

DE LA RECHERCHE À L'INDUSTRIE

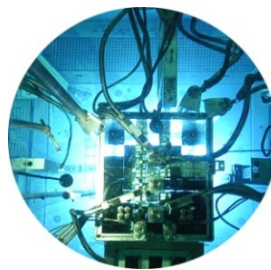
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# FROM RESEARCH TO INDUSTRY

*Alternative Energies and Atomic Energy Commission*



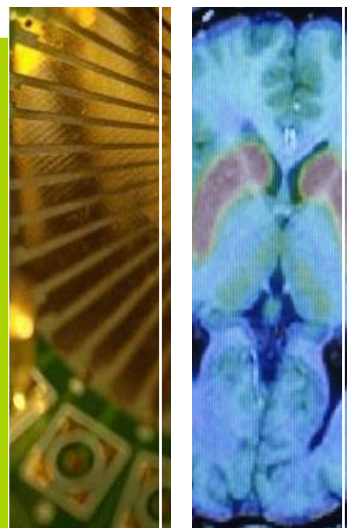
PHILIPPE DELAUNE  
DEPUTY DIRECTOR FOR INTERNATIONAL AFFAIRS



**Low-Carbon  
Energies**



**Information and  
HealthTechnologies**



**Very Large  
scale facilities**



**Defence and  
Global security**



**Fundamental Research**  
≈ 30% of the subsidies

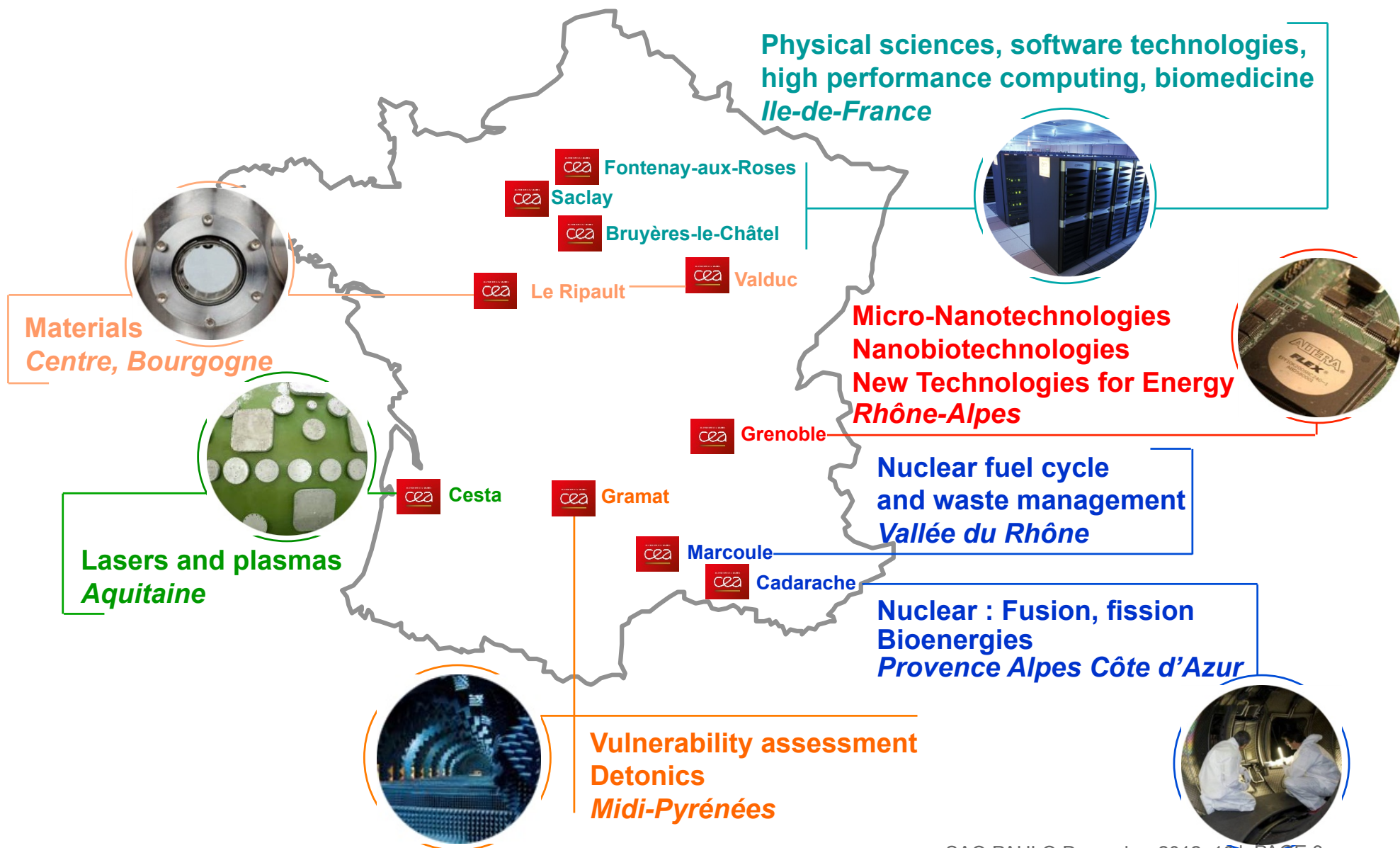
**Training and dissemination  
of knowledge**



