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# TECHNICAL AND ECONOMICAL FEATURES OF COMMERCIAL SODIUM FAST REACTOR IN FRANCE

# Summary

1. Presentation of the technical features of the industrial French Sodium Fast Reactor

2. Comparizon of Investment Cost estimation between SFR and PWR in France

# Background

The French nuclear policy for closed fuel cycle provides the deployment of Sodium Fast Reactors (SFRs) at the end of the 21st century.

Fast reactors can use the plutonium produced by Light Water Reactor (or by themselves) indefinitely, so they represent a key link in the closed-cycle strategy

Objectives :

1. Balancing the spent PWR MOX fuel inventory,
2. Using the recycled plutonium reprocessed from MOX spent fuel.

For the balancing of the PWR MOX inventory in France, around 2000 eGW of SFRs are necessary, in a predominantly PWR fleet, with a total nuclear power (PWR + SFR) of 50 to 60 GW in the French energy mix.

# Safety requirements of the commercial French SFR 1000

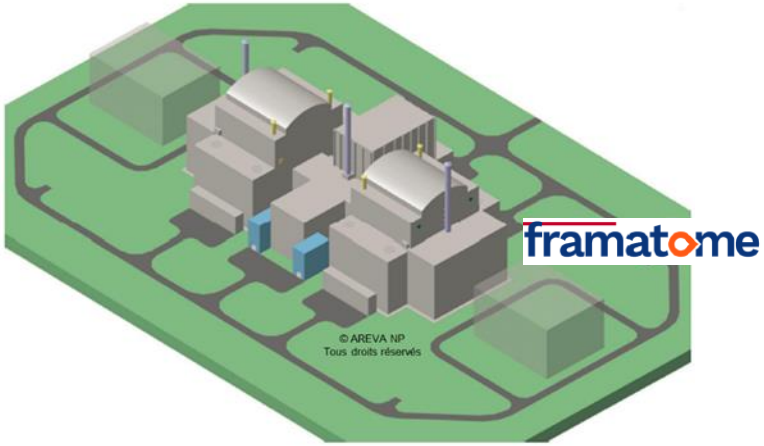
The GEN IV ambitious objectives of safety that meet the best standards are considered at the reactor sketch stage:

- ✓ Probabilistic targets: generalized core melting $<10^{-5}$ per year per reactor
- ✓ Limitation of releases in case of severe accident: no need for off-site emergency measures
- ✓ Extreme natural aggressions: sufficient margins beyond the basis design to prevent cliff edge effects
- ✓ Feedback experience in terms of lessons learned:
    - Fukushima accident,
    - Extreme natural external hazards,
    - Prolonged loss of external electrical supply and heat sink,
    - Risk of reactivity transients.

# Technical requirements of the commercial French SFR 1000

- Pool-type reactor, 2500 thMW – 1000 eMW
- Two twin-reactors sharing the same Fuel Building and the same Large Components Maintenance Building
- Design life-time: 60 years
- Iso-generator Core, able to evolute to Breeder with breeding blankets addition
- SFR MOX Fuel using plutonium from spent LWR MOX Fuel
- ODS cladding (Oxide Dispersed Strengthened) 150 dpa – average burn-up 120 GWd/tHM
- Low void effect Core « heterogeneous and compact »

# Sketch of the commercial French SFR 1000




Main **Nuclear Island design** options:

- Above Core cover plug can be replaced.
- Melted core catcher inside Main Vessel.
- Reactor pit in steel-concrete structure with a Safety Vessel
- 4 Primary Pumps
- 4 Intermediate Heat Exchangers, one per secondary loop
- 2 in-reactor Decay Heat Removal (DHR) exchangers able to operate in passive mode
- 4 helical Steam Generators

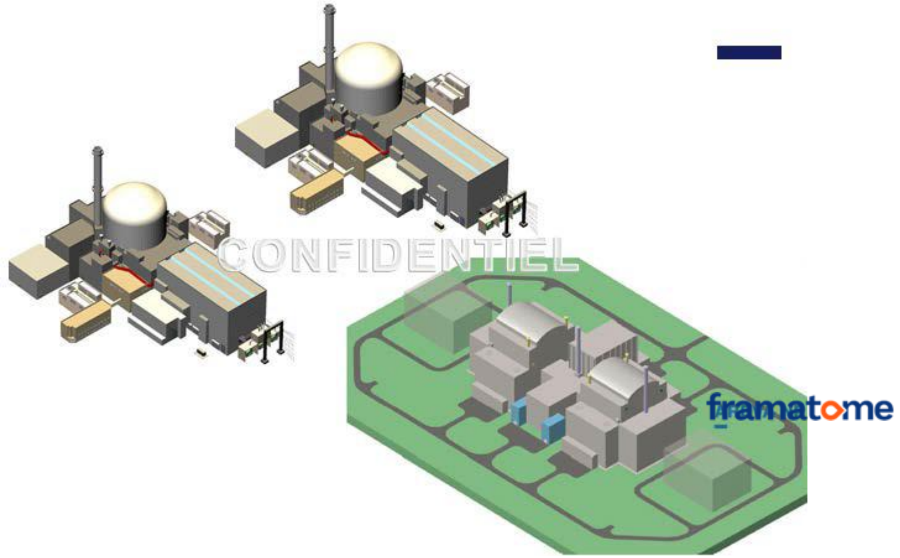
The **general lay-out** for the NI contains:

