

企画セッション | 部会・連絡会セッション：海外情報連絡会

📅 2022年9月9日(金) 13:00 ~ 14:30 | 📍 D会場 E1棟2F 23番教室

[3D_PL] フランスにおける原子力エネルギーの新たな動き：カーボンニュートラル達成への柱

座長：石川 顕一 (東大)

[3D_PL01] フランスにおける原子力エネルギーの新たな動き：カーボンニュートラル達成への柱

*Vincent Bessiron¹ (1. Framatome Japan)

海外情報連絡会セッション

New dynamics of the nuclear energy in France: a pillar to reach carbon neutrality

*Vincent BESSIRON¹, Vincent DUFOUR², Jean-Pierre GROS³¹Framatome Japan KK, ²EDF, ³Orano Japan KK**1. Summary of the presentation**

The nuclear energy is a major pillar of France's roadmap to reach the target of -40% of greenhouse emission between 1990 and 2030 and carbon neutrality in 2050. The paper aims at presenting the current situation and the perspectives of nuclear energy in France. It is structured in 5 parts:

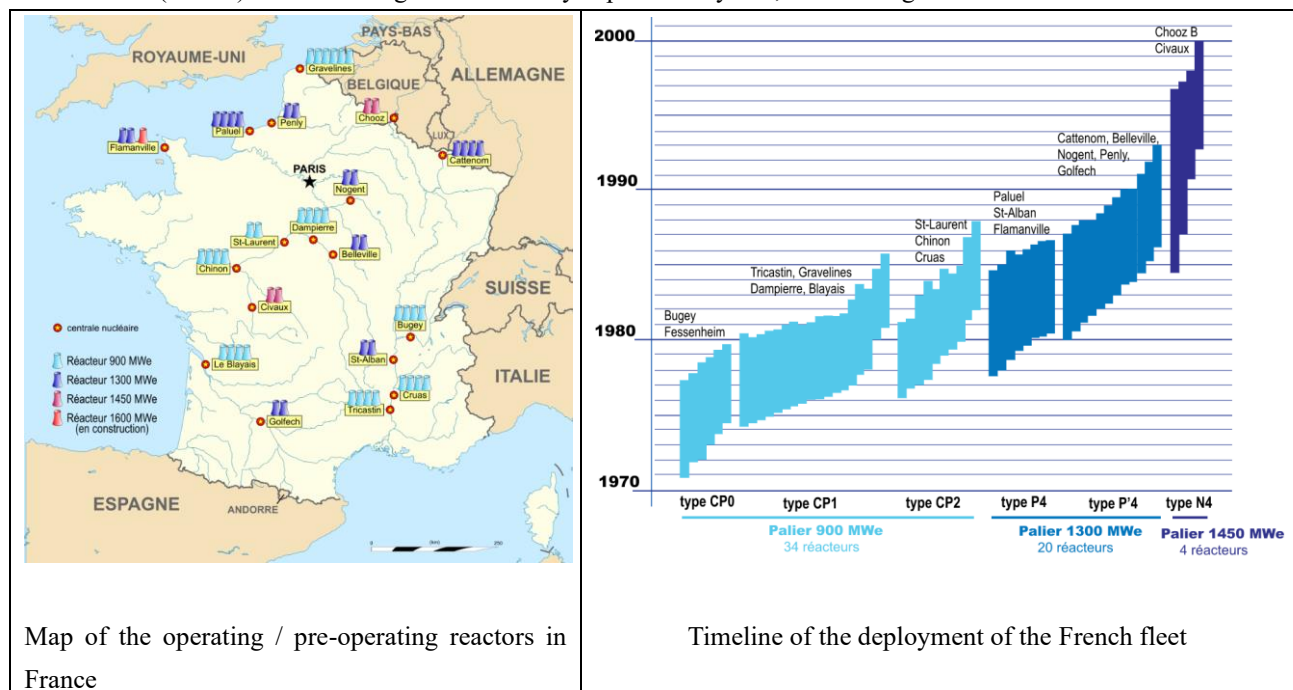
- The first part presents the current situation on the fleet with 56 operating reactors; a presentation of the main actors is given.
- The second part describes the new nuclear program of EPR2s that has been announced by the government.
- The third part deals with axes of innovation with the SMR Nuward, other advanced reactors, Accident Tolerant Fuel, medical radioisotopes etc.
- The fourth part shows how the closed cycle and D&D put the nuclear energy at the forefront of the circular economy in France.
- Finally, the fifth part emphasizes on the renewal of competences.

