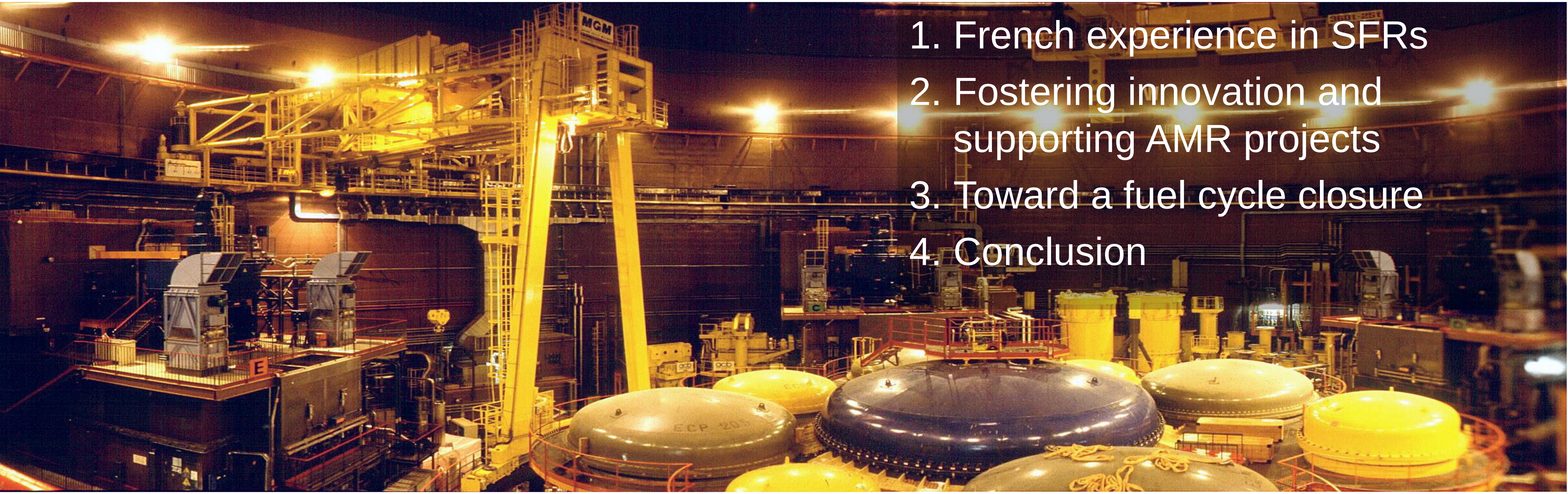
Recent developments toward a fleet of Fast Reactors in France

V. Barbe, D. Settimo – EDF
A. Dauphin, J.-M. Hamy – Framatome
F. Payot, P. Gavoille – CEA

IAEA Event EVT2103425
Technical Meeting on Advances and Innovations in Fast Reactor Design and Technology
Sept 29th - Oct 3d, 2025, Vienna

OUTLINE

1. French experience in SFRs
2. Fostering innovation and supporting AMR projects
3. Toward a fuel cycle closure
4. Conclusion



French experience in Sodium Fast Reactors

France has accumulated decades of experience related to fast reactors, among which:

- **PHENIX (250 MWe): 35-year operation**
- **SUPERPHENIX (1200 MWe): most powerful non-WCR ever operated**
- **ASTRID (600 MWe) and New ASTRID (150 MWe): designs intended to meet the GEN-IV criteria**


EFR


ASTRID

Fostering innovation: France 2030 (1/2)

In 2022, the French government issued a Call for Innovative reactors projects (in the broader frame of the investment program France 2030)

Selected projects were granted:

- **Financial support (under condition of equal private funding)**
- **Access to technical support by the CEA**

Iin paralel, ASNR set up a graduated process to anticipate and streamline technical exchanges with newcomers (not mandatory):

- **Step 1 : screening**
- **Step 2 : preparatory review (topical meetings)**
- **Step 3 : pre-licensing (Safety Option Report)**

1 reactor type
1 designer
1 operator

→

X reactor types
Y designers
?? operators

Fostering innovation: France 2030 (2/2)

From 2023 to 2024, 11 projects were selected with a total financial support of 130 M€.
Among them were 6 Fast Reactor Projects, 3 Liquid-Metal-cooled Fast Reactors, 3 Molten-Salt Fast Reactors

HEXANA	2 x 140 eMW	SFR	Thermal storage (molten salt) between NI and BOP
otrera	2-3 x 110 eMW	SFR	Reactors are connected to the same turbine but operate alternatively
newcleo (Futurable Energy)	200 eMW	LFR	Also develops an experimental LFR (30 MWe) and dedicated fuel fabrication and treatment facilities

Fuel : all three projects would use MOX fuel
Licensing : all three projects are in Phase 2 (preparatory review)
Market : all three projects target a mixed power + heat generation.

Steps toward a closed fuel cycle

Closure of the fuel cycle has remained a long-term target of the French nuclear policy since the construction of the current PWR fleet. Recent decisions reversed the context of nuclear slowdown (shutdown of Fesenheim PWRs, end of ASTRID project).

