Mono-Recycling of Americium in PWR

A Waiting Strategy

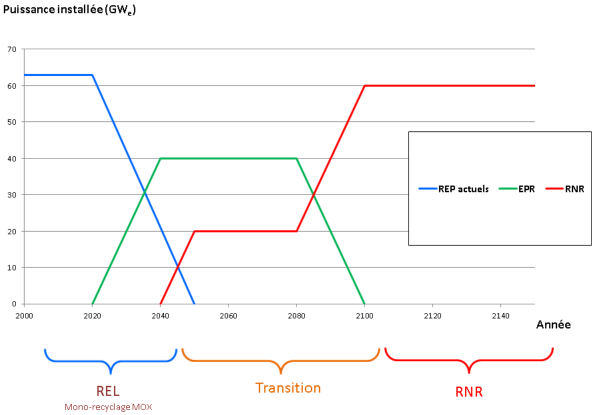
A.-A Zakari-Issoufou

institut de physique nucléaire d'orsay

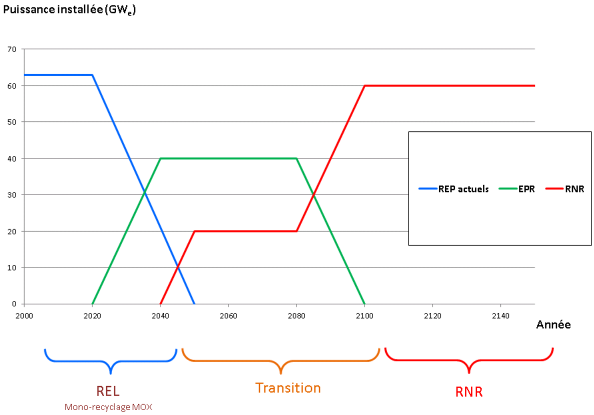
Physique de l'Aval du Cycle et de la Spallation

Outline

A reference scenario



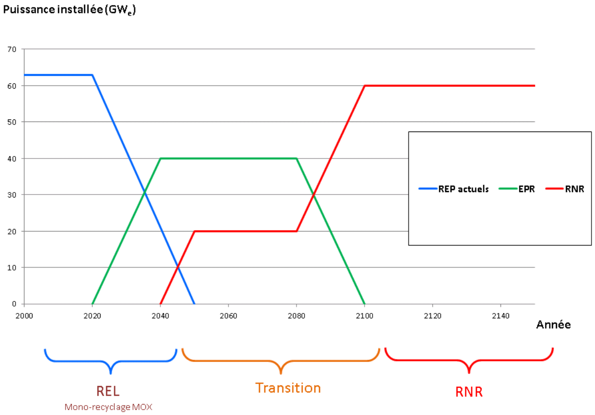
A reference scenario



Why ?

- We are fanatic nuclear power believers

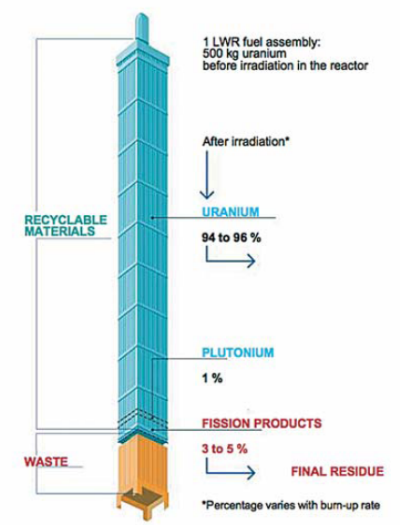
A reference scenario



Why ?

- Ensure the fissile material supply
- Better management of the spent fuel ($\Rightarrow$ closed cycle)

Current Spent Fuel Management



Fissile Will Survive

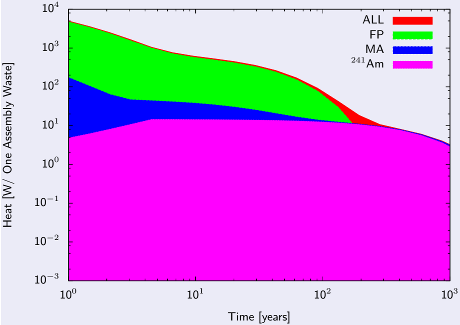
- All fissile material are recovered
  - Pu → MOx fuels (20 reactors)
  - U → URE fuels (4 reactors)
- Other are waste
  - Fission Products (≈ 100 y)
  - Minor Actinides ($\times 1000$ y)