The conclusion is that the French nuclear industry is mobilized and ready to deploy and achieve the new nuclear program that will be at the core of the decarbonation roadmap for the country.

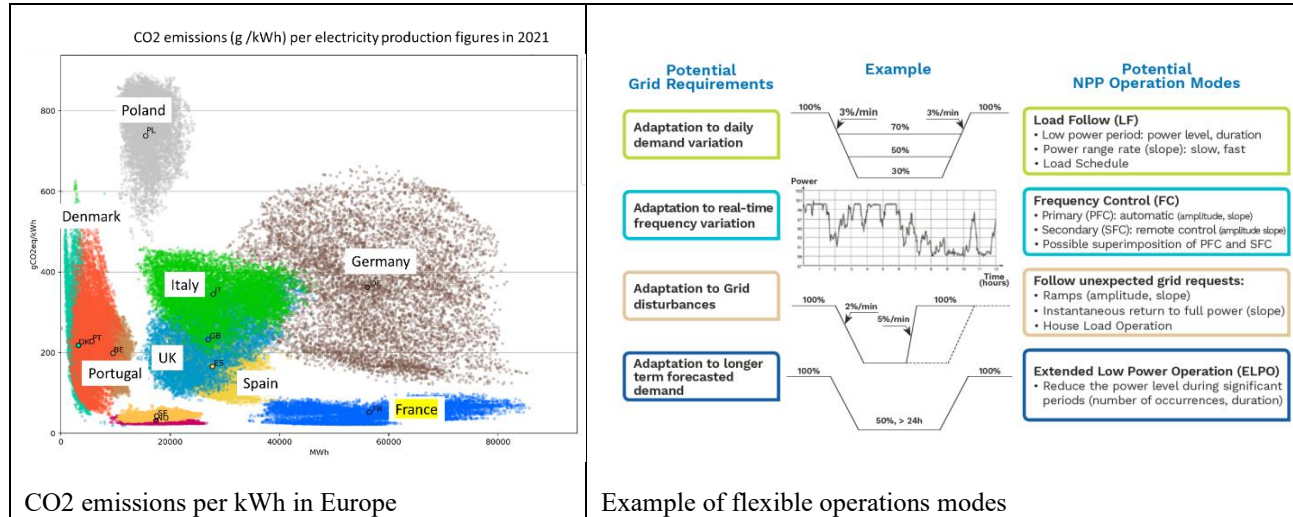
2. Current situation the nuclear fleet

France has a fleet of 56 operating PWRs on 18 sites which represents a total installed capacity of 61.4 GWe. The reactors have started operation between 1979 and 2000 with three main reactor types: 900 MWe, 1300 MWe and 1450 MWe. In addition the Flamanville-3 EPR (1650 MWe) is in pre-operation stage.

These reactors provide about 70% of the electricity in France (close to 350 TWh) and the remaining production is ensured mostly by hydropower (20%) and renewables. Thanks to this electricity mix, the electricity in France is largely decarbonized (~ 90%) and the average CO₂ intensity is particularly low, around 50 g CO₂/kWh.