**Technology development  
and transfer**

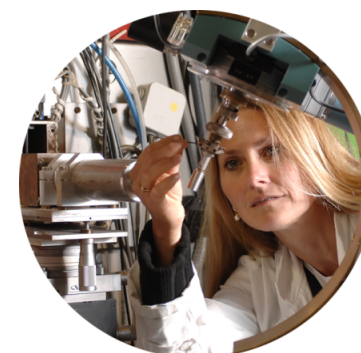


# 10 RESEARCH CENTRES IN FRANCE

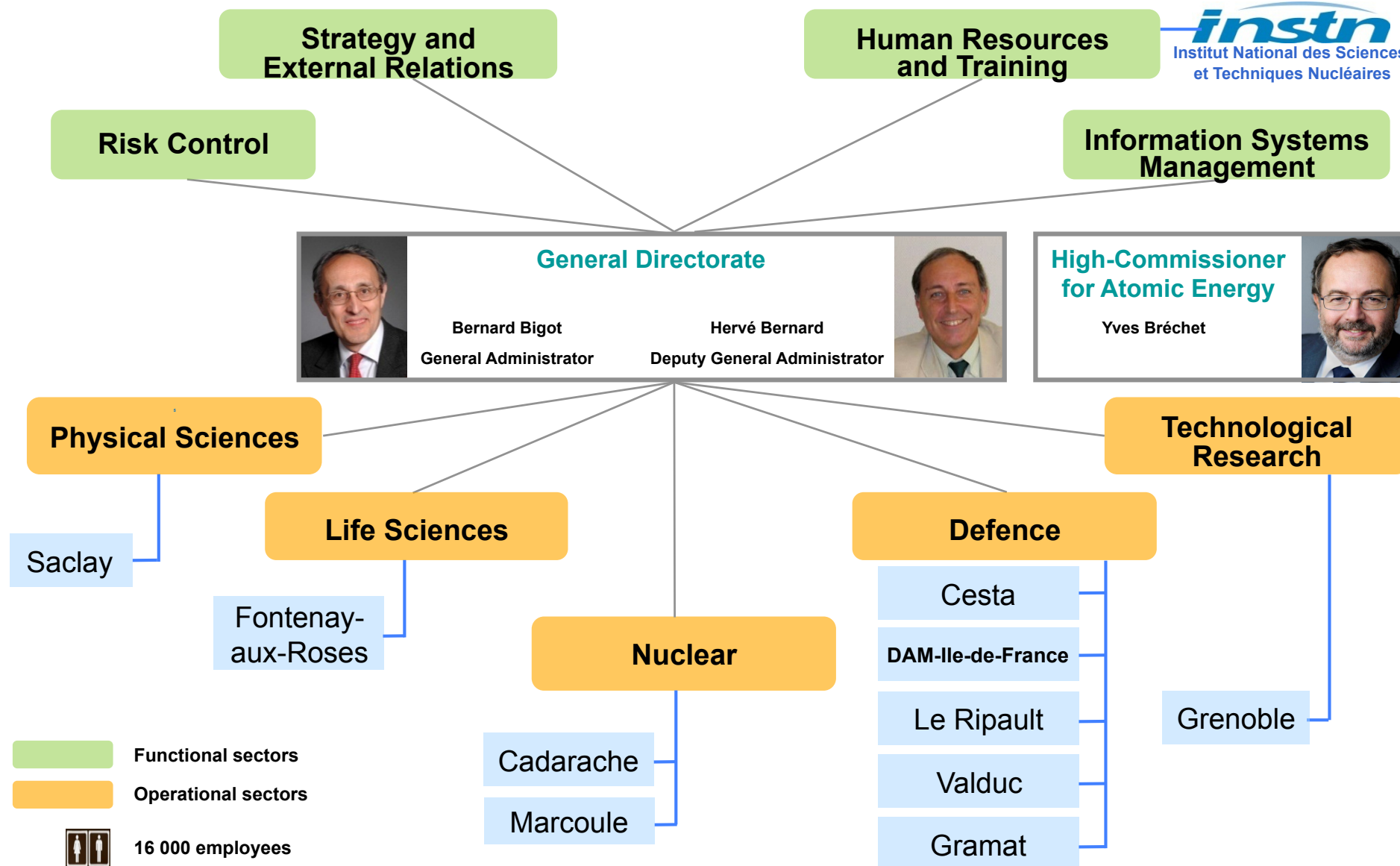


## KEY FIGURES 2011

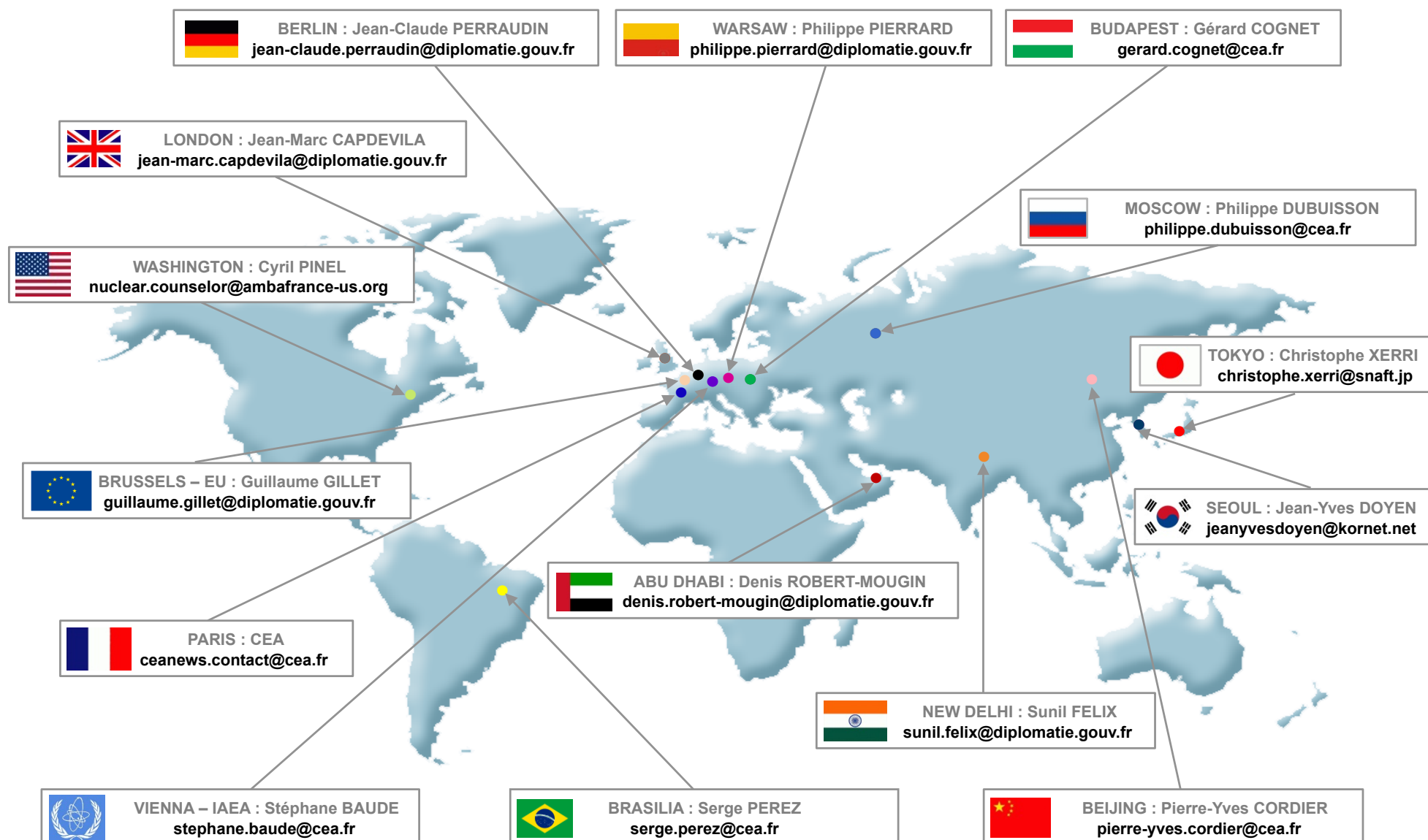
- 15 867 Employees
- 4,3 Md€ Civil and military budget
- 4 200 Patent families in portfolio
- 4 357 Scientific publications in 2010 (ISI base)
- 1 524 PhD students
- 665 Delivered priority patents : **3<sup>rd</sup> national depositant**
- 596 Current licence agreements
- 530 Projects financed by Europe (FP7)
- 150 Innovative technology start-ups created since 1984
- 55 Agreements with universities and research establishments
- 52 Joint research units
- 31 Competitiveness clusters
- 27 Correspondent Research Laboratories
- 27 Equipex
- 16 Labex



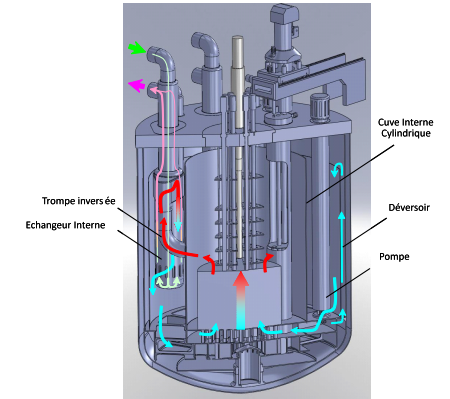
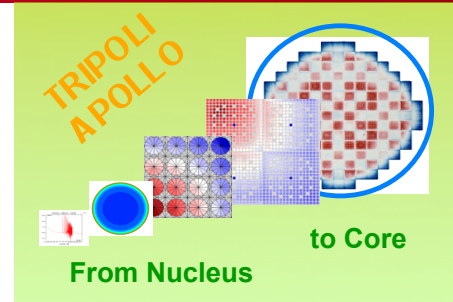
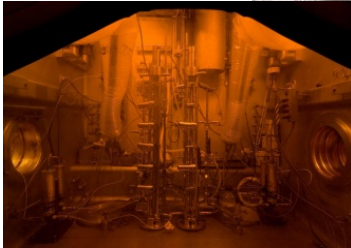
# ORGANIZATION



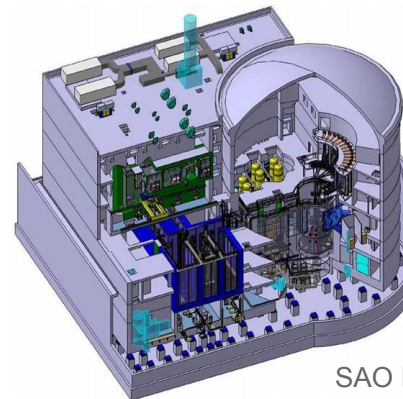
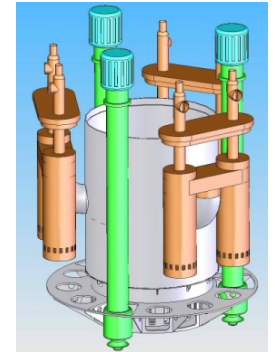
# NUCLEAR COUNSELORS NETWORK IN FRENCH EMBASSIES

