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OVERVIEW OF FUEL CYCLE PERSPECTIVE FOR FRANCE

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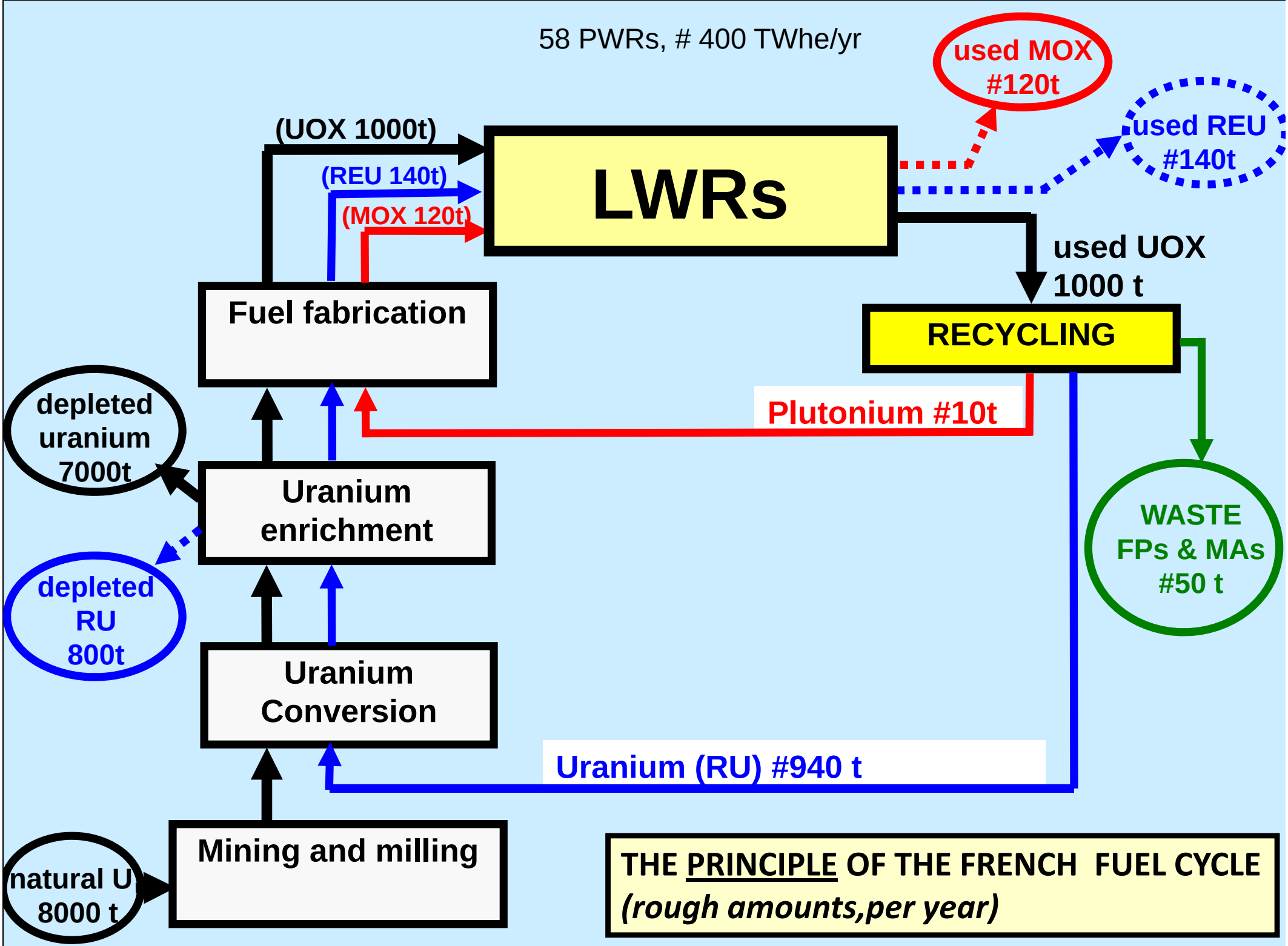
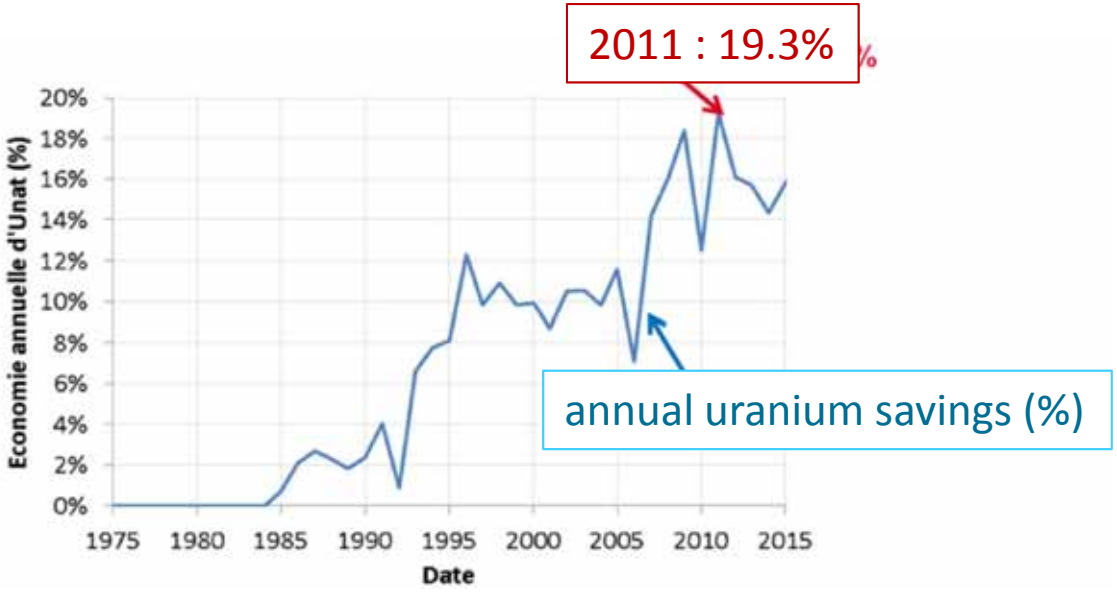
SACSESS INTERNATIONAL WORKSHOP
WARSAW, POLAND, APRIL 22, 2015