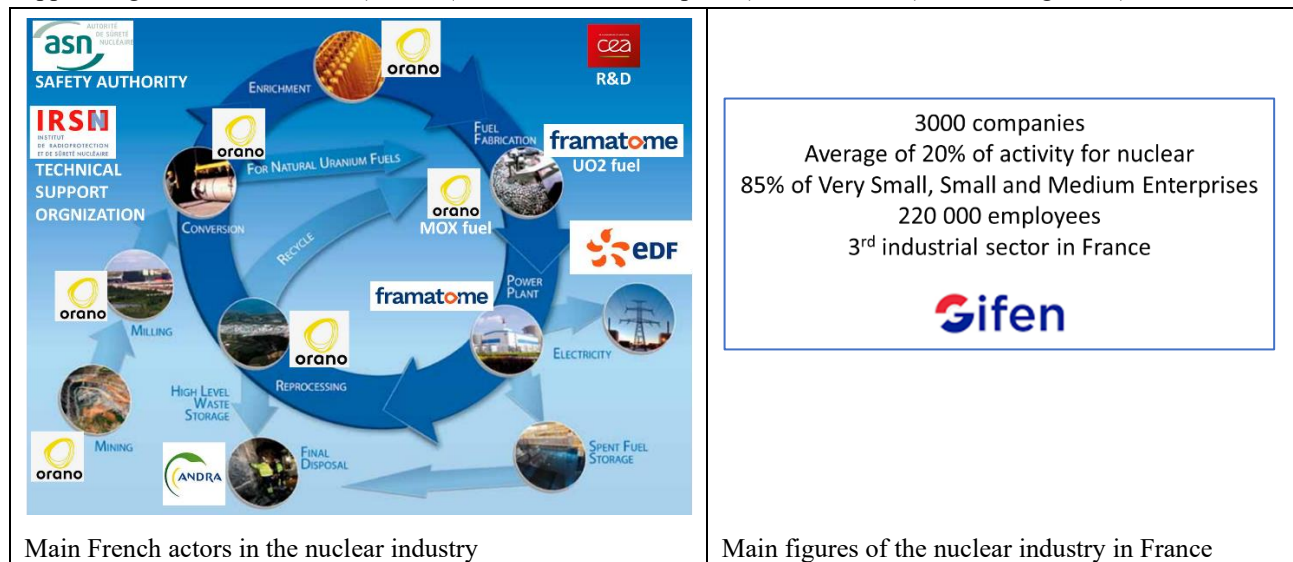


The challenges associated with the current fleet are the life time extension beyond 40 years and the safety upgrades to account for the lessons learned of the Fukushima accident. In addition to the continuous efforts for the highest level of safety, the whole nuclear industry strives to increase the economics of the fleet with optimized outages, efficient operation and globally optimized costs along the whole fuel cycle. The operating mode of the French reactors is based on the possibility to modulate the power: this is a necessary condition for the coexistence of the nuclear and intermittent renewables.



The main French actors are:

EDF (operator), Framatome (designer and manufacturer of the Nuclear Steam Supply System and UO₂ fuel), Orano (mining, conversion, enrichment, reprocessing, MOX fuel manufacturing), ASN (Safety authority), IRSN (Technical Support Organization of the ASN), CEA (Research and Development) and ANDRA (waste management).