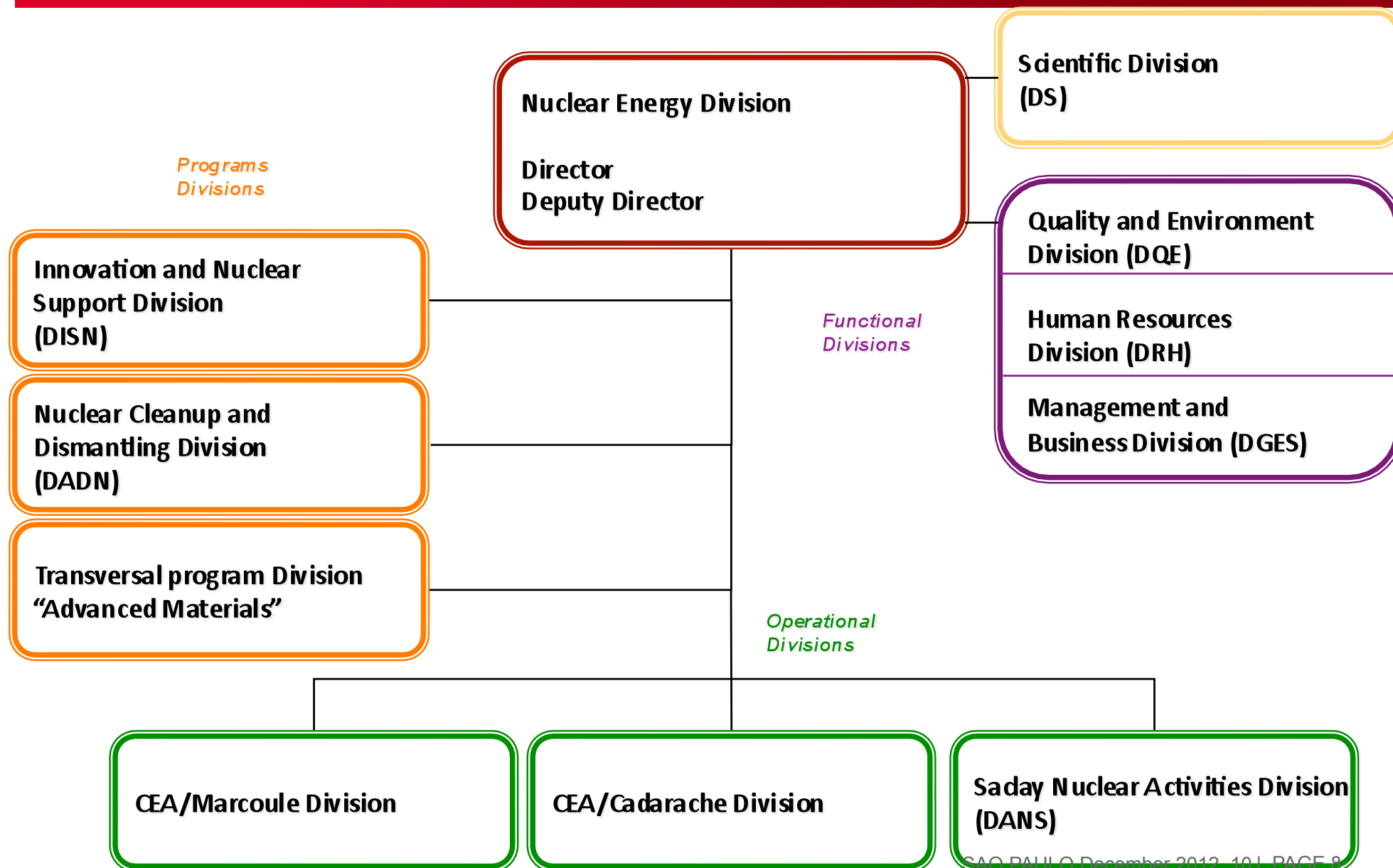


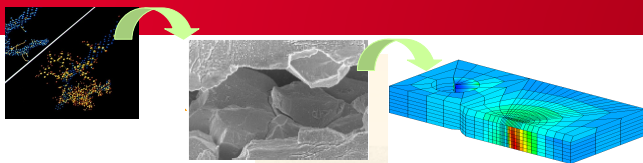




## R&D Strategy of the Nuclear Energy Division





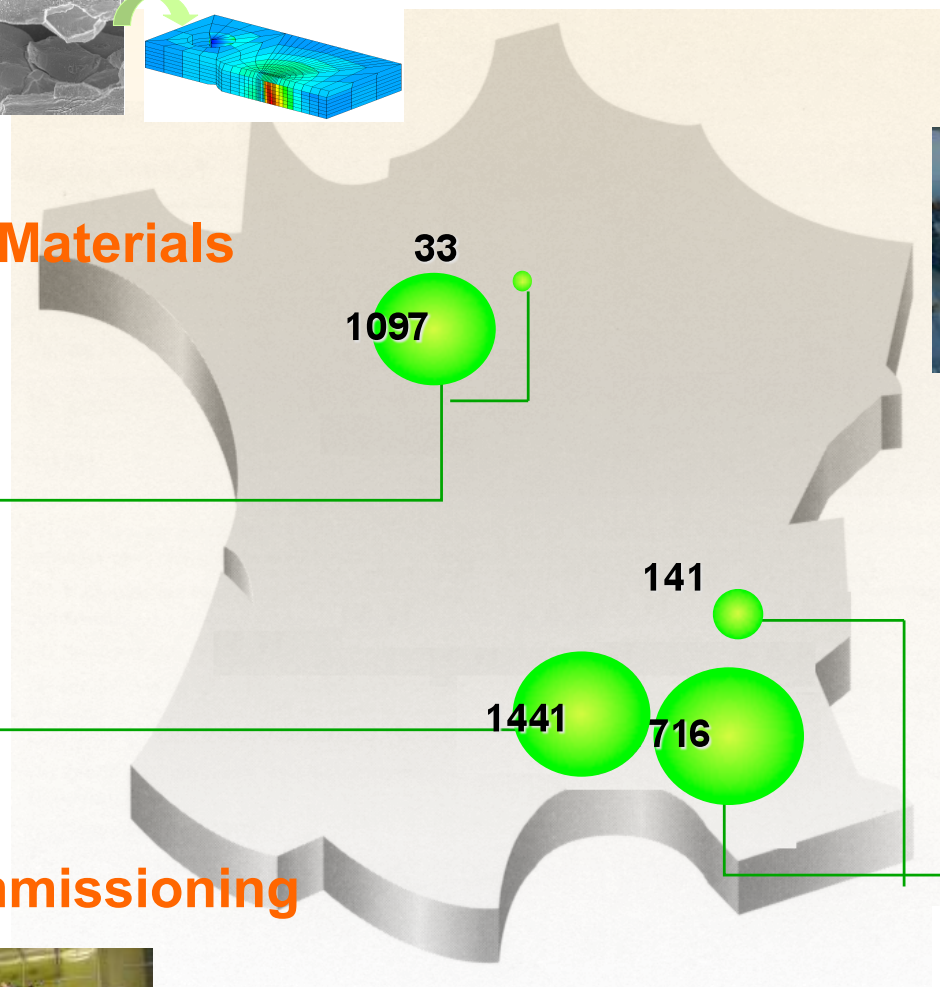


## Simulation, Advanced Nuclear Materials

**DANS**  
**SACLAY** (+ *Far*)

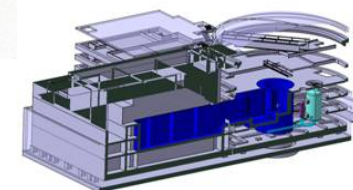
**MARCOULE**

## Nuclear fuel cycle, Dismantling/decommissioning



## Reactors

**CADARACHE**  
(+ *Grenoble*)



**JHR**



Programs

Nuclear  
EnergyDismantling  
DecommissioningBack-end of  
future Fuel CycleFront end of  
Fuel Cycle

Simulation

Research  
ValorizationDismantling  
Marcoule

4th Generation

2<sup>nd</sup> and 3<sup>rd</sup>  
Generation

JHR Reactor

Dismantling Saclay  
& FontenayScientific and  
Technologic  
Basic ResearchBack-end of  
present Fuel  
Cycle

Infrastructures

- Naval propulsion
- Fusion materials
- Facility management
- Industrial Nuclear applications
- Fight against proliferation
- ...