58 PWRs, # 400 TWhe/yr
used MOX #120t
used REU #140t
(UOX 1000t)
(REU 140t)
(MOX 120t)
LWRs
used UOX 1000 t
Fuel fabrication
RECYCLING
depleted uranium 7000t
Plutonium #10t
Uranium enrichment
WASTE FPs & MAs #50 t
depleted RU 800t
Uranium Conversion
Uranium (RU) #940 t
Mining and milling
natural U 8000 t
THE PRINCIPLE OF THE FRENCH FUEL CYCLE
(rough amounts,per year)

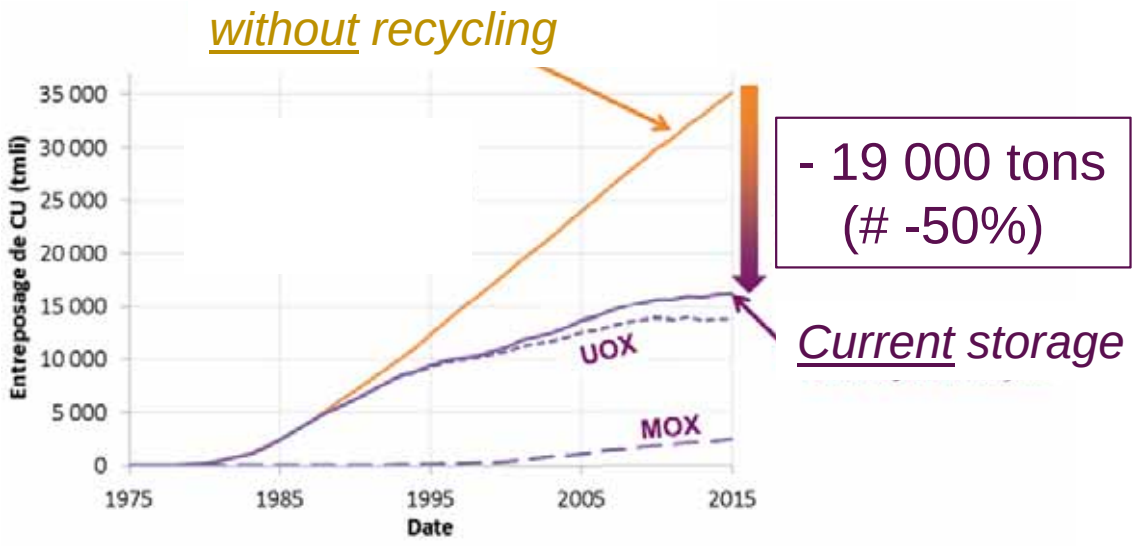
CURRENT RECYCLING STRATEGY : *SOME RECORDS…*

- Natural <u>uranium savings</u> in the french fleet

  (25500 tons)



- Used fuels <u>storage</u>



A SUSTAINABLE MANAGEMENT FOR NUCLEAR MATERIALS AND WASTE (*2006 French Act*)

THE REPORT ISSUED BY CEA *(12-2012)*

MAIN CONCLUSIONS:

Closing Pu and U Cycle, the first condition
for a sustainable management of nuclear materials