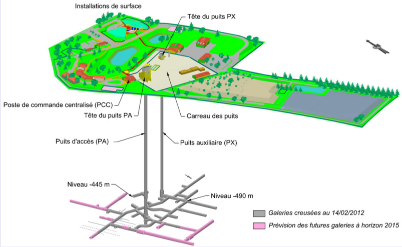
Nuclear Waste Management

Transmutation

- Decrease and cap waste masses : (multi)recycling
- A technology shift : Fast Reactors, ADS

Final Disposal





† Underground surface : **30** km^2

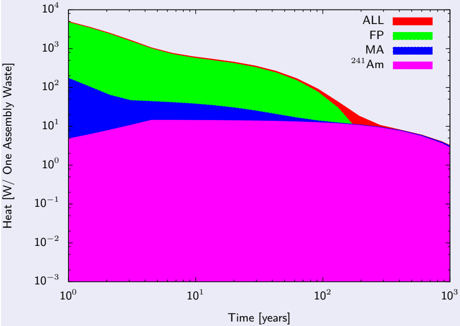
Americium plays an important role in dimensioning the storage site

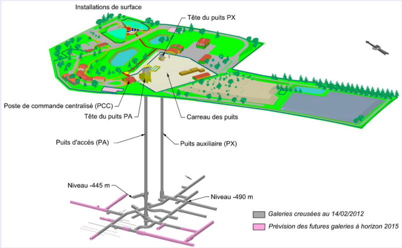
Nuclear Waste Management

Transmutation

- Decrease and cap waste masses : (multi)recycling
- A technology shift : Fast Reactors, ADS (not ready, benefit can be lost)

Final Disposal





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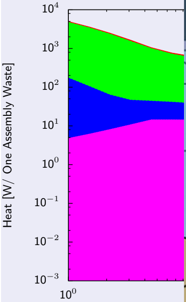
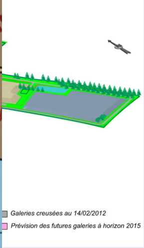


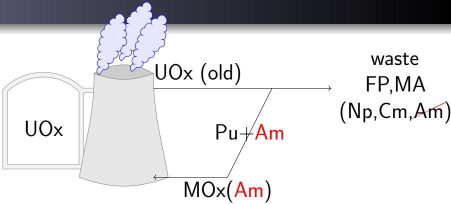


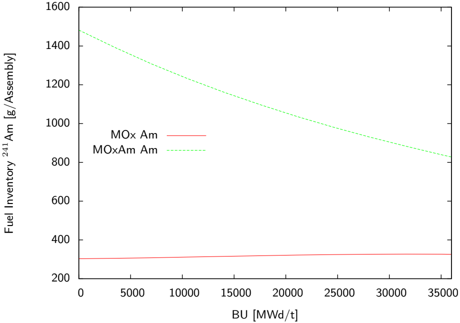
30 km^2

Americi ... age site

Americium Transmutation in PWR

New Fuel Management : Recover americium with plutonium for a new fuel type MOx(Am)





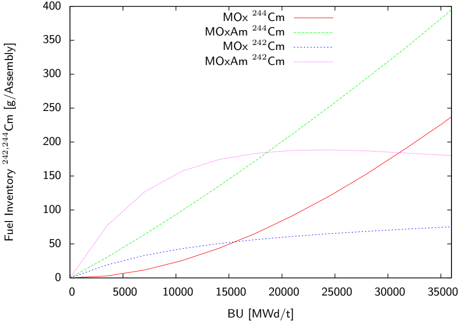
† Fuel composition : % Am $\approx$ 5% of Pu isotopic vector (max = 3%)
$\Rightarrow$ An upgrade in fuel fabrication is needed

† After one irradiation cycle the americium in the fuel is decreased by 43%

Thermal reactors are capable of efficiently decrease the americium produced in spent UOx fuels

Do not fool us : What about Curium isotopes ?

