Plutonium Management in France

Current Policy and Long Term Strategy for the Used Fuel Recycling by LWR and Fast Reactors

Christophe XERRI, Nuclear Counsellor

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RÉPUBLIQUE FRANÇAISE

The French nuclear fuel cycle's policy is based on two main principles

French Code of the Environment : reuse or recycling of waste must be a priority.

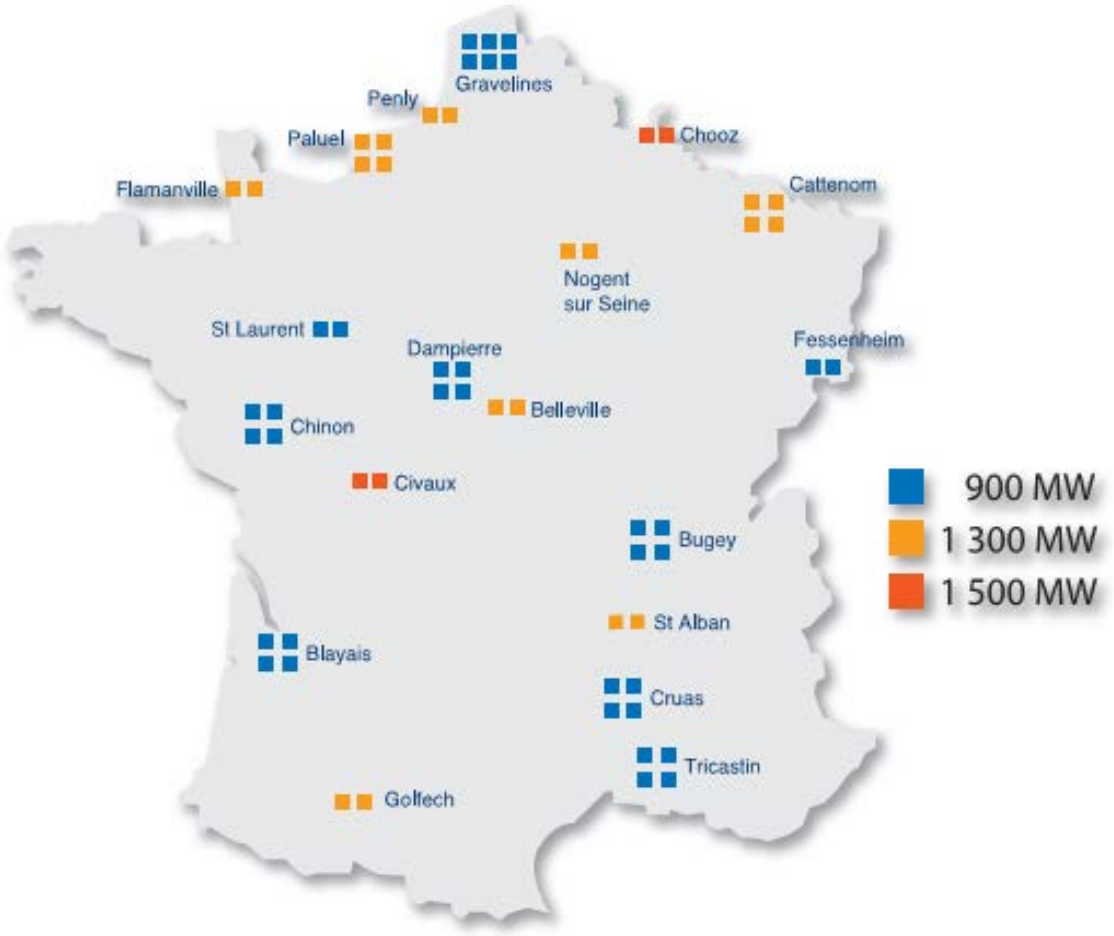
- Spare natural ressources
- Limitate the impact on the environment of waste disposal

Principle of non-proliferation : keep the stock of plutonium steady by recycling it.

resent

French Nuclear Fleet – 2013

One operator: EDF



19 stations

58 PWRs

+ 1 under construction

63 GWe

406 TWh/year*

Nuclear = 75% of production*

Nuclear + hydraulic = 90% of production*

* 2012, EDF

French Nuclear Fuel Cycle

- **Domestic Approach:**

-All **UOX** spent fuel recycled
  - in 22 LWR reactors
- **U** recycled (4 reactors licensed)
- **Pu** recycled (24 reactors licensed)

