Consequences on Using Macro Power Reactors in Nuclear Scenarios

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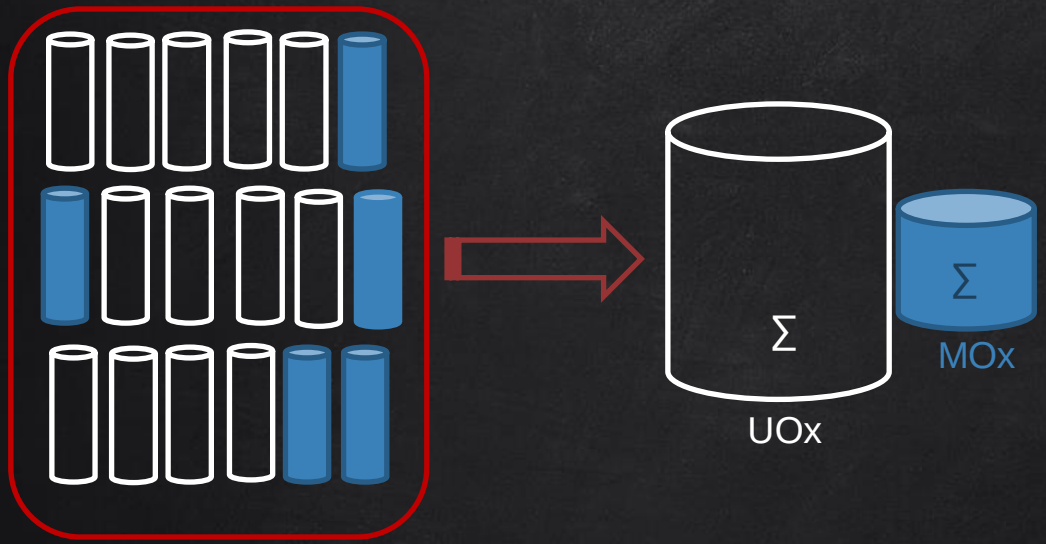
Macro reactor simplifications



Second Factor Approximation :

1. Nuclear fleet divided by fuel type
2. Same fuel reactors >> ONE

➔

a. One irradiation level by fuel type
b. Same fuel cycle dynamic for reactors

- Significantly reduce the complexity of the simulation: Only 1 macro reactor to follow
- Core physics taken into account the same way as a single reactor w.r.t Burn-up

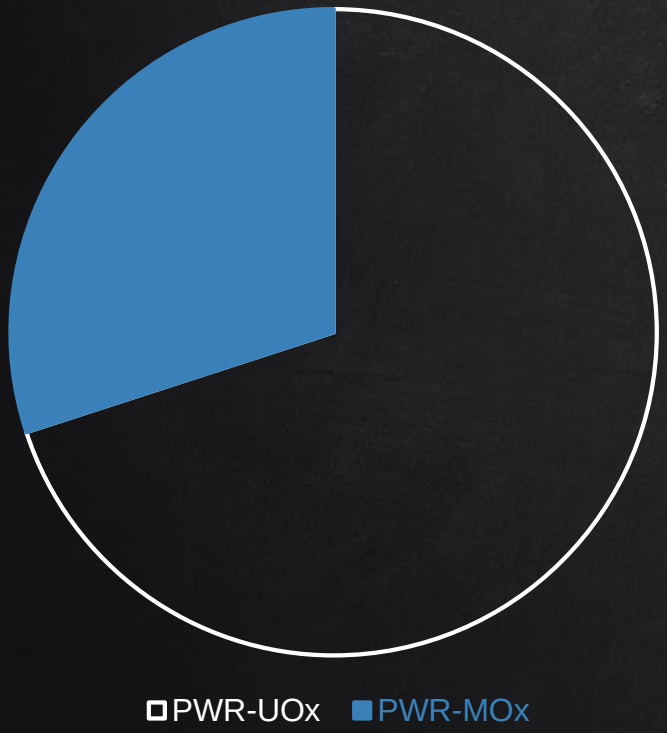
We lose some timing effects of the fuel cycle (cooling, material flows…)

How do macro reactors impact a scenario ?