◊ **Americium Disappearance ⟺ Curium Production**

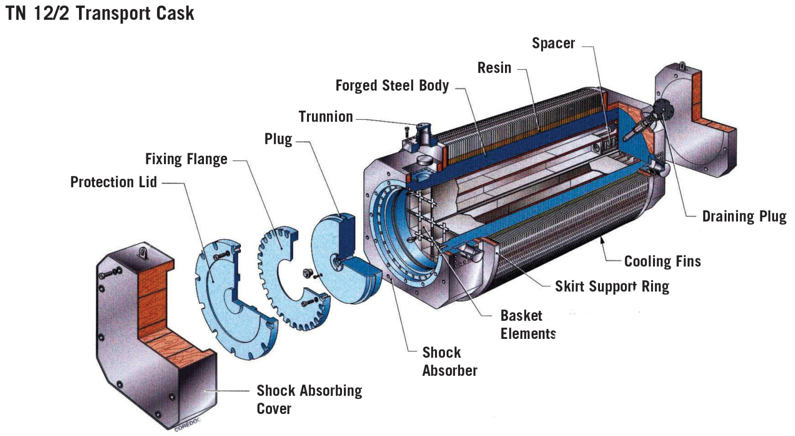


Curium are important neutron emitters of nuclear spent fuels and impact *short time* storage and fuel management

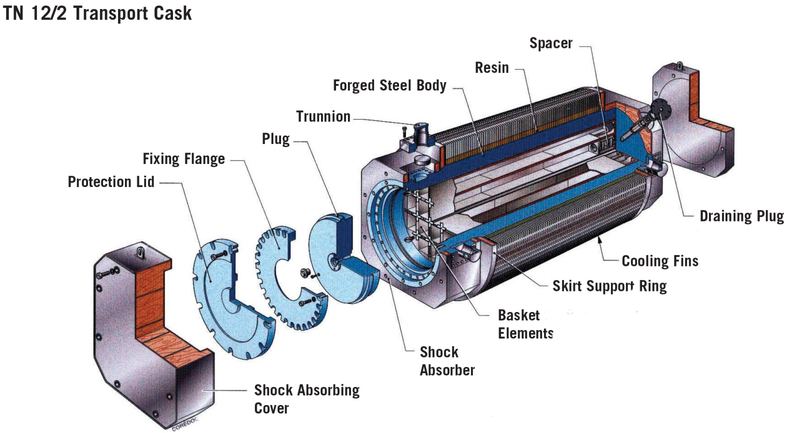
- ^{242}Cm, $T_{1/2}$ = 163 d
- ^{244}Cm, $T_{1/2}$ = 18.1 y
- ^{241}Am, $T_{1/2}$ = 432.2 y

The problematic of curium and americium differs in term of time scale - after 60 y of cooling Am remains the most active element of the spent fuel

Residual Power and Toxicity for Transportation



Residual Power and Toxicity for Transportation

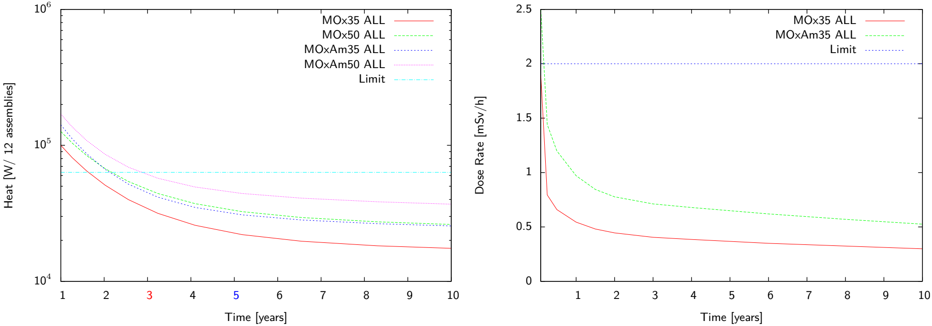


1. Total Weight (with payload) : 111 t, 12 Spent PWR Fuel
2. Decay-Heat : 63 .25 kW inside
3. Toxicity : Max 2 mSv/h @ surface

Residual Power and Toxicity for Transportation

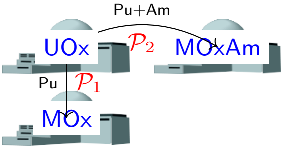
◊ Monte Carlo simulation of the emitted radiations from MOx/Mox(Am) spent fuels