- ***Two main guidelines:***

  (1) Systematic recycle of U and Pu

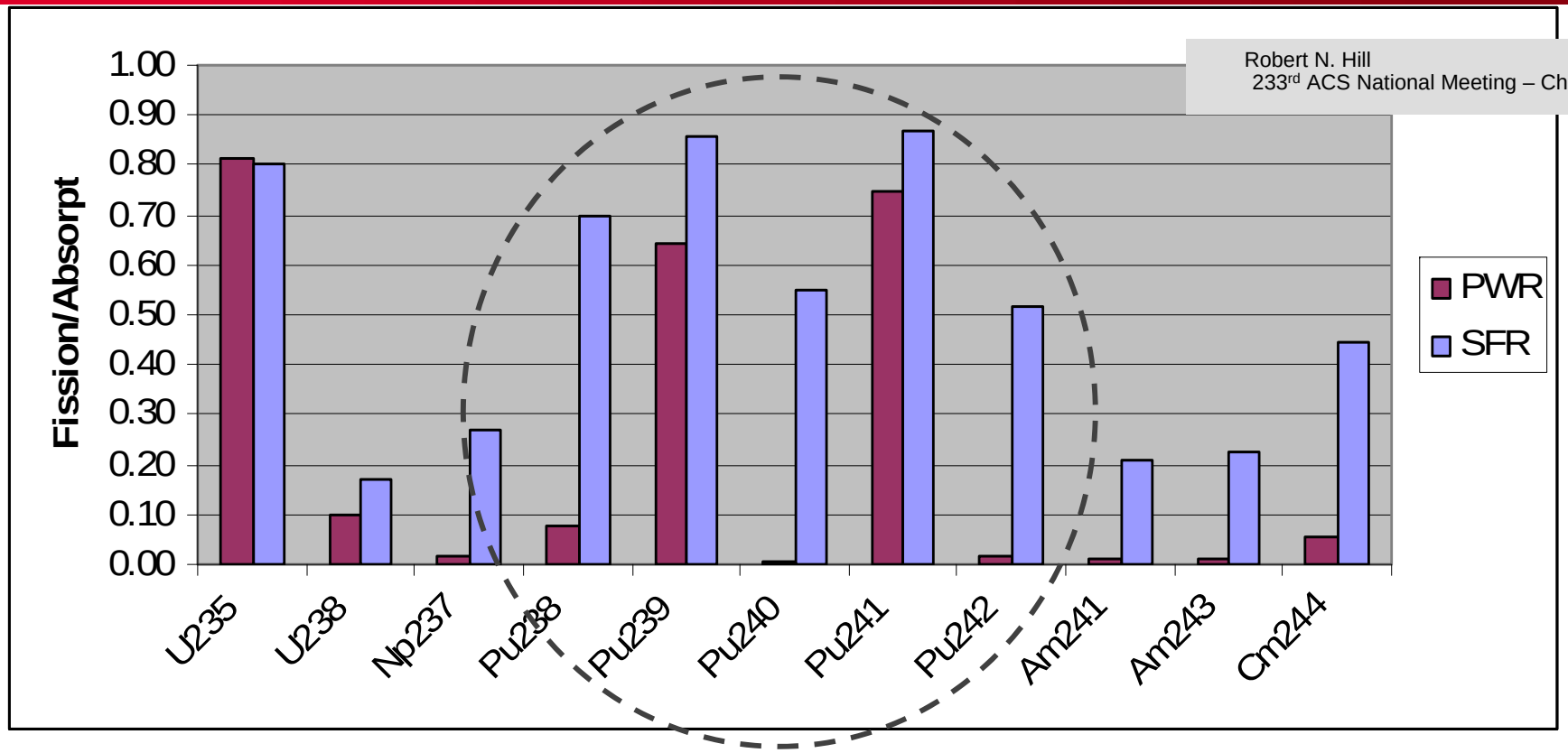
  (2) fast neutron reactors

. *to burn and take advantage of plutonium amounts in spent fuels (avoiding the growth of important un-used stockpiles);*

. *to allow a drastic extension of ^{238}U valorization (uranium resource utilization yield :*

- *from 0.7 - 0.85% in LWRs*
- *up to >90% in FRs)*

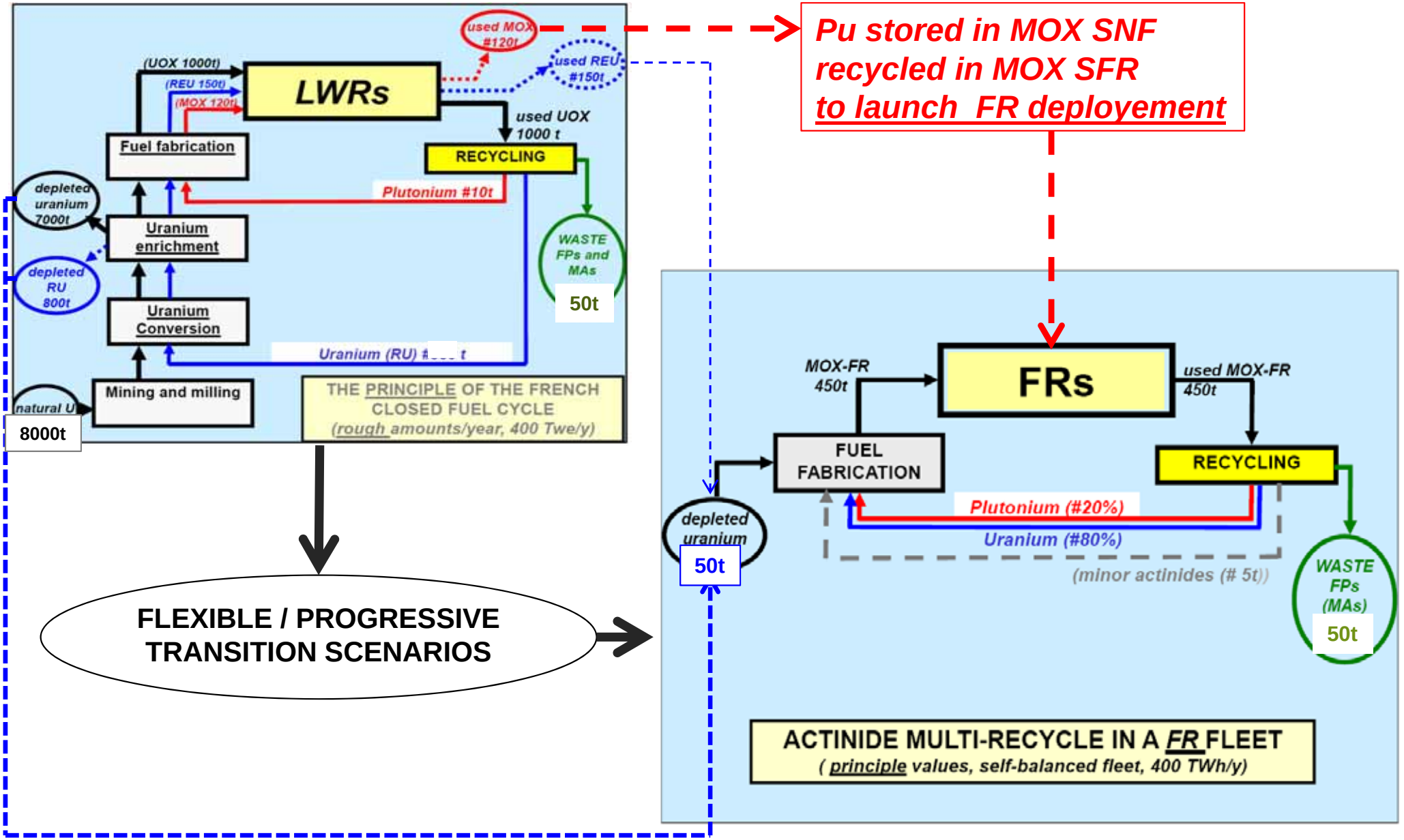
WHY FAST NEUTRON REACTORS ?