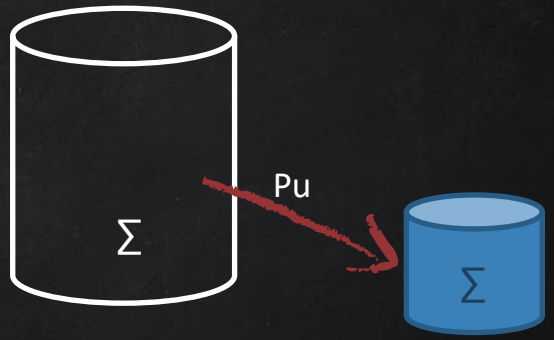
Let’s start with an example nuclear fleet.

A self-sustainable nuclear fleet

Fleet Power Share

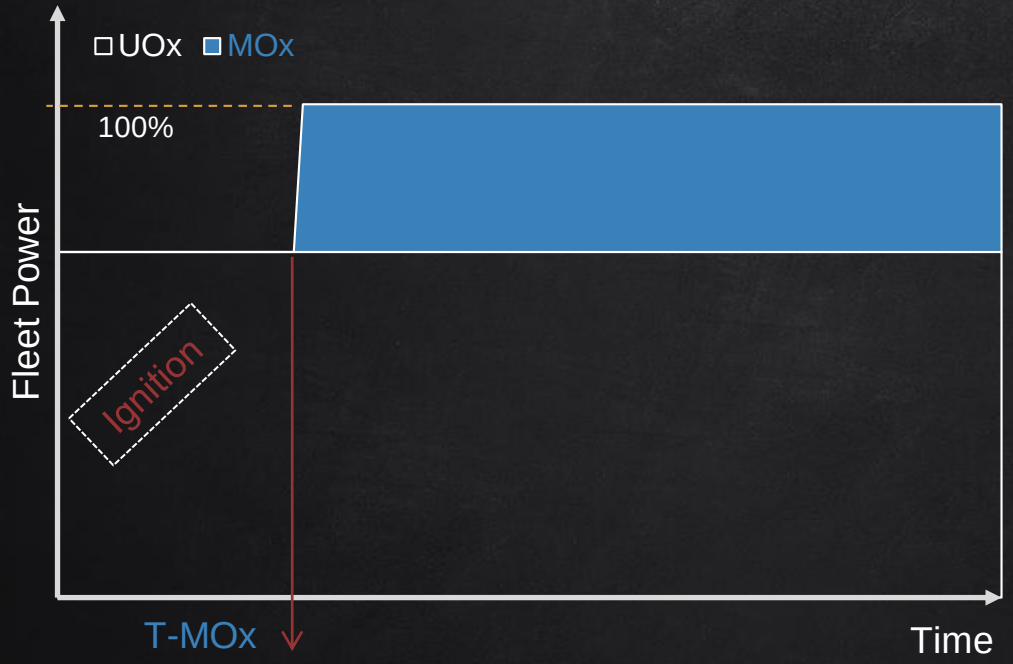


A constant flow equilibrium for the plutonium



- Deploys maximum available capacity for MOx
- Perfect Matching : No Pu in spent UOx Stocks

Doing the exercice with CLASS



Hypotheses :

- BU-UOx = BU-MOx = 40 GWd/t
- T-MOx = Cycle + Cooling + Fab

Solution : iterative

- Power = UOx(87.54%) + MOx(12.46%)
- No Misloading

This is our reference macro reactor scenario simulation

From macro to ‘‘single’’ reactors

A. Segment Macro reactors to smaller parts

1. 1 UOx -> M0x/3
2. 1 UOx -> MOx/5
3. UOx/3 -> 1 MOx

B. Same as A. but adding delays

1. *MOx 1/3 of power each year*
2. *MOx 1/5 of power each year*
3. *UOx 1/3 of Power each year, T-MOx+3y*