Step 1 (2022) : secure use of nuclear energy on the middle and long terms

- **Extend operation of existing plants as long as safety criteria are met**
- **Build additional capacities (EPR2s) to be in service in the 2030s**

Step 2 (2024) : expand the fuel reprocessing / recycling strategy until the end of the century

- **Extend operation of fuel cycle facilities (La Hague, Melox) beyond 2040**
- **Plan and design new capacities to be operated by 2050**
- **Beyond the current practice of one-fold re-use of spent fuel (mono-recycling, MOX fuel), study the conditions of two-fold recycling of the spent fuel in PWRs**

Step 3 (2025) : demand for a roadmap toward the fuel cycle closure by means of a fleet of fast reactors and associated fuel cycle facilities.

SFR1000: A CLOSED-CYCLE-ORIENTED DESIGN

The SFR1000 was Introduced in 2017 as the industrial follow-up of ASTRID.

Objectives and technical options were defined by the three major partners:

- **CEA, leader of ASTRID project**
- **Framatome, designer of ASTRID NSSS**
- **EDF, reference operator of the SFR1000**

The design was first used as an input for ramp-up studies of an SFR fleet:

- **Sufficiency of fissile inventory, related to the expected conversion ratio**
- **Projected cost of the reactor (with respect to PWRs) → slightly over the 1.5 target**

Since the termination of ASTRID project, design optimization studies have been continued.

SFR1000: MAIN OBJECTIVES

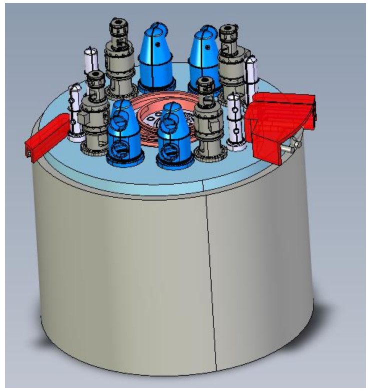
- Closing the fuel cycle
  - Breeding ability (favored by a 1 eGW size)
- Industrial targets
  - 60 years lifetime
  - Load following capability
  - Significant progress in ISI&R compared to past operated SFR
- Safety
  - Compliance with GIF standards especially with
    - Core damage frequency
    - Lessons of the Fukushima Daiichi accident
  - Probability of severe core damage below 10^{-5} per reactor and per year
    - SFR favorable characteristics such as reactivity feedback, margin from boiling and capability to remove decay heat with natural convection are used
    - Practical elimination of severe events with a deterministic approach supported by a probabilistic calculation

SFR1000 TECHNICAL OPTIONS

Pool-type, suspended vessel.

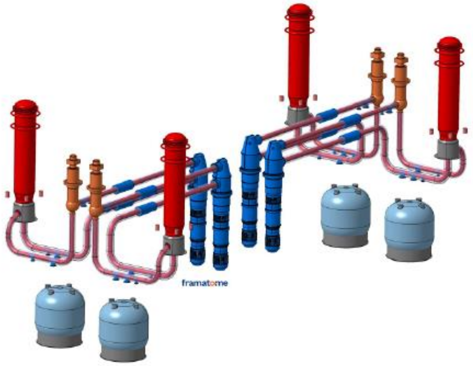
MOX fuel with heterogeneous pins (low void effect).

ODS fuel cladding (higher burn-up)

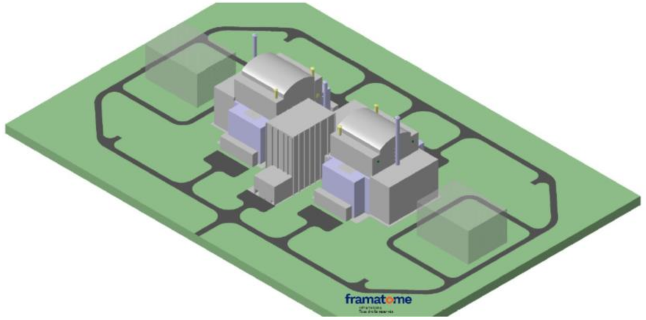


Helical tube Steam Generators.

Compact secondary loops with expansion bellows.



Twinned reactors with common building for fuel handling and sodium-specific operations.



Being defined as a long-term goal, technological solutions can be selected if they are reasonably available in the 2d half of the century

➔ The SFR1000 design shows a heterogeneous level of maturity

➔ Tool to drive R&D activities and verify that the main challenges are addressed.

Conclusion

France confirmed the importance of GW-size PWRs in the energy roadmap on the middle-term (current fleet) and long-term (EPR2 series).

Alongside this decision, interest toward Fast Reactors is being revived through two independent streams:

/1/ France 2030 call for Innovative reactors selected 6 fast reactor projects (among 11 selected projects)

- 3 Liquid-metal cooled reactors (2 SFRs, 1 LFR)
  - ➔ Reflects France's experience in the field of SFRs and the related fuel cycle
  - ➔ Preferred size of 100-200 eGW to address the market needs
- 3 Molten-chloride reactors (fast spectrum)
  - ➔ Time to market is expected to be higher than liquid-metal models

/2/ « Historical » actors of the field were asked to propose a roadmap toward fuel cycle closure

- ➔ Preferred option of a GW-size SFR

Both streams need to communicate on common interests: technological developments, fuel, etc