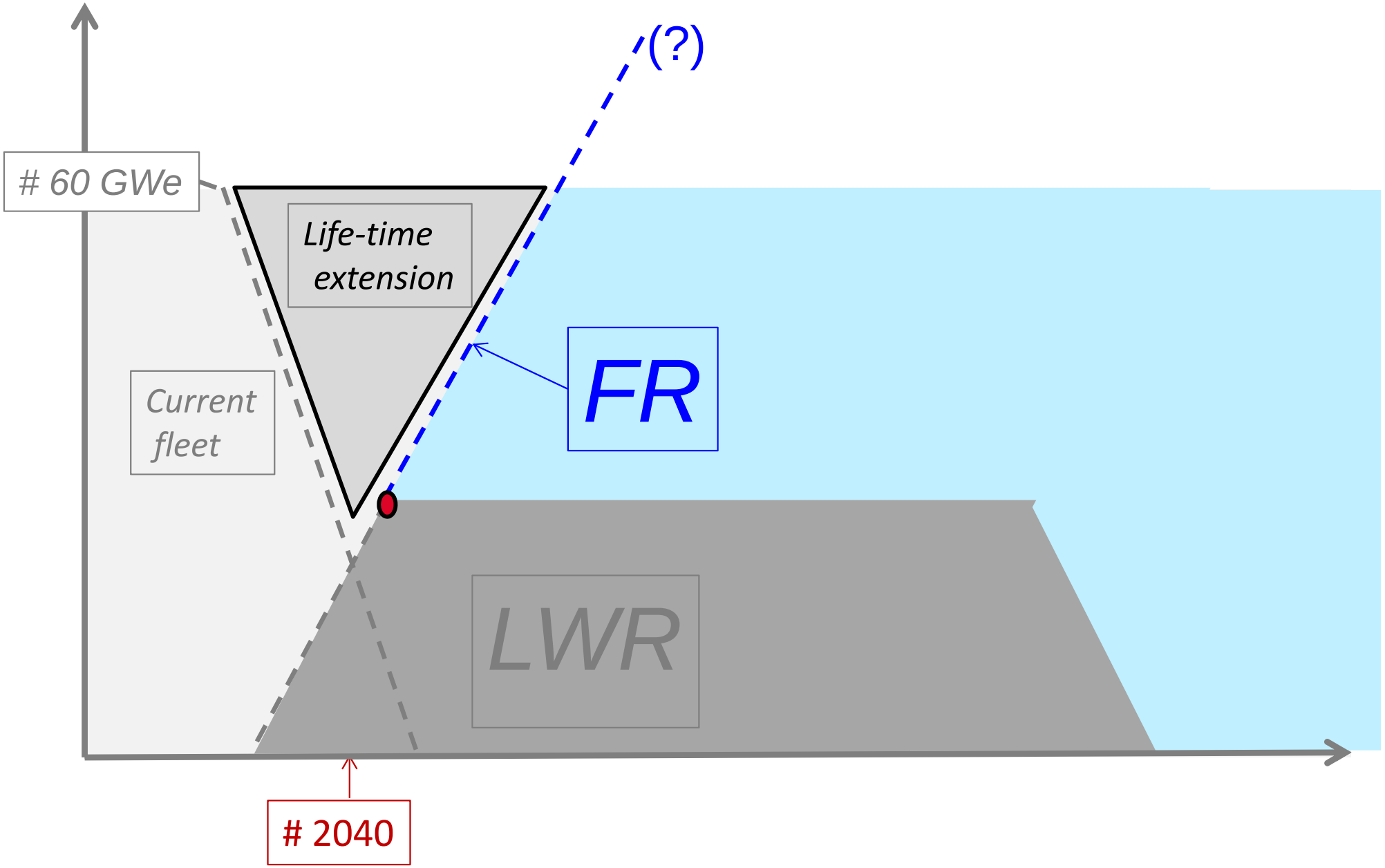
- ***Pu** burning **in LWRs lead to heavier Pu isotops** (and to minor actinides) not suitable for recurrent simple recycle*