- Rectangular reactor building,
- 2 Steam generator buildings, including the DHR circuits,
- A Fuel Handling Building, for the spent fuel facilities, the storage pool for fresh and spent fuel,
- A Maintenance Building for large components washing and repair,
- Main buildings of the Nuclear Island are on an anti-seismic double foundation-raft.

# Capital Cost Comparison between PWR and SFR

METHOD: from the “Bid of Quantities” databases

- Cost baseline EPR (1640 eMW PWR) for export tenders, extrapolated to a theorical 1000 eMW EPR reactor
- ASTRID (600 eMW SFR) costing, extrapolated to a 1000 eMW SFR reactor




**Estimation of cost ratio between 2 RNR 1000 / 2 EPR 1000**

# Decomposition of CAPEX  for SFR Vs EPR

Nuclear Island is different between EPR™ and SFR

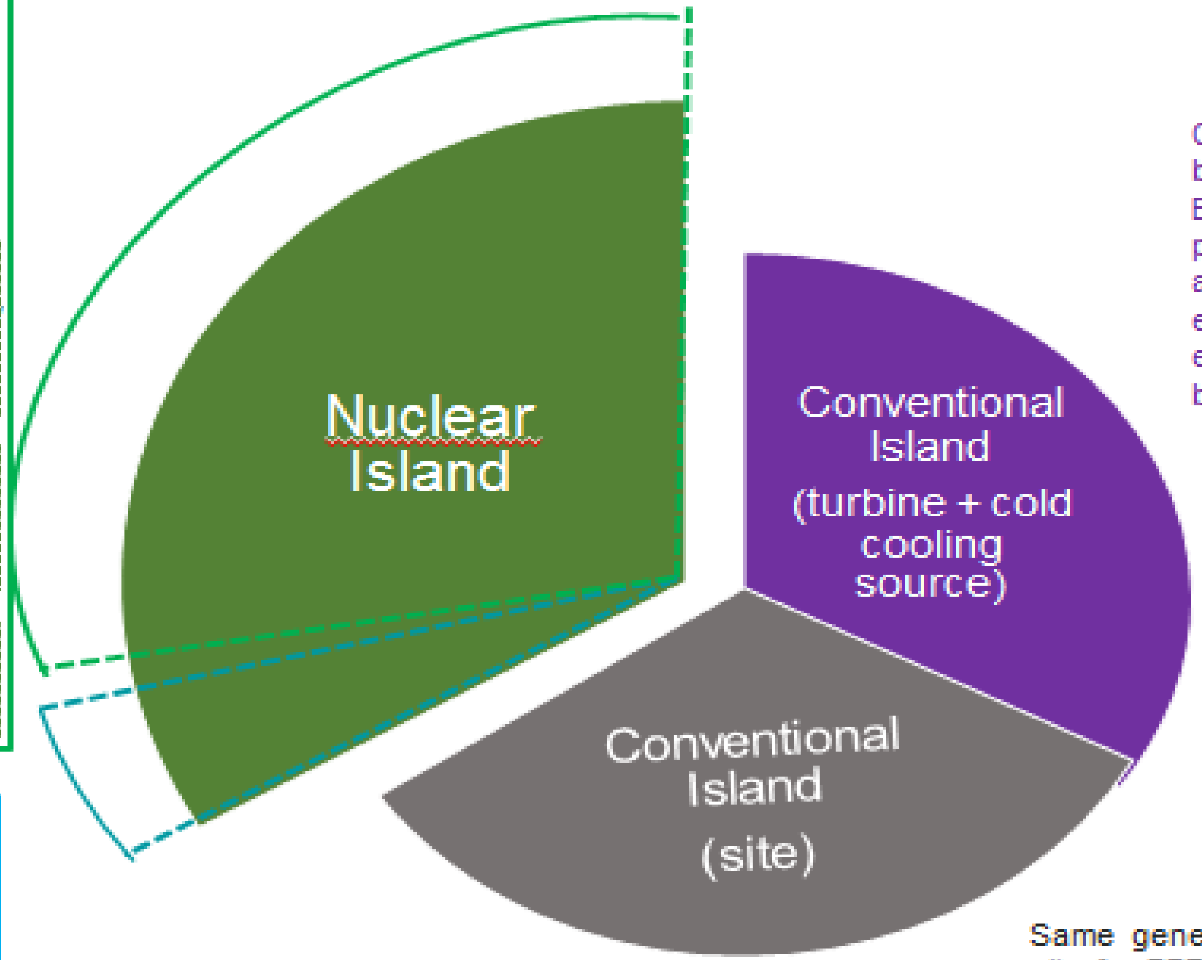
**Civil Work :**
SFR
reactor building : rectangular Shape with seismic isolation,
EPR™
reactor building : circular shape with prestress concrete and liner