- **Providing services to international customers**
  - **Avoiding proliferation of sensitive facilities**
- **Enrichment**
- **Reprocessing and MOX fuel fabrication**

ENRICHMENT

Georges Besse II

Conversion

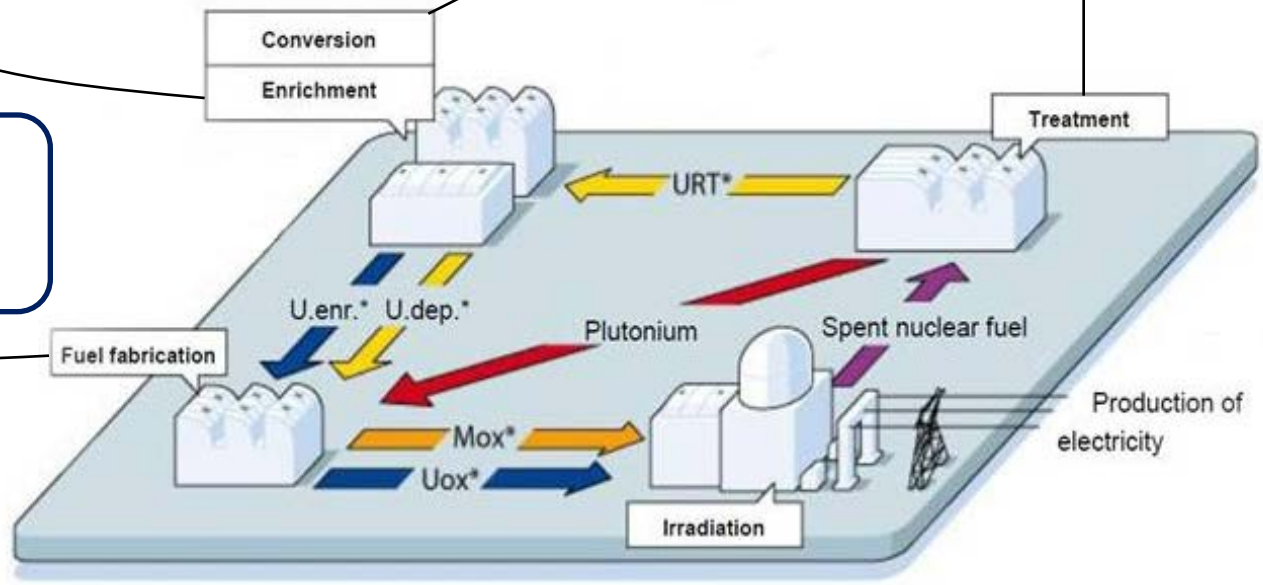
Comurhex I & II

REPROCESSING

La Hague

Fabrication and RECYCLING

Melox + Romans



RECYCLING STRATEGY :THE RATIONALE

- **saving uranium resources**
(#10% of French nuclear electricity from MOX fuels)

- **safe & secure *ultimate waste without plutonium*;**
(volume , heat load , radiotoxicity decreased)