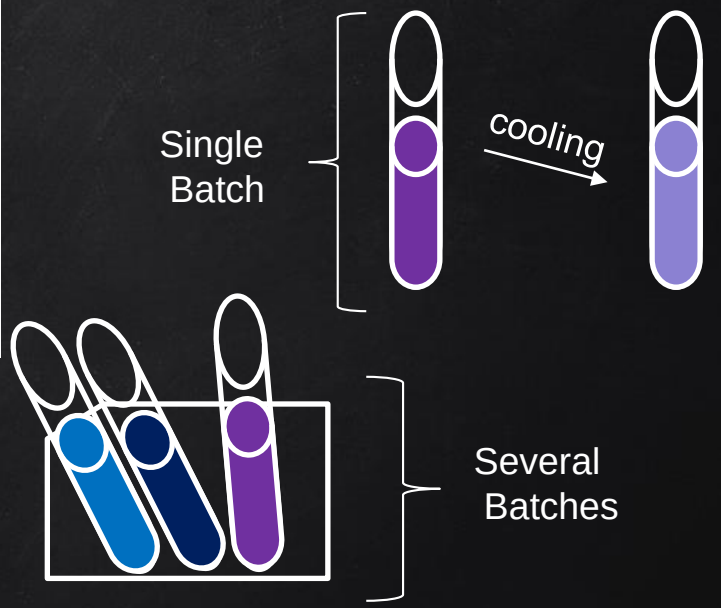
C. Effect of fuel management option

- UOx (3 unloads) -> 1 MOx : deduce Max MOx
- UOx (3 unloads) -> MOx /5 : check Max MOx

We observe power shares and misloading effects => scenario OK or not OK

Results of the tests

	A (/)			B (+delays)			C (FM)
	1.	2.	3.	1.	2.	3.	Max=29.15 %
Scenario	ok	ok	ok	no	no	no	no



A : Same fuel batch used -> Macro == Singles

B : Involve extra cooling of the spent fuel => lower grade plutonium

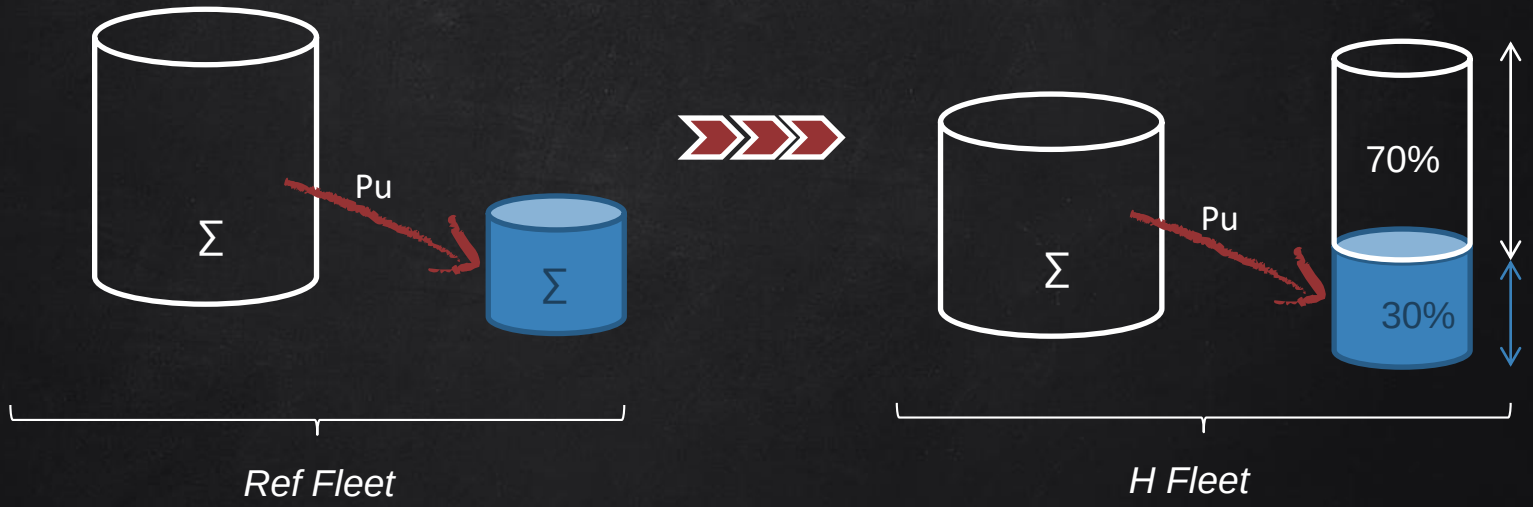
The 2. benefits form a 2nd discharge from UOx, but still lower grade plutonium

