SCENARIOS FOR FAST REACTOR DEPLOYMENT WITH PLUTONIUM RECYCLING

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Abstract

For the future, the long term sustainable nuclear systems will be fast reactors which allow full use of uranium with no enrichment needs, efficient burning of plutonium and potentialities for improving waste management. These reactors will be initially fuelled with plutonium coming from spent MOX fuels, the breeding being adjusted according to energy needs. In this context, scenarios of Sodium cooled Fast Reactor deployment in progressive replacement of the French PWR fleet are assessed. Different chronologies are considered to evaluate the capability of SFR to renew a 60 GWe PWR fleet and the sustainability of this deployment in function of plutonium availability. The first scenario considers the deployment of SFR in two steps with 20 GWe from 2040 to 2050 and 40 GWe in addition from 2080 to 2100. The impact of a SFR deployment delayed in 2080 with 60 GWe deployed from 2080 to 2110 is assessed in a second scenario. In both cases, it is possible to deploy a 60 GWe SFR fleet at the end of the century, either by reducing the minimum cooling time before reprocessing of SFR fuel from 2080, or by adding fertile blankets to SFR.

The sensibility of scenarios to the SFR core design has been evaluated by considering different SFR types:

- the SFR V2B with a homogeneous core design;
- the CFV with a new heterogeneous core design with a significant gain on the sodium void effect.

The feasibility of SFR deployment is not affected by the change of core design and impacts on facilities are limited.

In addition to these scenarios with SFR deployed to replace the PWR fleet, scenarios of symbiotic fleet, in which a 60 GWe PWR fleet is maintained while SFR are progressively introduced from 2040 depending on the plutonium produced by the PWR fleet, can be envisaged.

The first evaluation focuses on the maximal achievable installed SFR power using plutonium in PWR spent fuel. Both cases of PWR fleet with and without MOX fuel are evaluated. The halt in 2040 of plutonium recycling in MOX PWR fuel allows indeed to deploy an additional 50 GWe of SFR in 2150.

The second part presents different key drivers to modulate the SFR deployment:

- increasing the PWR spent fuel cooling time to slow down the introduction of first SFR;

- increasing the SFR spent fuel cooling time to reduce the rhythm of SFR deployment;
- sizing spent fuel reprocessing capacities to realistic values.

These studies allow to identify configurations in which spent fuel storage are stabilized to values consistent with current values, in particular in the case of a PWR fuel cooling time fixed to 20 years or in the case of limited reprocessing capacities.