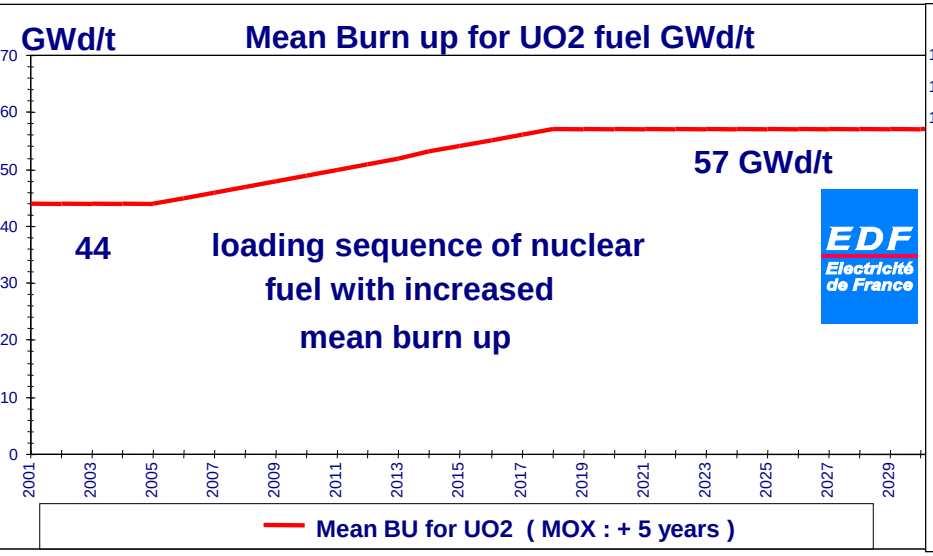
12 canisters/ Gwe/year

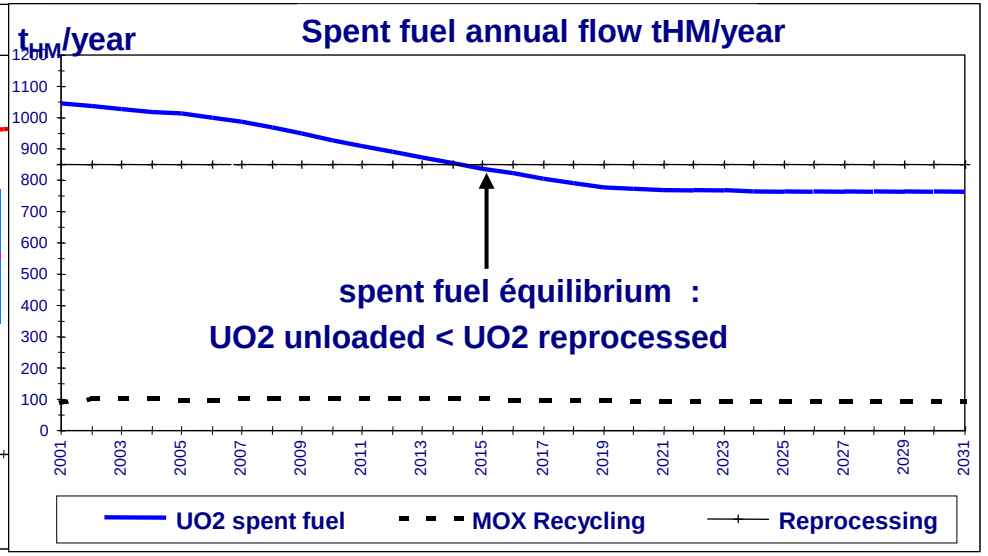
- **mastering the growth of plutonium inventory**
(Pu flux adequacy : Pu from processing= Pu refueled)

- **plutonium safely concentrated in used MOX fuels**
(available for future use)

Stabilization of the spent fuel inventory in interim storage

- **To be achieved by 2015**





A progressive increase in average burn up between 2006 and 2015

Burn up increase
=> equilibrium in spent fuel management, ~2015
Q reprocessed/year (850 tHM) = Q spent fuel/year
30 ↘ 27 kg Pu/TWh

Reducing long term proliferation risks

- **Limitation of the global Pu inventory**
  - 1/3 MOX core PWR = zero net Pu production
  - 1/3 Pu in MOX destroyed, 2/3 isotopic degradation
- **concentration (x7) of Pu in MOX spent fuel**
  with higher & longer lasting radiation barrier than UOx
  (> 7 UOx spent FAs · 1 MOX FA)
- **avoids underground disposal of 1100 t_{HM} spent UOx fuel per year (10 t/y Pu) and the associated proliferation risks for future generations**
  (associated environmental benefit : removing the main contributor to long term radiotoxicity and heat in the final waste)

Pu Management Strategy

Pu isotope	Pu from LWR-UOX (%)	Pu from LWR-MOX (%)
238	2.48	3.8
239	53.3	39.9
240	24.8	31.1
241	12.1	13.4
242	7.3	11.8