- **Pu burning in FRs favors Pu fission , allowing (infinite) multi-recycle**

FROM CURRENT FUEL CYCLE…
TO FUTURE FAST REACTORS FUEL CYCLES

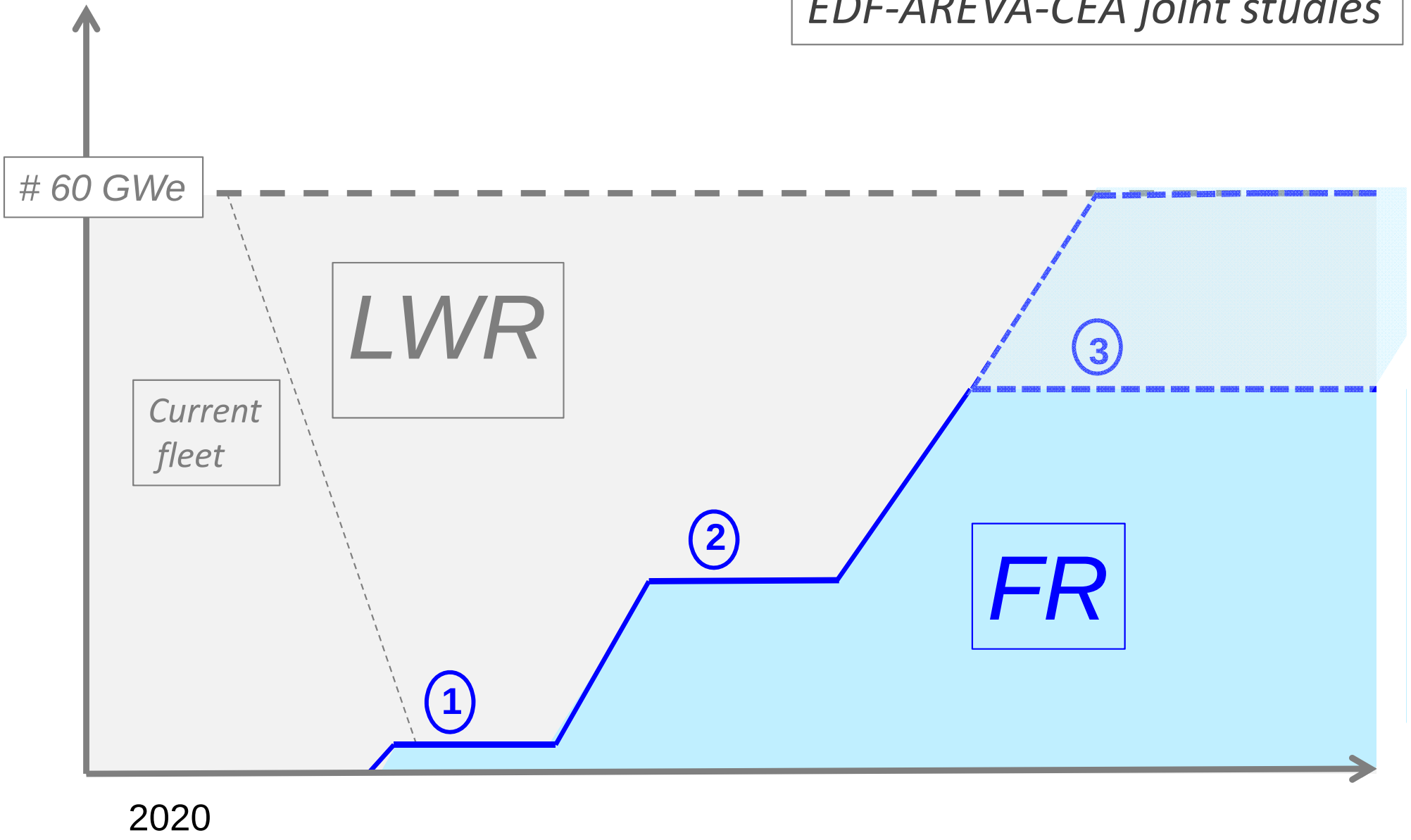


FR REACTORS DEPLOYMENT : *THE FORMER VIEWS*