C : Highlights Burn-up dependence on isotopic vector rather than Heavy Mass

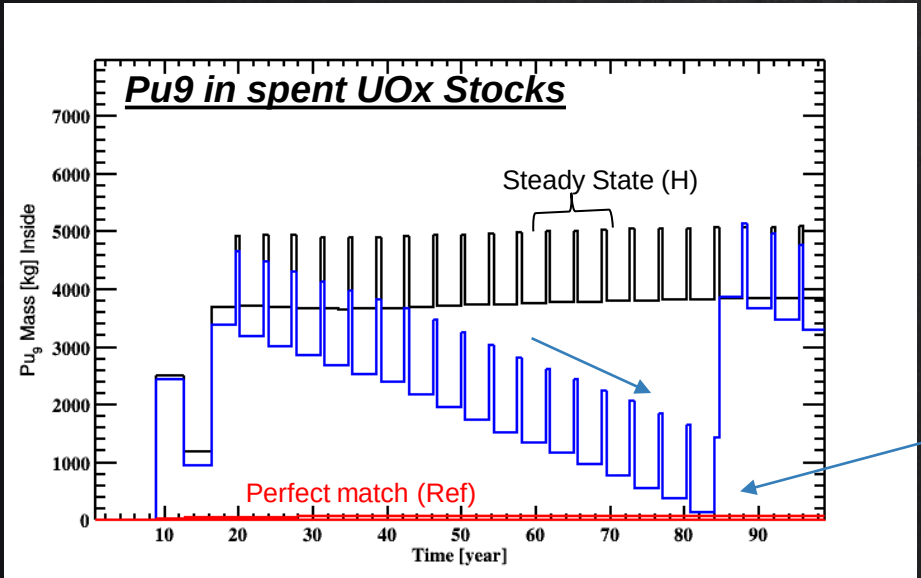
Fuel in Mox Reactors are not Homogeneous

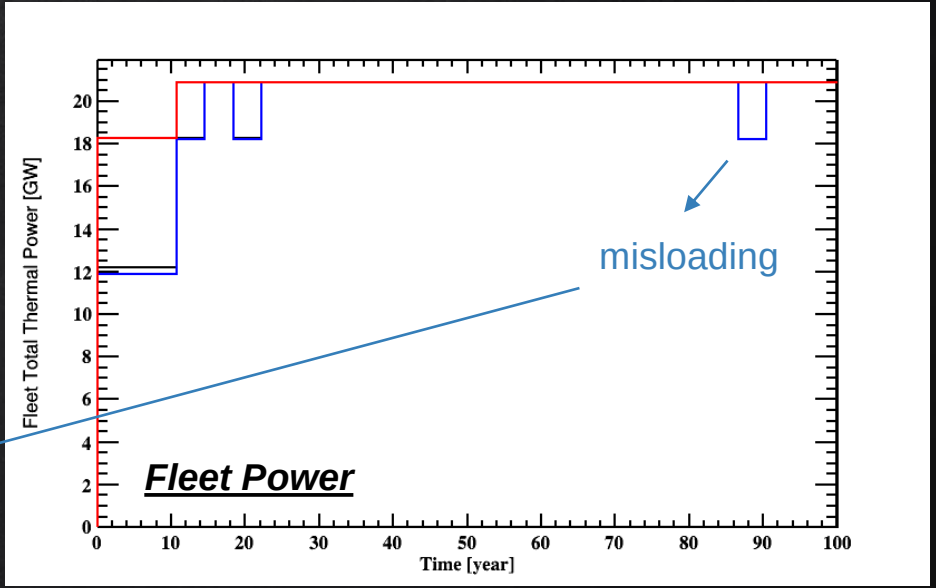
In general UOx are mixed with MOx fuel (30%)

Reactors are not linked to a fuel type



The equilibrium mechanism





- Both modelled fleets share the same equilibrium settings
- With H fleet a higher floor level of Pu is observed in UOx Stocks

Conclusions & outlooks

- Macro reactor approximation should be in consistency with fuel management options
- This simplification affects misloading effects and the nuclear fleet power shares between reactor types:
  - A parameter of importance in robustness analysis of scenarios @ equilibrium
- It appears that in the equilibrium assessment of a transition scenario the rate of deployment of capacities also matters

- More investigations are needed in order to evaluate how macro reactors impacts the solution phase space in equilibrium scenarios
- Especial care has to be taken when using reactor by fuel type as a higher floor level may exists in more realistic scenarios (i.e. cap the plutonium amount)