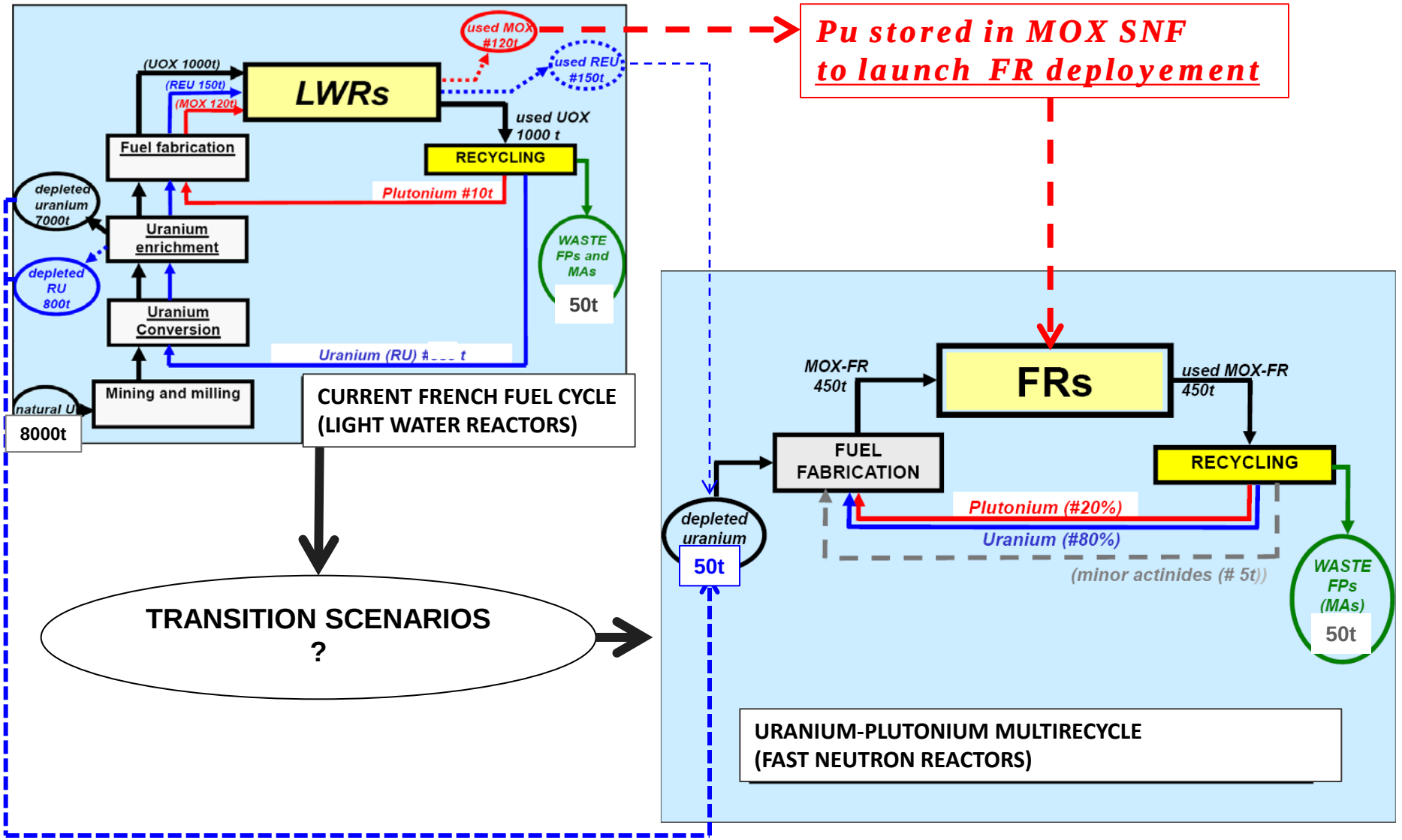
[UOX et MOX 46 GWj/t

(^{239}Pu eq) # 45% → (^{239}Pu eq) # 25%

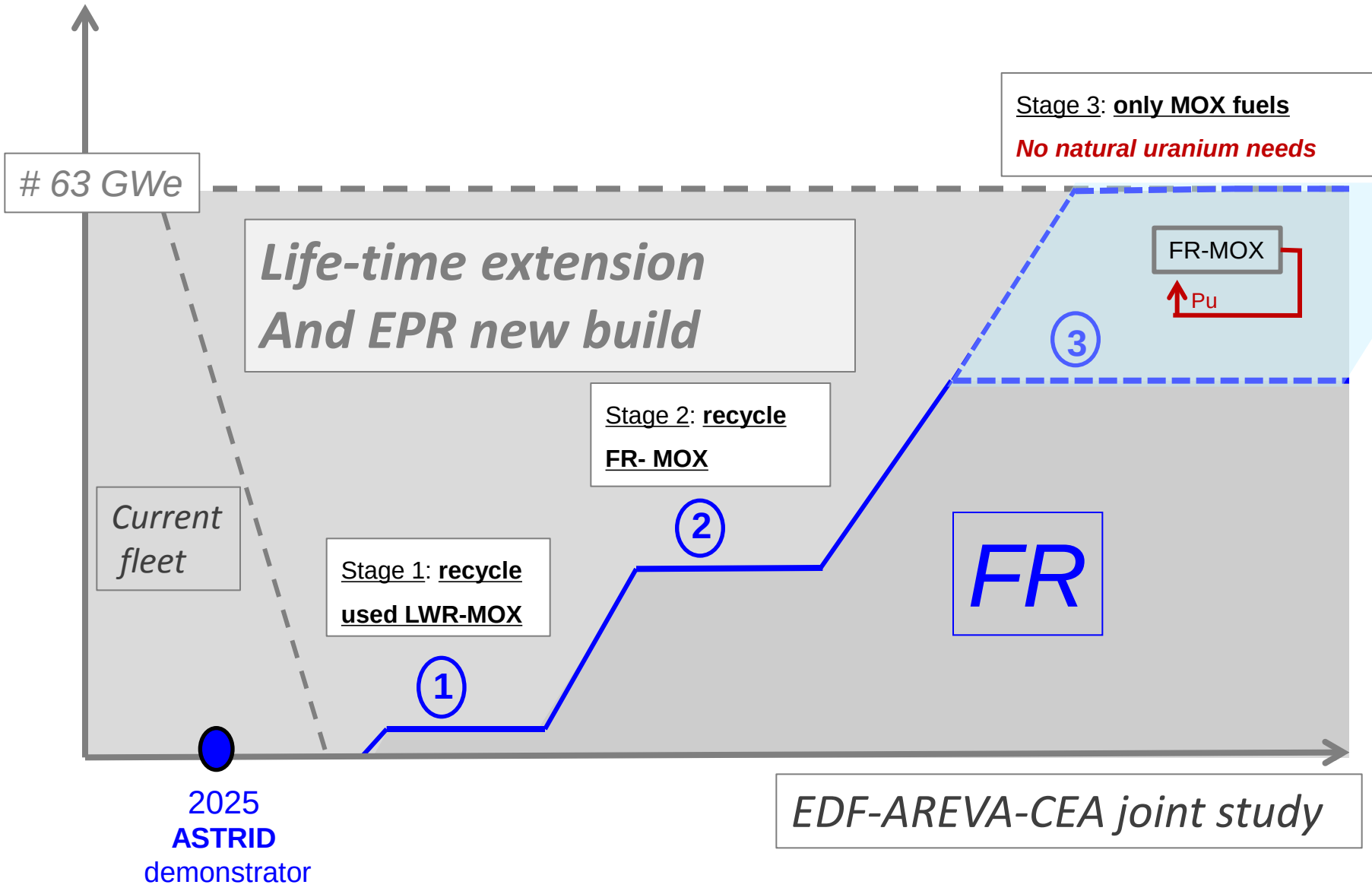
First Spent UOX recycling in LWRs
- isotopic degradation

Spent MOX fuel Recycling
- More efficient in Fast Neutron Reactors