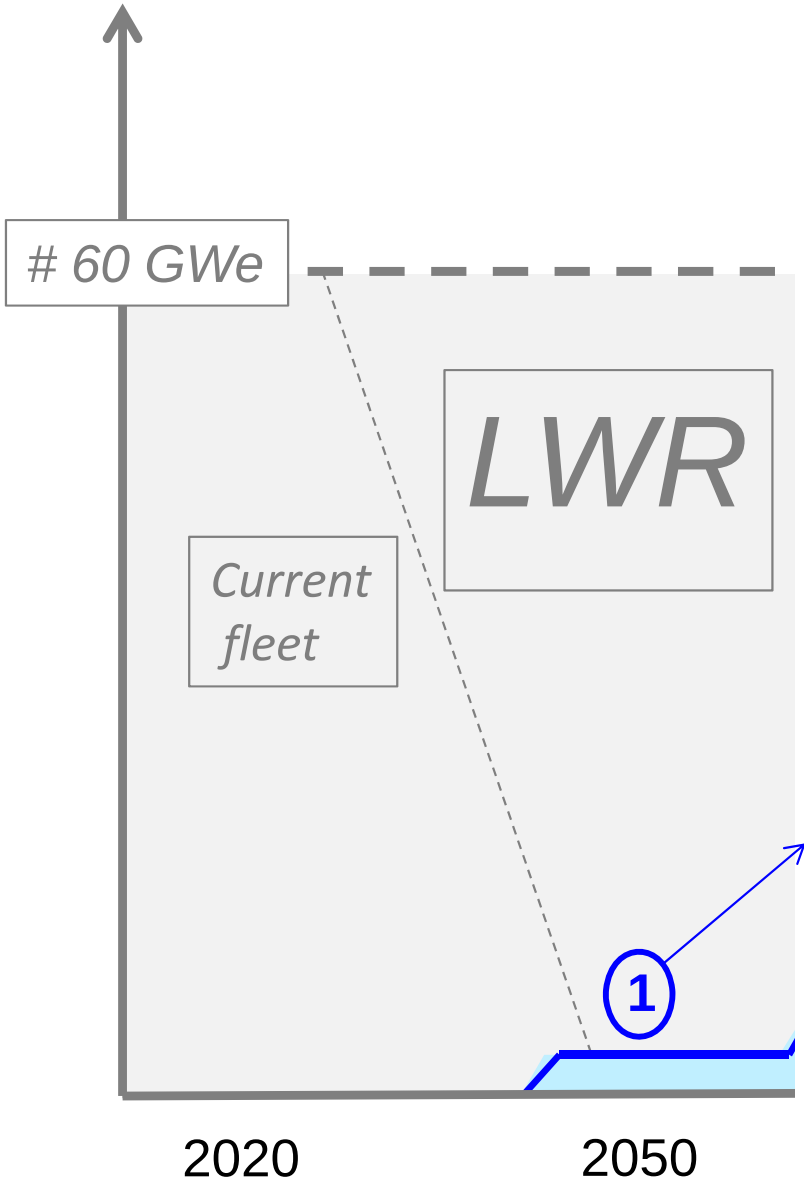


FR REACTORS DEPLOYMENT: *CURRENT SCENARIO STUDIES*

EDF-AREVA-CEA joint studies



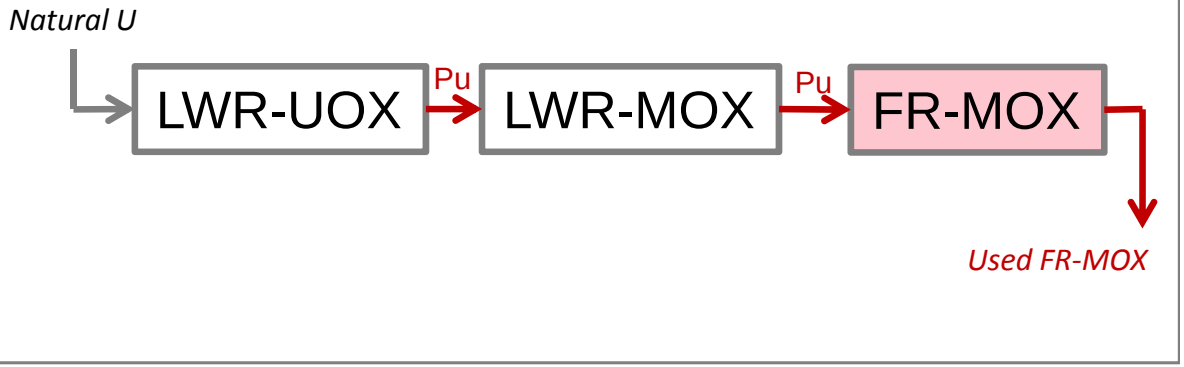
FR REACTORS DEPLOYMENT: *CURRENT SCENARIO STUDIES*



Stage 1: **recycle used LWR-MOX**