Based on *BaL* PhD Work

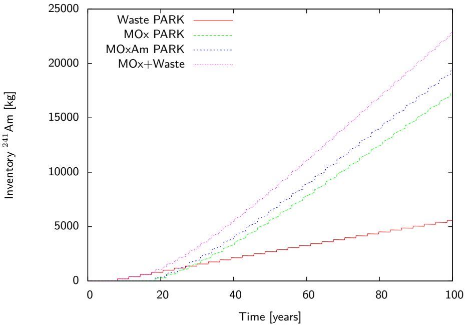


- Decay-Heat is the most constraining parameter for spent fuels transportation
- Current standards are already high enough even for the innovative MOx(Am) fuel

Parks comparison in a steady-state configuration



Reactor	$\mathcal{P}_1$	$\mathcal{P}_2$
UOx/MOx	6.96	8.35



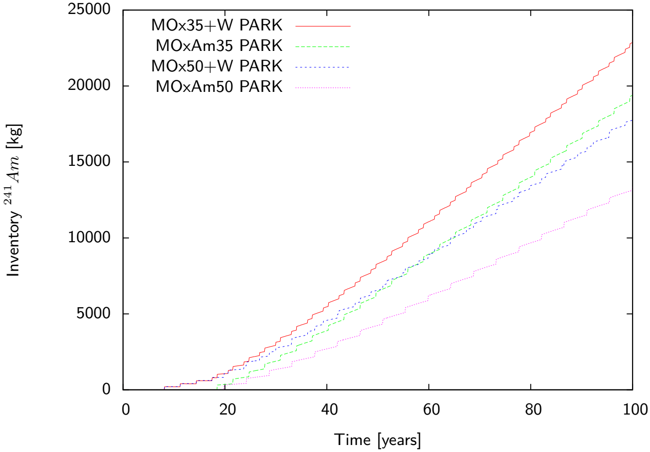
$\mathcal{P}_1$ and $\mathcal{P}_2$ provide the same total power
Burn-Up : 35 GWd/t
† Reactor $\tau_{\text{Am}} = 43\%$
† After 100 y $\tau_{\text{eff}} \approx 15\%$ $(\mathcal{P}_1/\mathcal{P}_2)$

$\Rightarrow$ Consider not only americium but ^{241}Pu in the spent fuels

- The transmutation behaviour is kept at park level : decreasing Am content
- The transmutation performance is being lost due to "Ice Cream" effect

Influence of the fuel burn-up

◊ UOx is set at 35 GWd/t while MOx/MOx(Am) fuels can be 35 or 50 GWd/t



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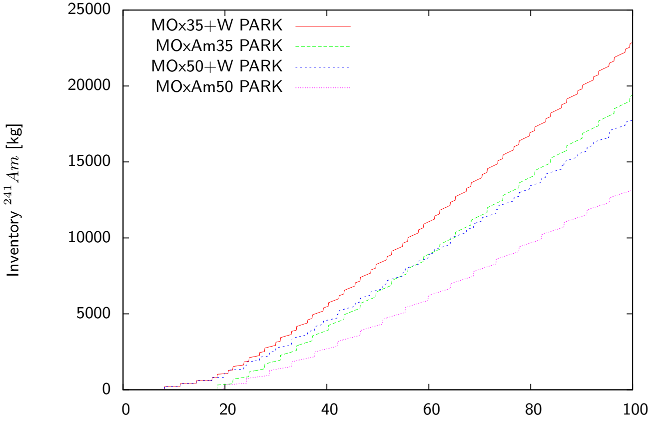

Higher Burn-Up

- Tend to improve ^{214}Pu contribution for energy production
- Keeps the fuel for longer cycle and postpone fuel management

Conclusions

- Decreasing the americium of the spent UOx fuel alleviate the decay heat of glasses
- PWR have a good performance in term of americium transmutation in MOx(Am)
  - MOx(Am) are more toxic @fabrication and as spent fuel
  - More flexibility is earned for waste transmutation
- As a waiting strategy MOx(Am) fuels could be a good compromise

- Less radiotoxicity footprint with selective isotopic transmutation
- Evaluation with conditional transition toward fast reactors

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