- Allow to manage MOX fuel and plutonium inventory

From CURRENT FUEL CYCLE…
to FAST REACTORS FUEL CYCLES



FR REACTORS DEPLOYMENT

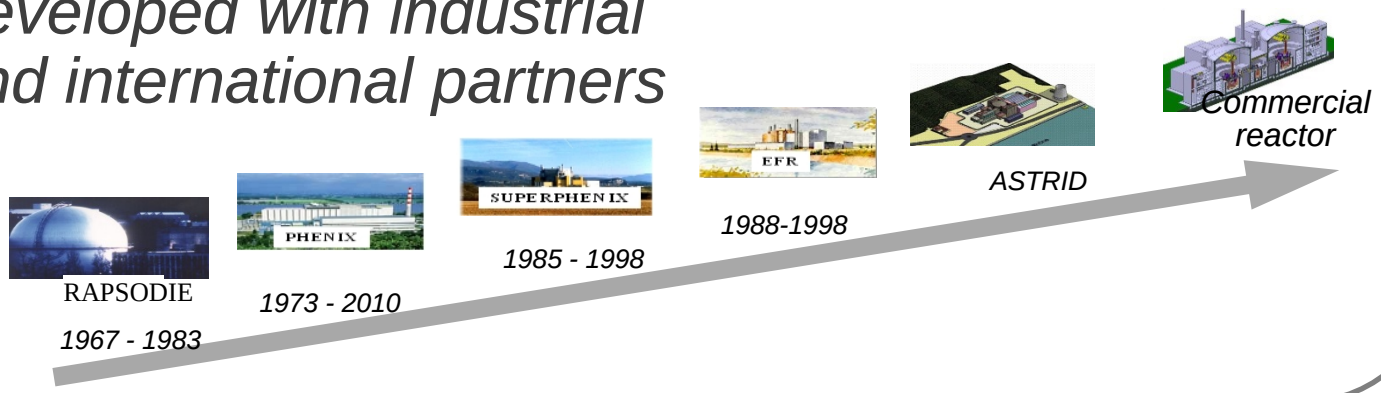


Fast Reactors : Development In Motion

- Sodium Fast Reactor, the reference option :
  [ASTRID, the technology demonstrator]