Dismantling  
Cadarache &  
GrenobleWaste  
ManagementWaste processing  
and storage  
facilities

Transport

Future Industrial  
Nuclear SystemsLarge multipurpos  
infrastructures  
for Nuclear  
Development



## 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

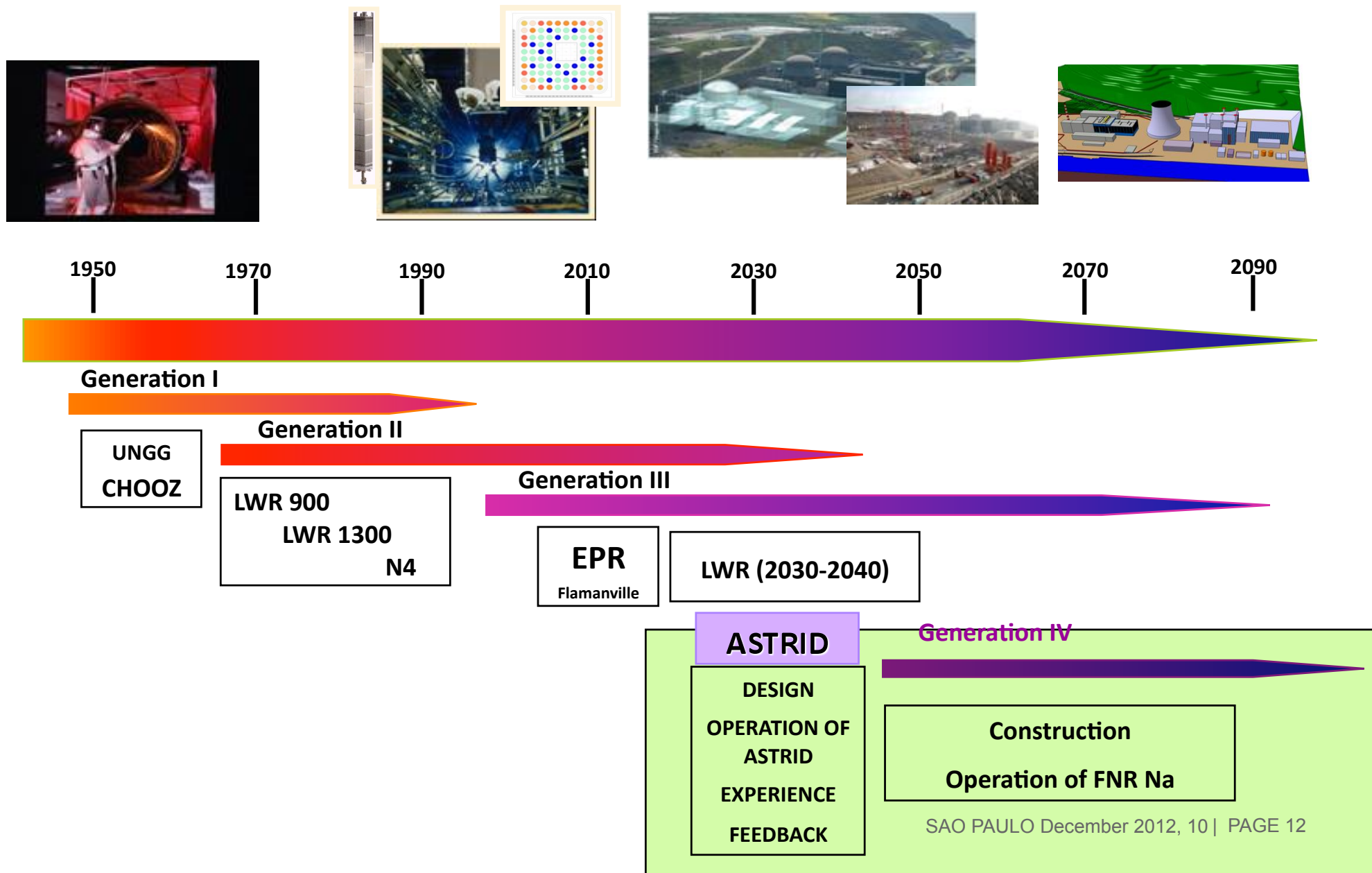
## Valorization

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

## Training

- ↪ Make up skills in the nuclear energy field

# Future Industrial Nuclear Systems

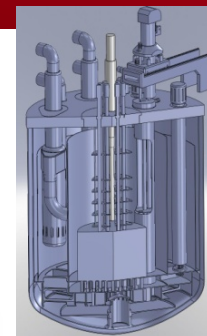


## *A fast neutron reactor for:*

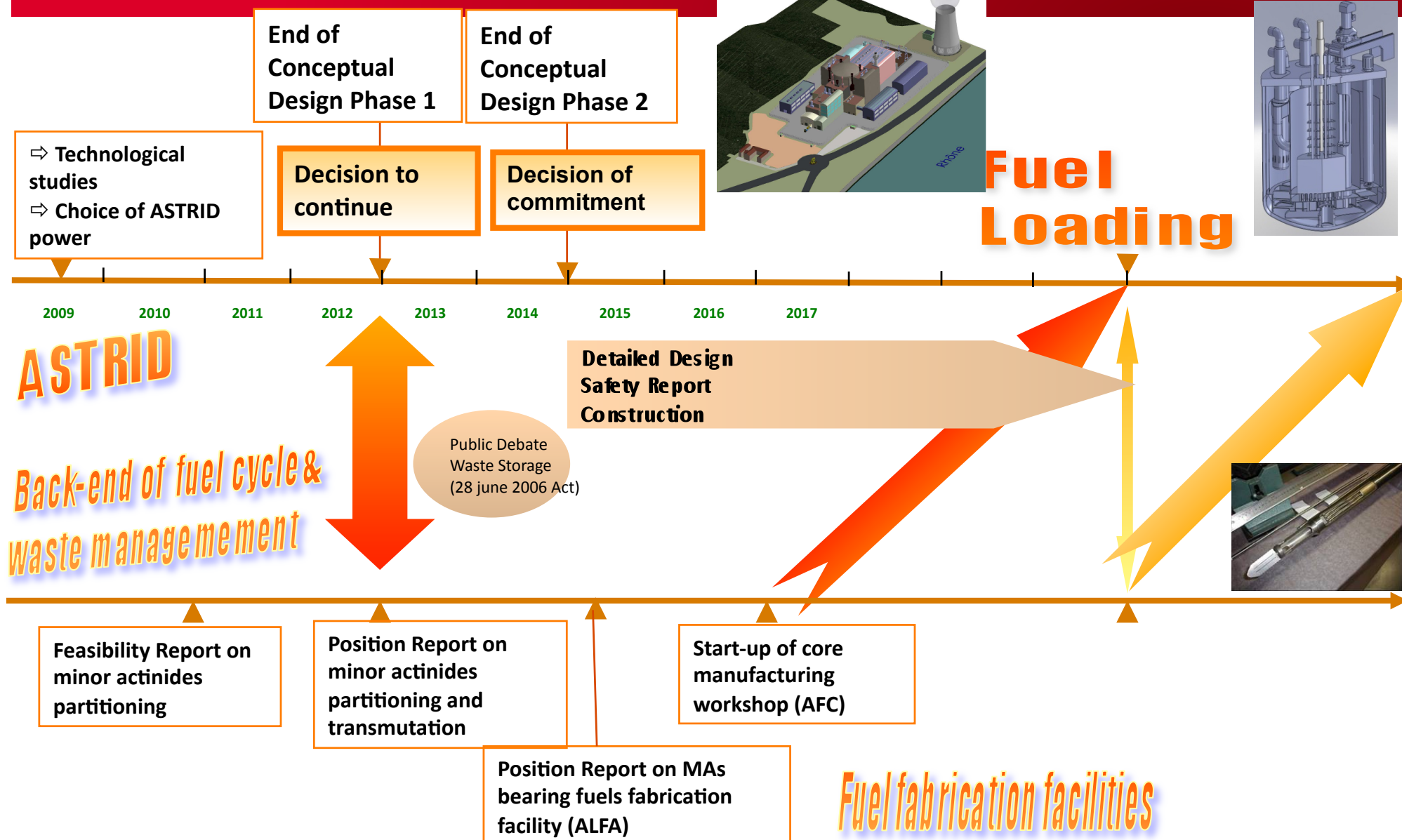
- **Total recycling of materials** 
- **Uranium resources conservation** 
- **Public acceptance → Separation/transmutation of minor actinides (28th June 2006 act)** 