**NSSS Equipment :**
Difference of materials (BOQ), factory process (forged vessel & pipes / boiler shell) and assembly

**Handling Equipment :**
Difference of BOQ / fuel and components handling devices under sodium

**Auxiliairy nuclear circuit :**
Difference of BOQ / sodium circuit

Similar Nuclear Island parts between EPR™ and SFR : except BoQ
- HVAC
- I&C, Electricity
- Cranes
- Spent fuel pool

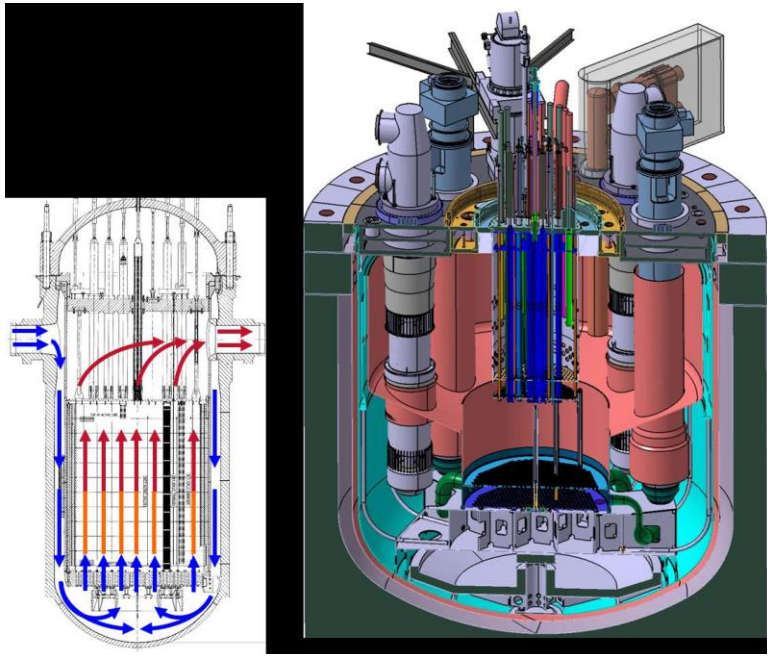



Cost are similar between SFR and EPR™ at the same power (taking into account the efficiency of output electricity production better)