a few FR needed (3 – 5 GWe?)

Used MOX-LWR amount stabilized



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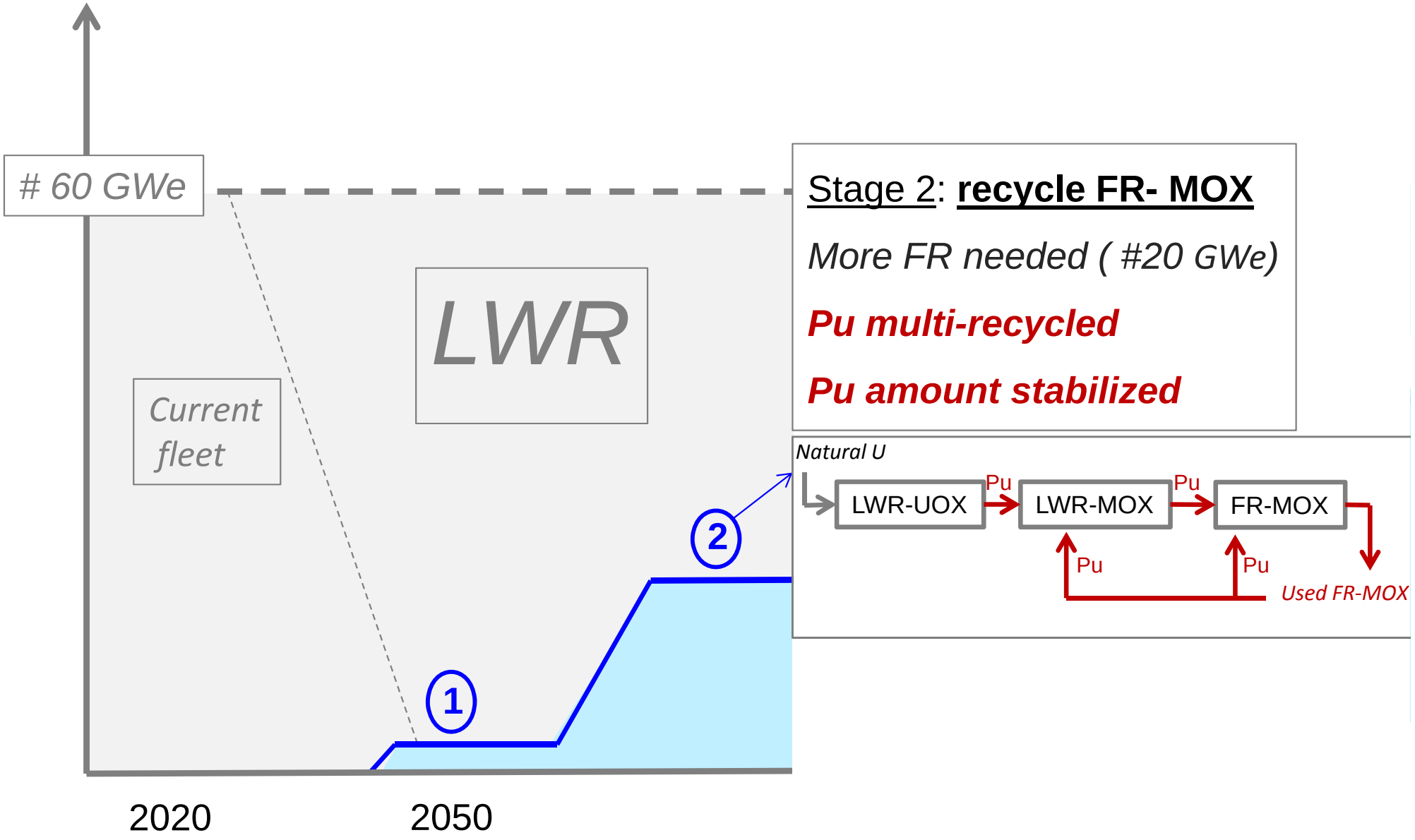
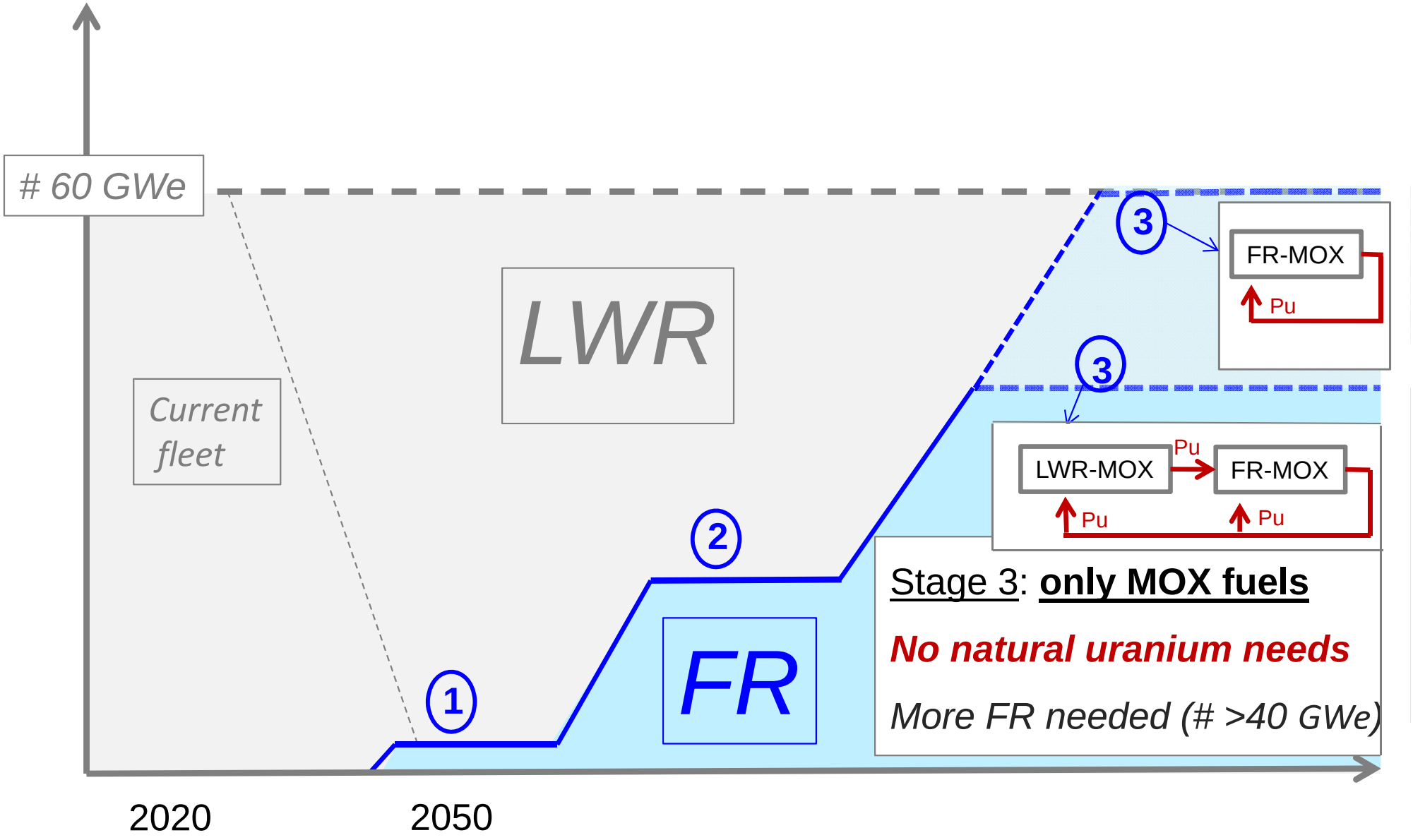
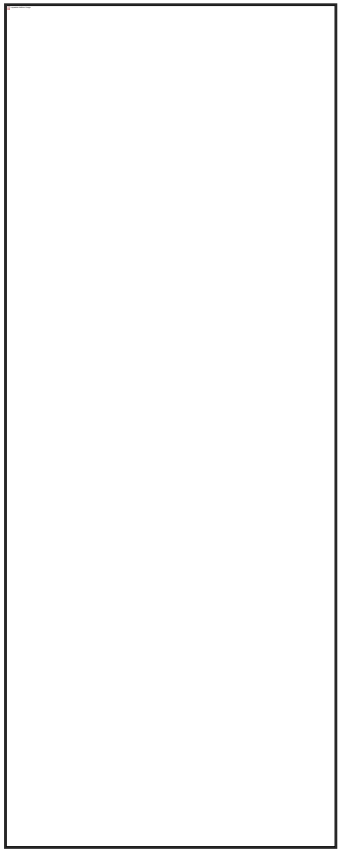