  - *maturity, possible further improvements (safety, operability, economics)*

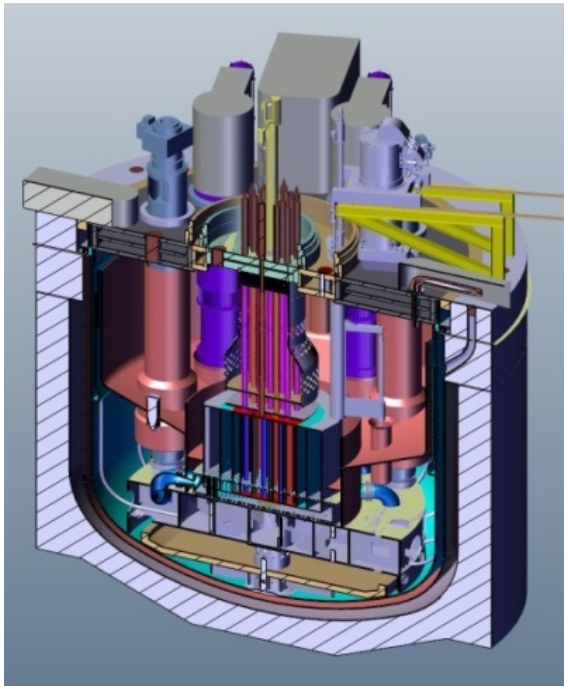
  - *developed with industrial and international partners*



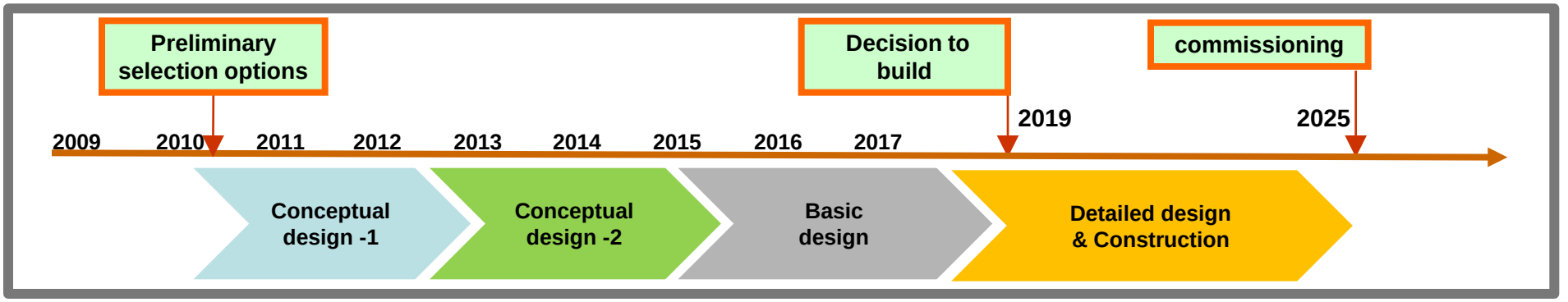
- *Gas-cooled Fast Reactor, a long-term option:*

  - *attractive potentialities but heavy challenges…*

THE ASTRID PROGRAM



- *600 Mwe , « pool » type*
- *oxyde fuel, transmutation capabilities*
- *<u>Innovative design</u>:*
  - self-sustainable **safer** core
  - *core catcher, residual heat removal*
  - *power conversion system*

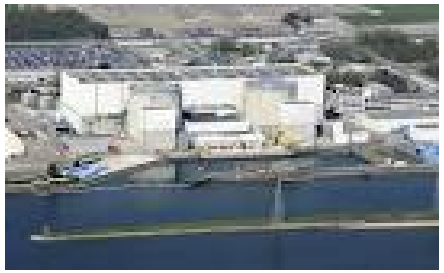


French Nuclear Panorama

La Hague
Reprocessing plant

MELOX - MOX fuel fabrication plant

MARCOULE – CEA – R/D lab



Fessenheim NPP

Paluel NPP

EPR Flamanville NPP

ANDRA Geological disposal lab

Open door – Public Consultation by law and by choice