**→ Development of reactors and back-end fuel cycle**

# ASTRID and associated facilities schedule

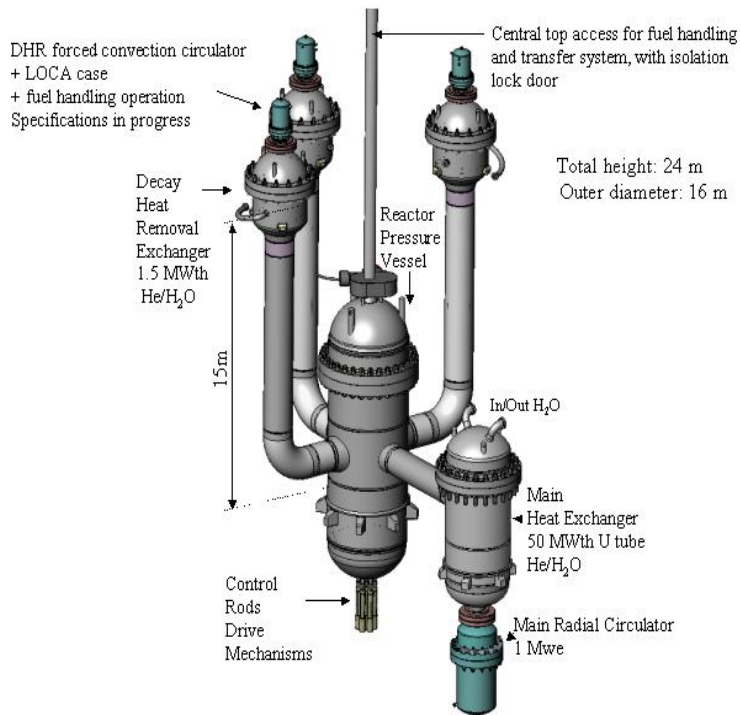


## Fuel Loading





# The Gas Fast Reactor (GFR)



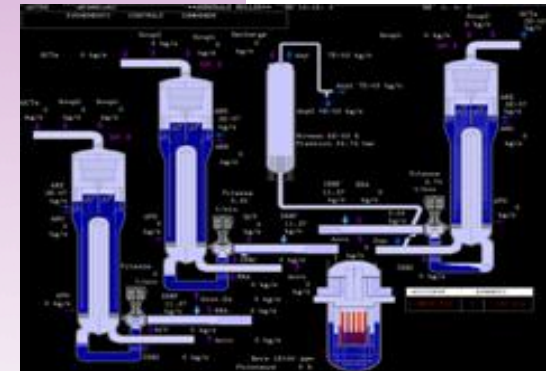
## OBJECTIVES

To concentrate on key technologies **(fuel and safety mainly)** and make **in Europe** the conditions favorable in 2012 for the launching of an experimental GFR **(ALLEGRO)**

**A 50-80 MWth reactor**

## Reactors and Fuel

- Increase Reactors Lifetime
- Improve Fuel Performances and Plant availability
- Improve Nuclear Power Plants Safety



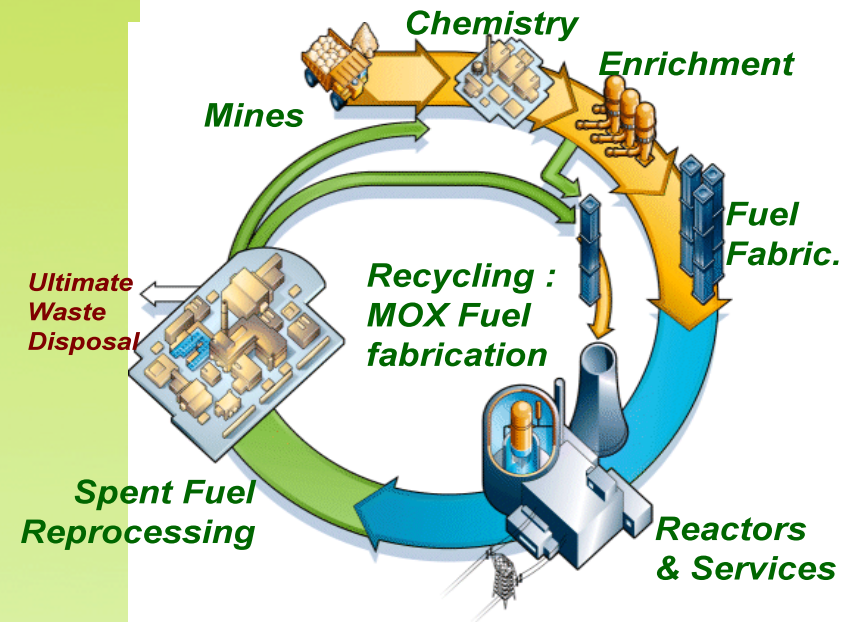
## Cycle

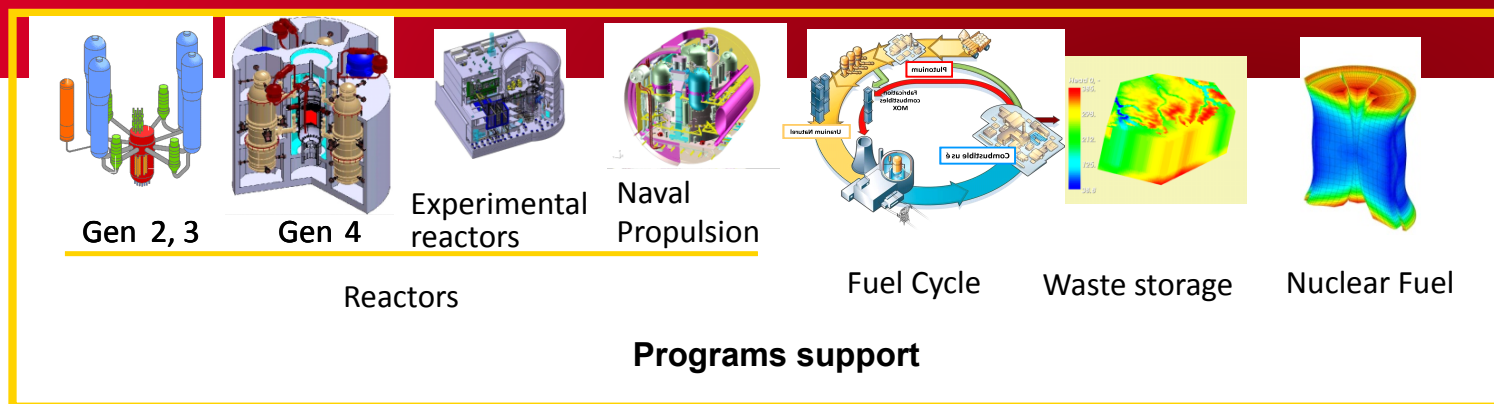
### Front-end Fuel Cycle

- improve the efficiency of extraction processes
- reduce environmental impact
- review isotope separation innovative processes

### Back-end Fuel Cycle

- keep on optimizing treatment processes and plants
- reduce environmental impact
- study waste conditioning and their behavior under repositories conditions