FR REACTORS DEPLOYMENT: *CURRENT SCENARIO STUDIES*

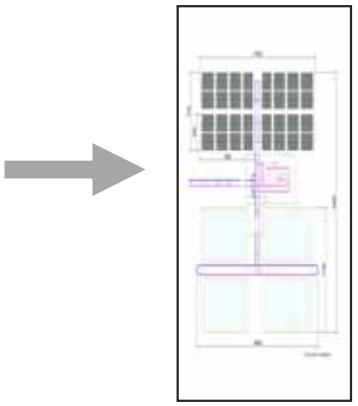


MINOR ACTINIDES TRANSMUTATION: *DRIVERS…*

1500 ha total, among which **1175 ha HAVL**, 7 Mm3 excavated



no transmutation

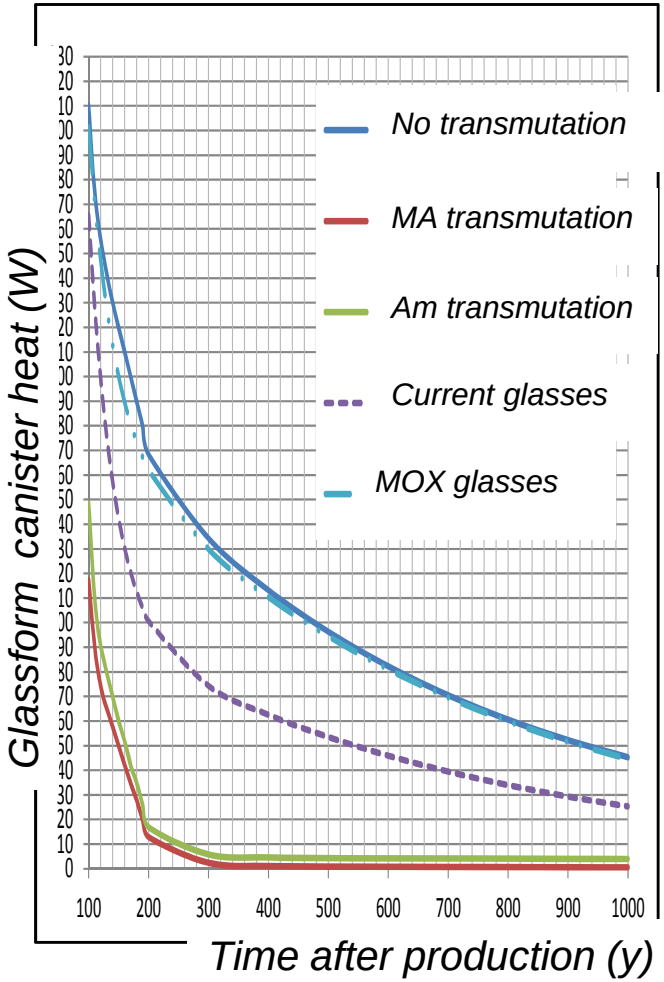


430 ha total, among which **120 ha HAVL**, 3 Mm3 excavated

MA transmutation

[Andra-CEA 2012, cooling phase120 years]

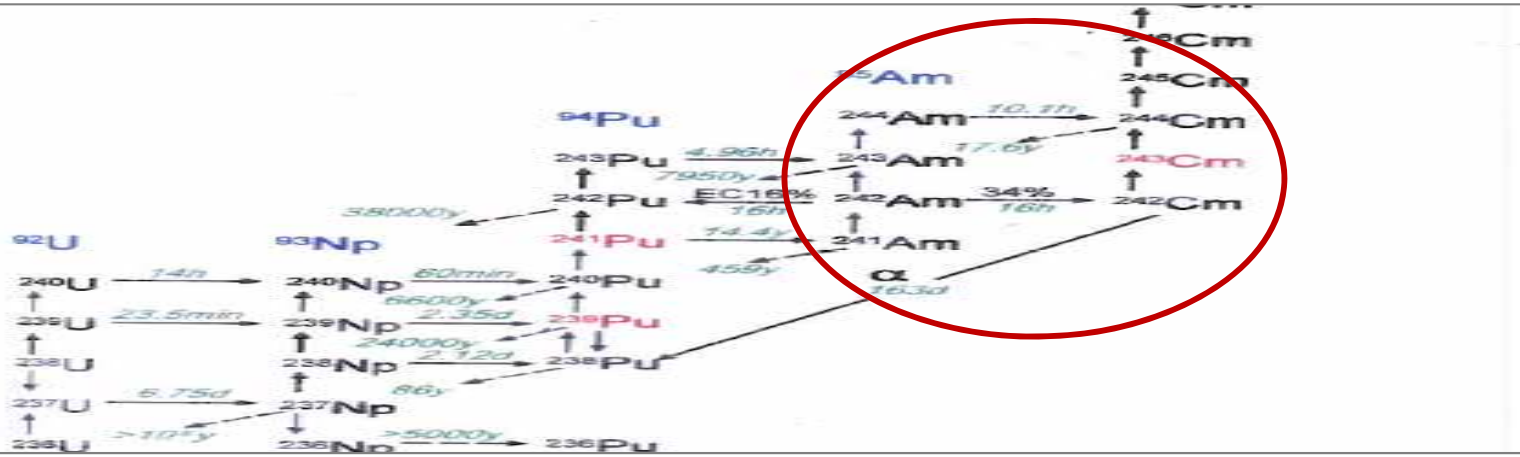
REPOSITORY FOOTPRINT



MINOR ACTINDE TRANSMUTATION: *FR POTENTIALITIES*

<u>Minor actinide</u> removal could provide an optimization of final waste management:

- ***by decreasing <u>waste long-term radiotoxicity</u>***
- ***by decreasing the <u>repository footprint</u> (Am recycle mainly)***



Fast neutron reactors incentives:

- **MA production : *3 -5 times lower in FR (vs. LWR)***
- **MA transmutation : possibly quantitative in FR**

(MA multi-recycle)

MINOR ACTINIDE P&T : *ON GOING…*

used fuel
(#4kg)

in-pile **2019**
Transmutation

The « integral experiment » for Am P&T

Dissolution

U et Pu separation

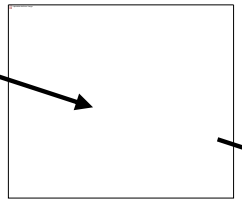
(U,Pu)

Concentration

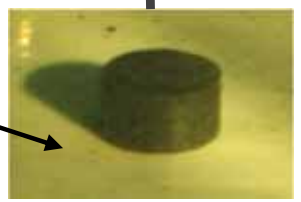
(FP, Cm)

Am separation EXAm

Concentration Am



Co-precipitation (U,Am)



Pellets
$(U,Am)O_2$

2010

2011

2015

2015

2016

2016-2017

2018

Conclusion

> Reprocessing and recycling today:

- **well-proven technologies, at commercial scale**
- **thanks to important R&D (research & industrial bodies)**
- **provides significant benefits:**
  - *natural resource savings*
  - *optimization of final waste management*

> suitable for current generation 2, then generation 3 LWRs

> in a long term perspective, could be further improved

- **a "step by step" approach,**
- **with the progressive deployment of generation 4 reactors**

(for Pu full burning, natural uranium utilization drastic increase, long-lived elements transmutation…)

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APRIL 22, 2015

Emmanuel Touron
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THANK YOU FOR YOUR ATTENTION !