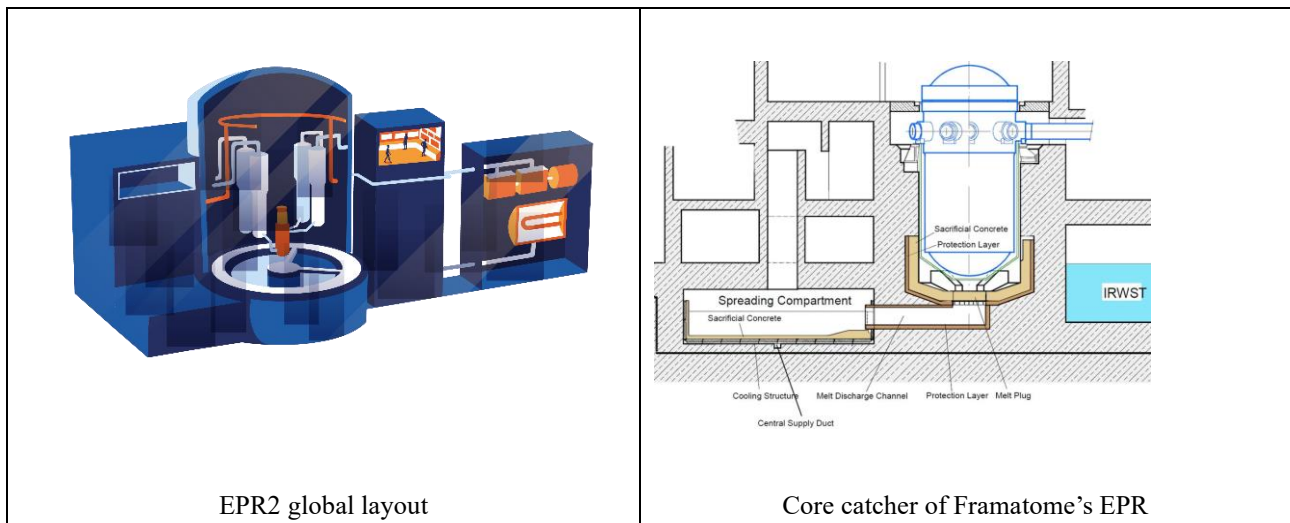
3. A new program of 6 EPR2s (+8 option) announced by the government

The reference forecast of electricity demand in 2050 considers an increase of 35% compared to the current period. The French government analyzed several scenarios at this horizon, from 100% renewables to 50% of nuclear. The most optimized scenario, on both CO₂ reduction and economics aspects, appeared to continue the massive deployment of renewables and to simultaneously launch a new nuclear program with 6 EPR2s plus 8 in option.

The EPR2 is an optimized version of the EPR which maintains the EPR safety standards among the highest in the world while significantly simplifying its construction.

The government also decided that no operating reactor be decommissioned if it still has the capacity to produce electricity

efficiently, as long as the highest standards of safety are ensured.



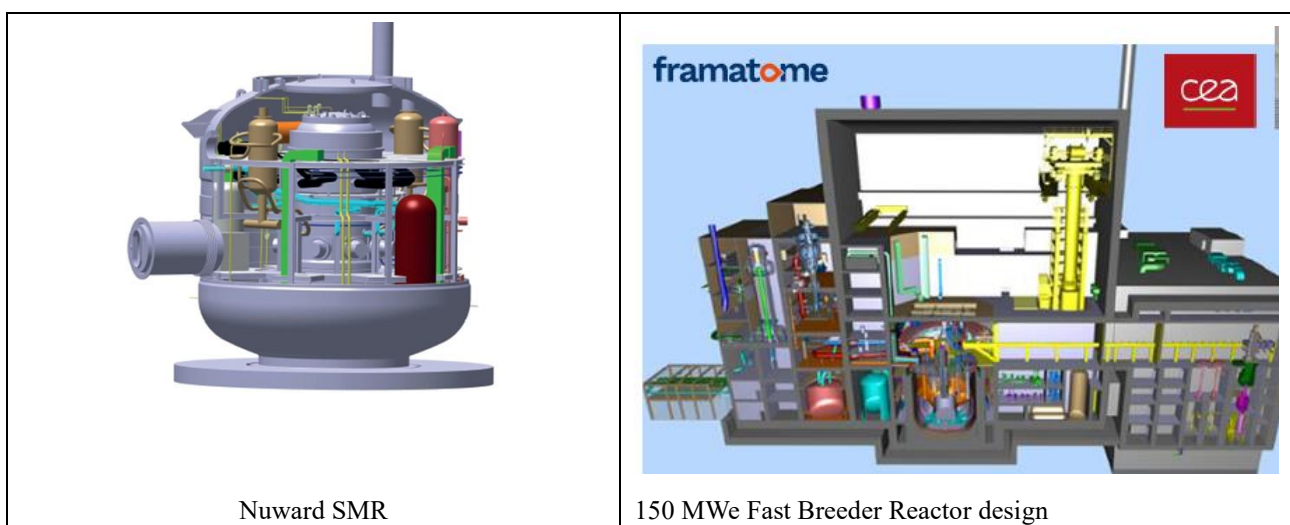
4. Innovation with SMRs, advanced reactors, fuel and medical radioisotopes