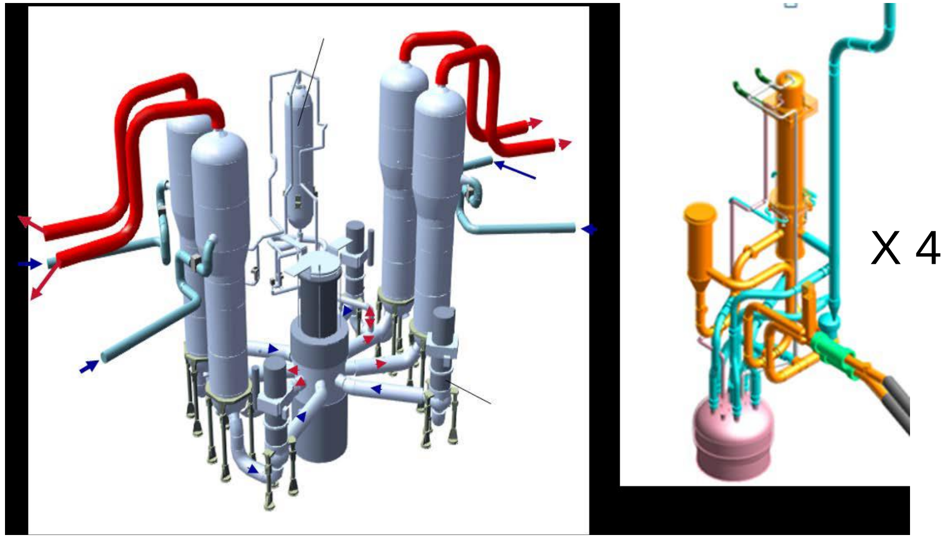
Same generic site for EPR™ & SFR

# Comparison of Reactor Designs

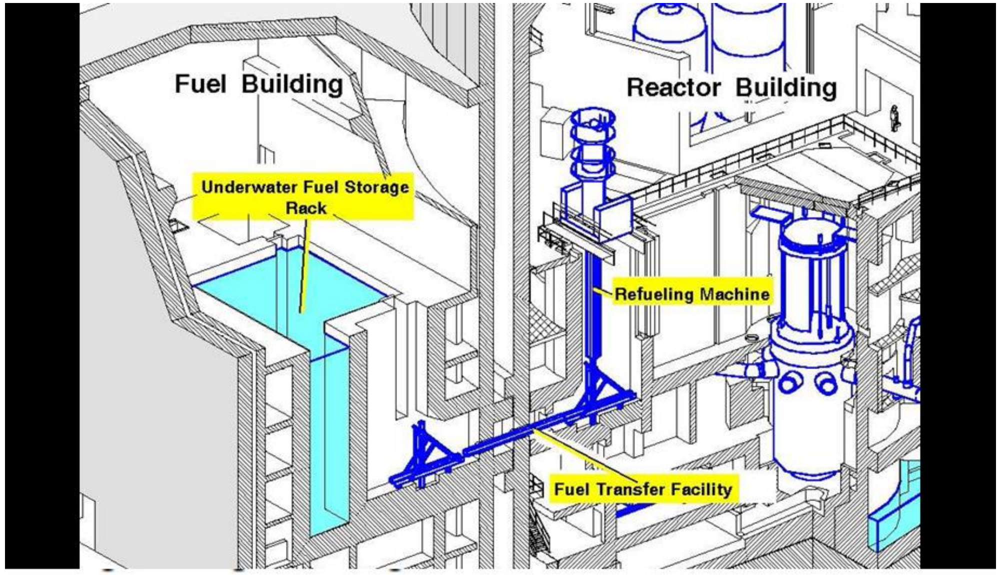
❑Primary Vessel

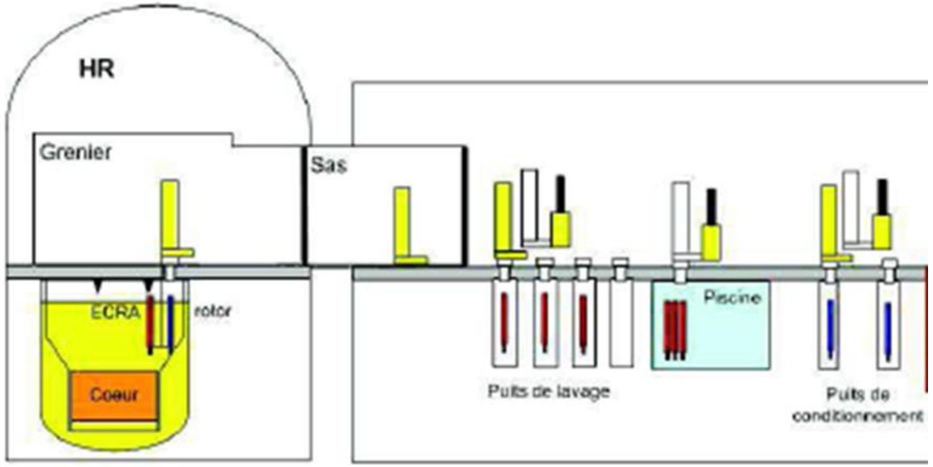


❑NSSS




❑Fuel Handling



# Intermediate Result

- The comparison of investment Cost between SFR 1000 et EPR 1650 is based on the calculation of transfer coefficients of cost for the following items:
  - NI Civil Works
  - « NSSS »
  - Fuel Handling Systems
  - NI HVAC
  - NI Auxiliairy Systems
  - NI Cranes and handling systems
  - Electrical Systems
  - I&C
  - Site facilities
  - CI-BOP
  - Engineering specifics costs

The transfert cost ratio between SFR 1000 and EPR 1640 MW NOAK extrapolated to 1000 MW is **1.61**

# Improvement solutions to reduce the cost ratio SFR/EPR under 1.5

- Increase of the core power, at reactor size constant -> 1100 eMW is possible
- Reduction of the primary vessel diameter
- Reduction or suppression of the Handling and Maintenance Building,
- Suppression of the anti seismic double foundation raft
- Containment extended to the Reactor Building without polar table
- Optimization of Steam Generator Buildings
- New concept of short secondary loops
- Optimization of primary auxiliary systems
- New concept of "extended safety vessel"

By integrating these potential economic improvements transfer cost ratio between the twinned 1,000 eMW SFRs and the twinned EPRs whose unit power has been reduced to 1,000 eMW can be evaluated at

**1.45**

# Thank You