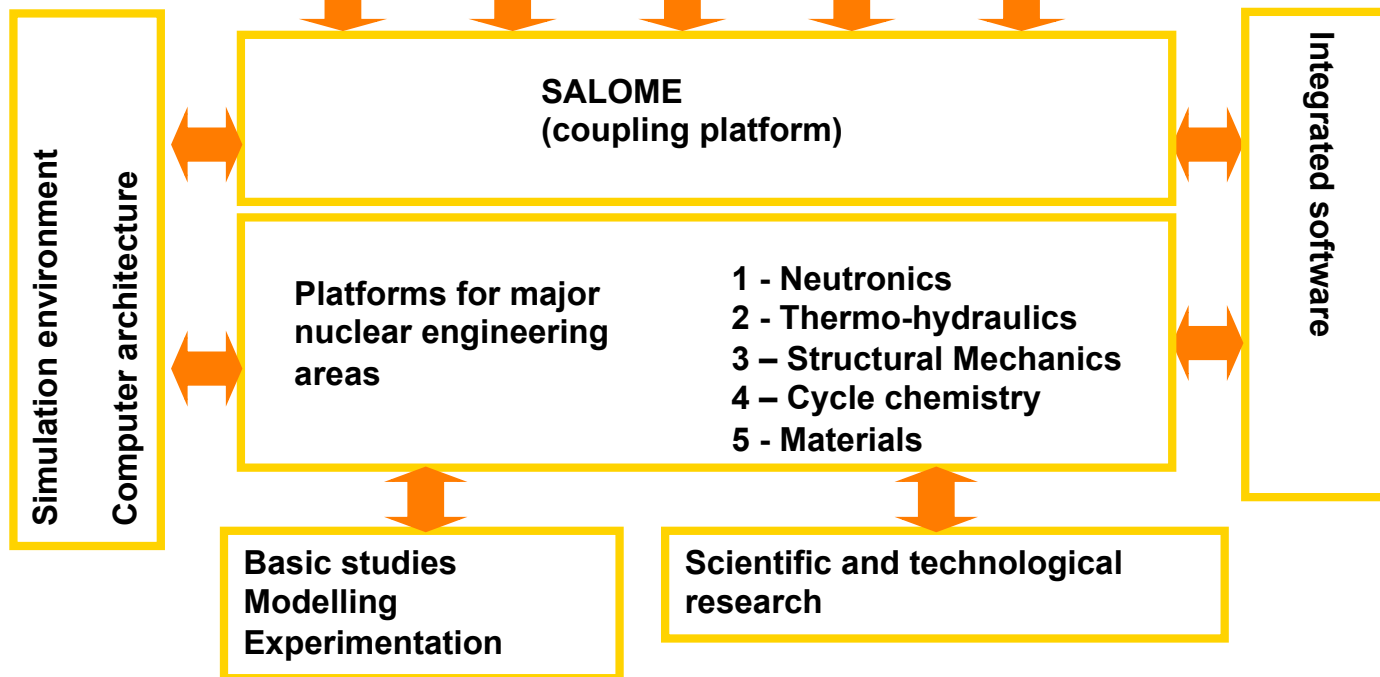


↪ Explore areas difficult to access by experimental means

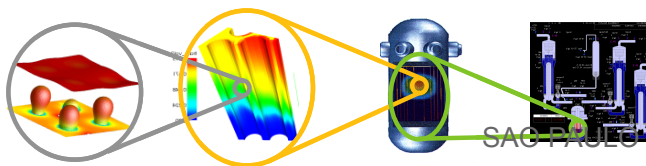
↪ Reduced research times

↪ Reduced investment costs

**Need to extend this activity**



**Multi-scale approach at 4 different levels**





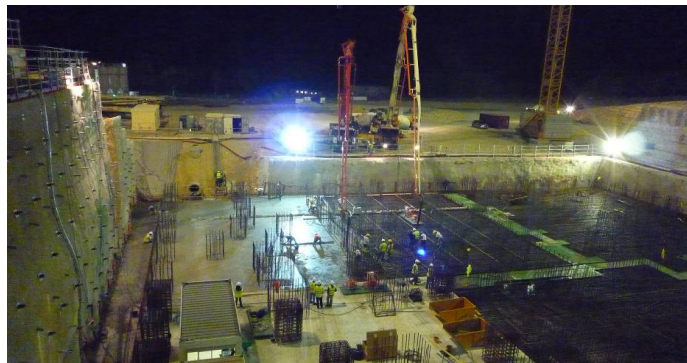
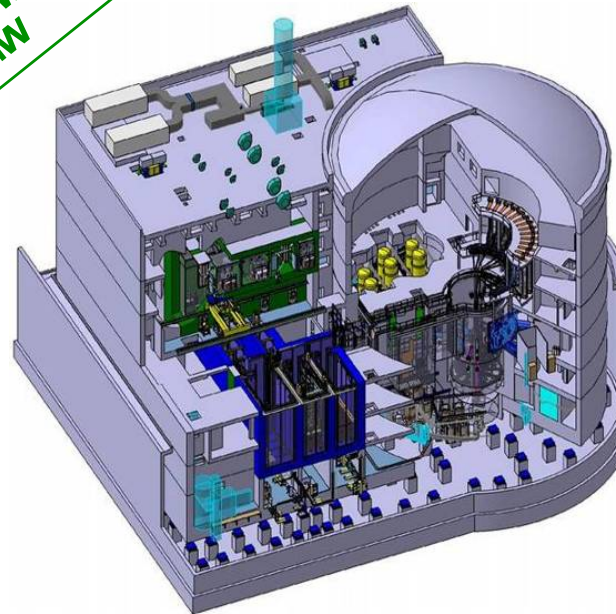
# JHR Reactor –

*A high performance material testing reactor under construction*

JHR power =  
100 MW



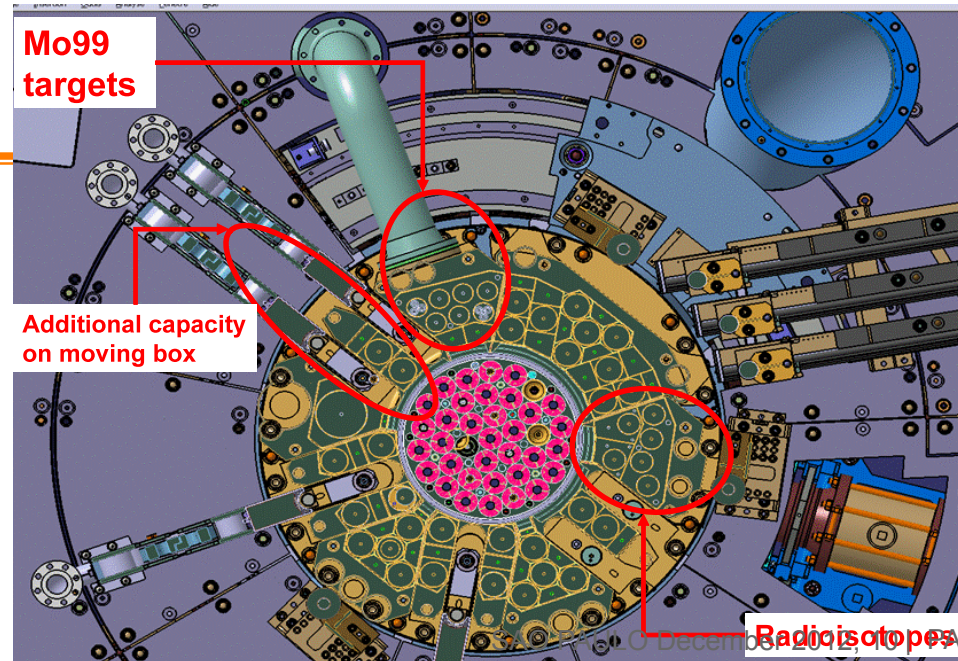
## Consortium Partnership and Associated Partners



EDF	20%
AREVA	10%
NRI (Czech Rep)	2 %
CIEMAT (Spain)	2 %
SCK (Belgium)	2 %
VTT (Finland)	2 %
IAEC (Israël)	2 %
DAE (India)	3 %
Vattenfall (Sweden)	2 %
Euratom	6 %

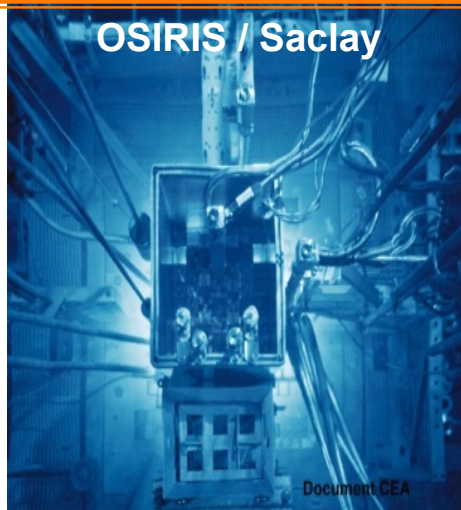
# JHR Reactor

- Research infrastructure to perform screening, qualification and safety experiments on material and fuel behavior under irradiation
- Significant production capacity to produce Radio Isotopes





- **Operate large Infrastructures** (reactors - labs - experimental platforms) **for R&D activities**
- **Renew the Infrastructures** to conduct new programs and satisfy administrative and legal constraints



**CADARACHE**



**CABRI**



## Goals

- A responsible waste management
- Clean-up and dismantling nuclear facilities at the end of their life cycle
- A program management taking into account technical and economical optimization

### ○ A responsible waste management



Intermediate-Level - Long Lived - Waste (ILW-LL) in hot cell



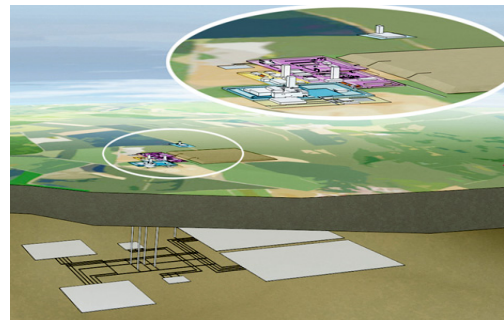
Conditioned waste in hot cell

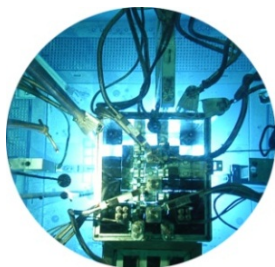


ILW-LL storage in CEDRA (CEA/Cadarache)