A consortium gathering EDF, CEA, Technicatome, Naval group and Framatome is developing the Nuward SMR with two twin units of 170 MWe in a single nuclear building. The objective is to build a first twin unit in France and then to export Nuward to replace 300-400 MWe coal plants, to provide energy for remote areas or intensive industrial sites and to supply networks that cannot be connected to high or medium sized reactors. The French government is supporting this project through the “France 2030” program.

In addition, the French nuclear industry develops advanced reactors such as Fast Breeder Reactors, High Temperature Gas Reactors, Molten Salt Reactors etc.

Innovation also concerns nuclear fuel with Framatome's PROtect Accident Tolerant Fuel (ATF) which is now in the latest stage of qualification.

Innovation in the use of nuclear energy for healthcare is developing significantly. These activities for the medical sector provide new and positive look from the public towards nuclear energy.



	
Cr coating on claddings for Accident Tolerant Fuel (PROtect).	  Innovation for the production of medical radioisotopes

5. Closed cycle and dismantling: nuclear energy at the forefront of the circular economy

France has set up a closed fuel cycle policy with recycling the plutonium in the form of MOX fuel in the current PWRs. The plutonium will also be burnt in Fast Breeder Reactors in the future. France is about to resume the use of reprocessed uranium fuel in several reactors.

The vitrified waste conditioning allows to considerably reduce the volume of waste (factor 5).

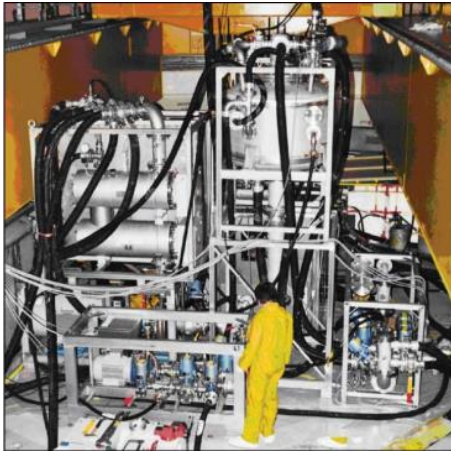
The CIGEO project for geological repository is advancing as planned with a recent declaration of Public Utility.

As regards the Decommissioning and Dismantling of reactors, the projects are on-going for first generation Graphite Gas reactors and for the oldest PWR units (Chooz A, Fessenheim). Key factors for the success of D&D projects are the careful identification of generated waste, the decontamination of circuits and specific attention to the overall planning of the D&D steps.

The D&D of the Superphenix Fast Breeder Reactor has considerably progressed as the vessel is now filled with water (all the sodium has been drained and treated).

France has capacities to manage large contaminated components to liberate the material below activity thresholds: this allows to reduce the waste of about 80% (EDF Cyclife).

	
Manufacturing of MOX fuel (Orano)	Cut of a vitrified waste canister (Orano)



Framatome's Full System Decontamination to be applied for the D&D of Fessenheim NPP



Management of contaminated large components (EDF Cyclife)

6. Renewing the competencies

The difficulties encountered in recent nuclear projects after several years without new constructions have highlighted the need to rebuild strong competencies in the nuclear industry, to strengthen the supply chain while better including it in the nuclear projects and to further standardize the processes and the equipment. The EDF Group has set up the Excell plan that addresses these items to ensure the success of the new EPR2 program. The government is supporting the consolidation of competencies through the program "France Relance".



Plan Excell (EDF)



School of welding (Framatome)



Recycling Campus (Orano)



University of nuclear gathering the industrial actors