP - FRANCE</td>
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<td>EDF - FRANCE</td>
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<td>BRITISH UNIVERSITIES – UNITED KINGDOM</td>
<td>JACOBS - FRANCE</td>
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<td>JRC – EUROPEAN UNION</td>
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### 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 2\(^{nd}\) and 3\(^{rd}\) generations and partly of the 4\(^{th}\) generation of reactors, especially the innovation of materials and fuels required by the various concepts of generation 4

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<tr>
<th>JHR consortium members</th>
<th>participation</th>
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<tr>
<td>EDF (France)</td>
<td>20%</td>
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<tr>
<td>AREVA (France)</td>
<td>10%</td>
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<tr>
<td>EURATOM/JRC (EU)</td>
<td>6%</td>
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<tr>
<td>SCK/CEN (Belgium)</td>
<td>2%</td>
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<tr>
<td>NRI (Szech Republic)</td>
<td>2%</td>
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<tr>
<td>CIEMAT (Spain)</td>
<td>2%</td>
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<td>VTT (Finland)</td>
<td>2%</td>
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<tr>
<td>Vattenfall (Sweden)</td>
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<tr>
<td>DAE (India)</td>
<td>3%</td>
</tr>
<tr>
<td>IAEC (Israel)</td>
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<tr>
<td>NNL (UK)</td>
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<tr>
<td>CEA(France)</td>
<td>balance</td>
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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 future JHR and its ancillary facilities

LECI : Hot Lab on Materials
- Hands-On Training (Equipments)
- R&D Projects

LECA : Mosaic
- R&D Projects
- Hands-On Training (Equipments)

ISIS : Education & Training

EOLE/MINERVE / (Zephyr)
- Education & Training
- Hands-On Training
- R&D Projects

OSIRIS / (JHR)
- Hands-On Training
- R&D Projects
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
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 ZEPHIR / 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

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<th>Needs</th>
<th>CEA Platform</th>
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| 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 m³ 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 m³ 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%

TOTAL (2011 EC) 17,6 Mds €
THANK YOU FOR ATTENTION