Future High Level Waste  
geological disposal





September 2012 - 10

# Thank you for your attention

# Obrigado por sua atenção

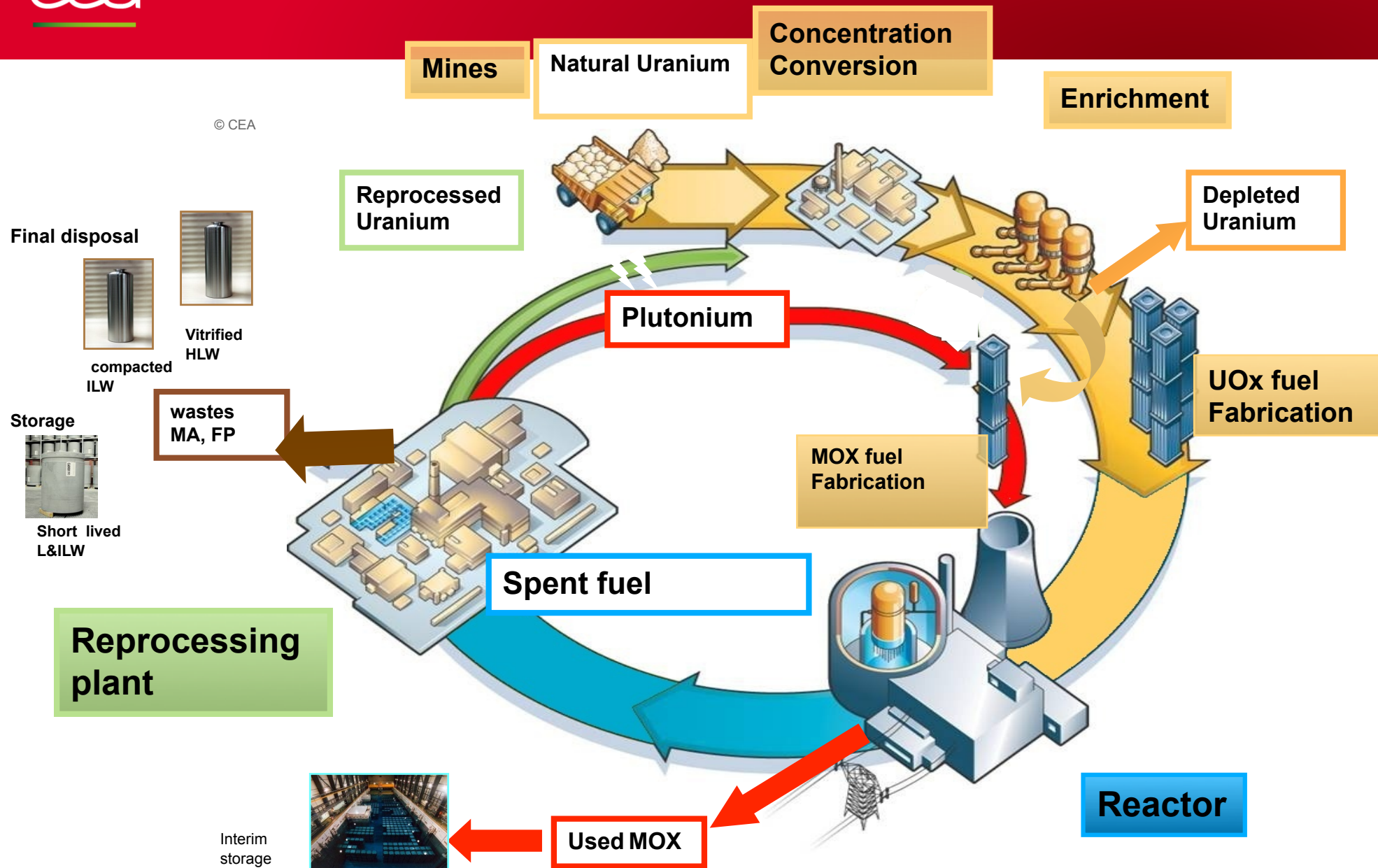
Commissariat à l'énergie atomique et aux énergies alternatives  
Centre de Saclay | 91191 Gif-sur-Yvette Cedex  
T. +33 (0)1 XX XX XX XX | F. +33 (0)1 XX XX XX XX

Direction  
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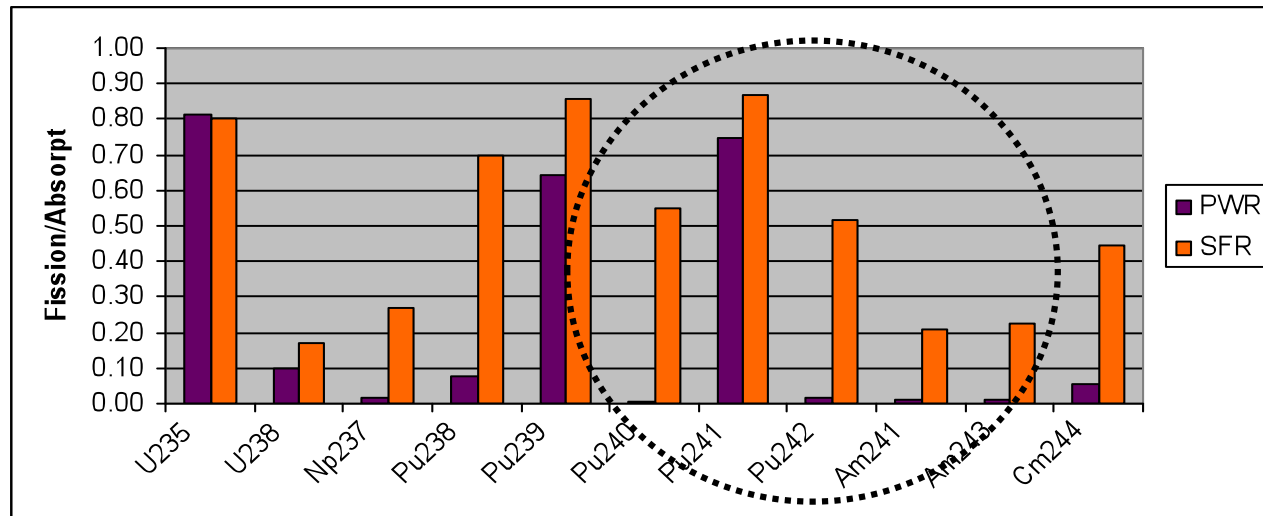
# French Strategy for fuel cycle



# PLUTONIUM MULTI-RECYCLING IN FAST REACTORS

**In Fast Reactors** : all plutonium isotopes are efficiently fissioned - **plutonium multi-recycling is possible**

**In Thermal Reactors** : plutonium recycling leads to the accumulation of isotopes greater than plutonium causing an **increase of plutonium stock**

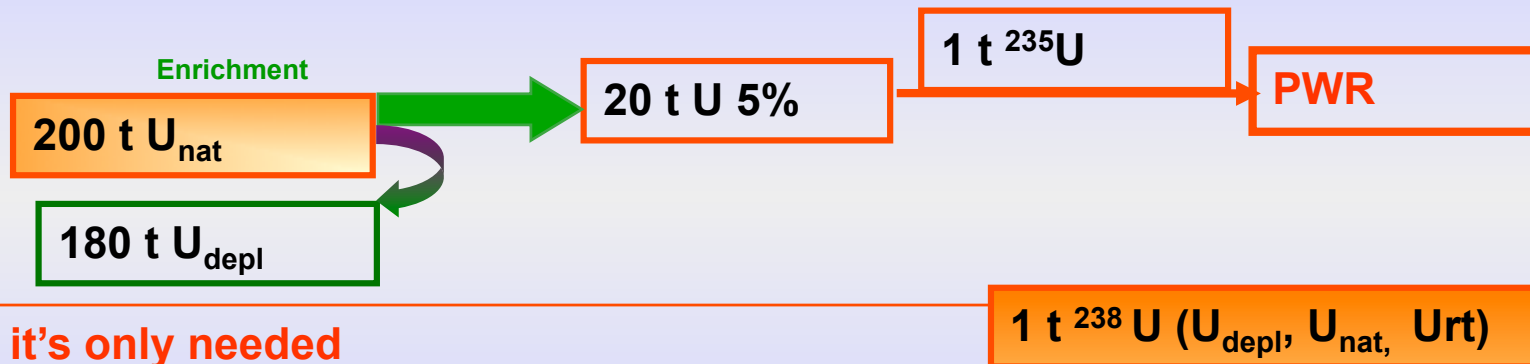


fission/absorption ratio for different elements in **PWR** and in **SFR**



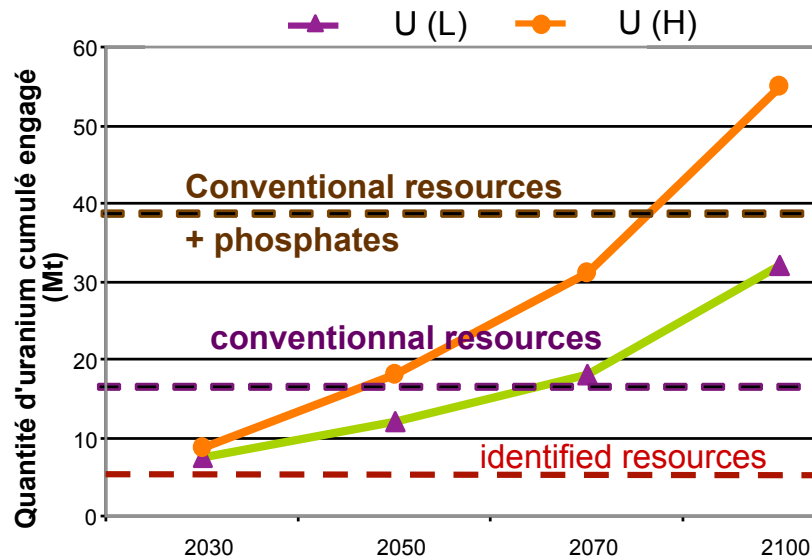
# Conservation of Uranium resource

IN A PWR, FOR 1 GWE X YEAR, IT'S NEEDED:

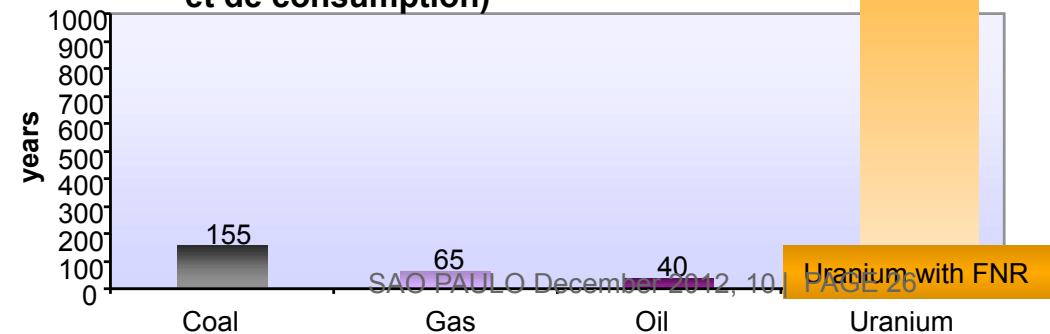


For FNR, it's only needed  
converted in plutonium and renewed

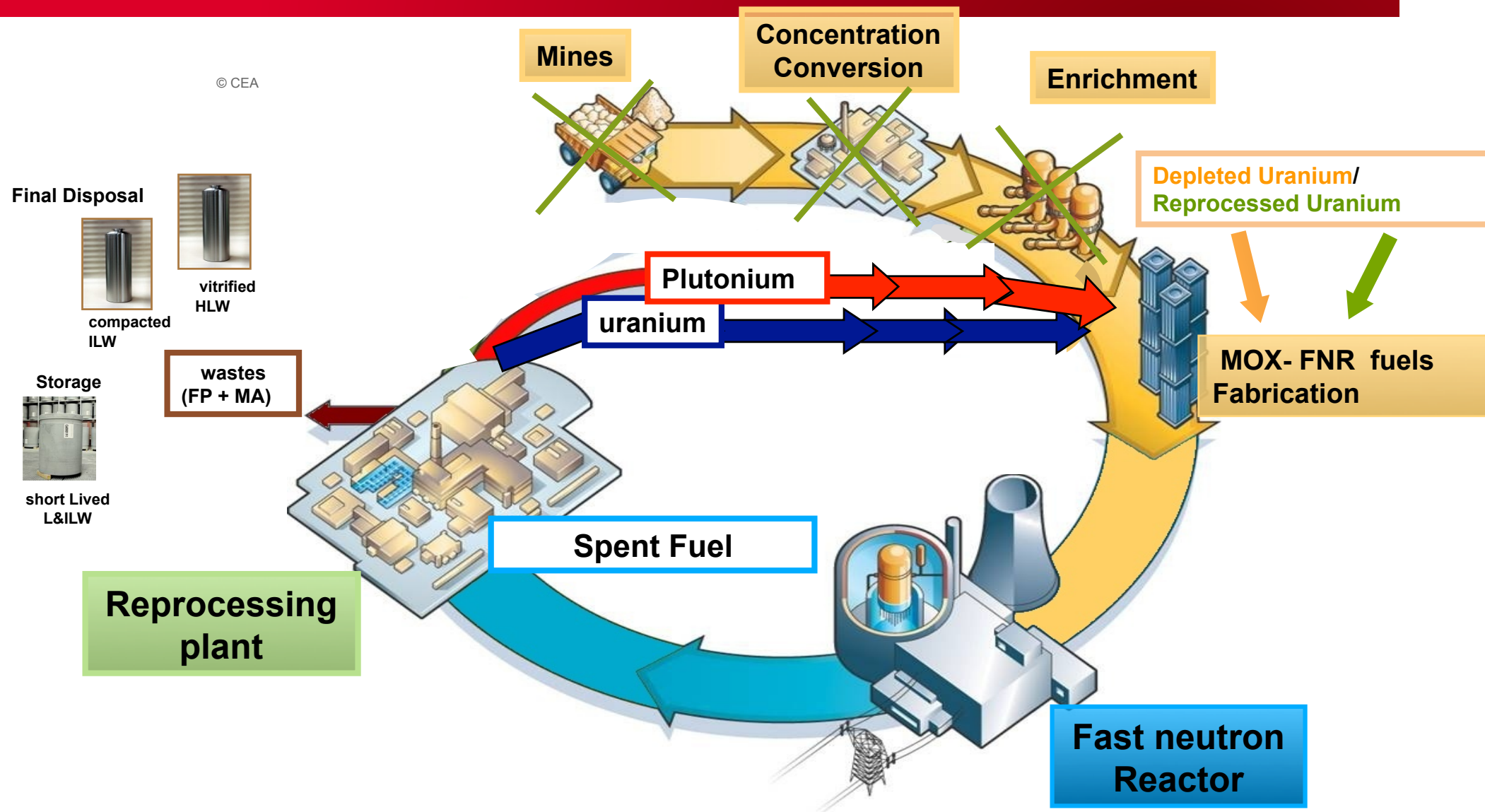
Use of uranium resources with PWR only  
for 2 scenarios (High and low)



Lifetime of natural resources  
(current rate of production  
et de consumption)

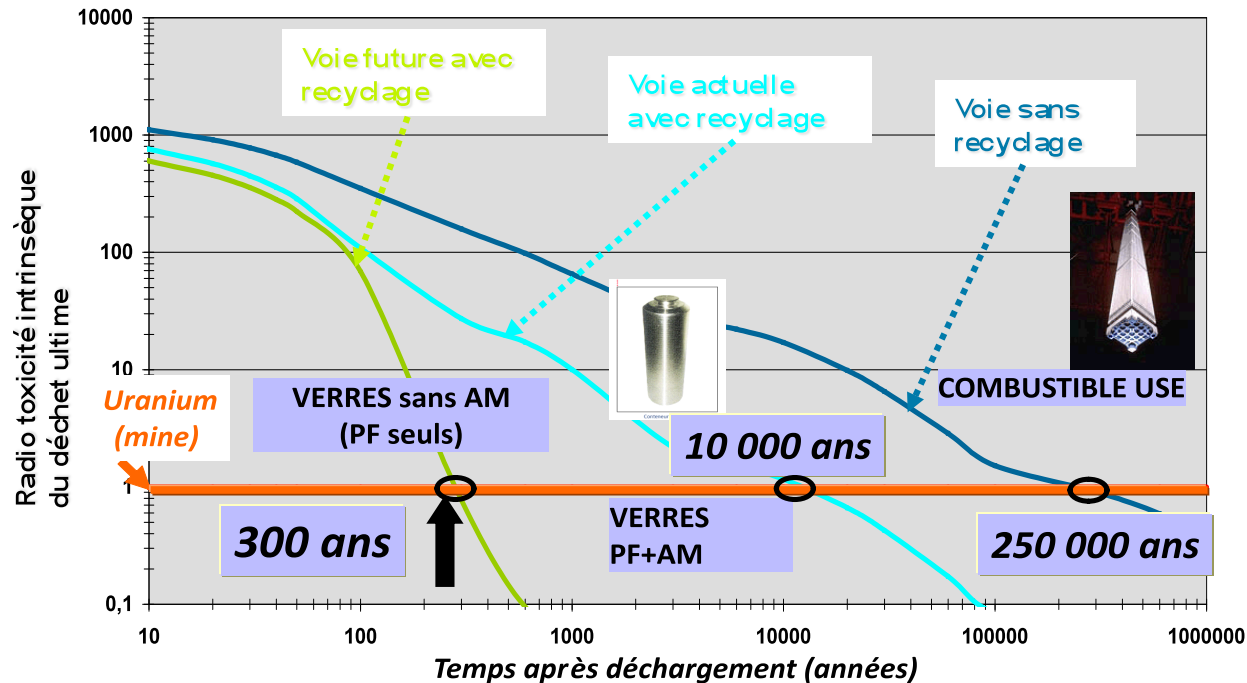


# Fuel Cycle for FNR



# Minor actinides Transmutation

→ decrease long-term radiotoxicity and thermal loading of ultimate wastes



→ Transmutation is a slow and complex process ;  
**fast neutrons systems are more appropriate.**

The fraction of fission is higher in a FNR

