

DE LA RECHERCHE À L'INDUSTRIE



NUCLEAR ENERGY : a pillar in the framework of the French energy transition law

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■ Nuclear Energy in France :

↪ Current situation, trends, position in Europe.

■ The energy transition in France :

↪ The principle and basics of the law, the current discussions.

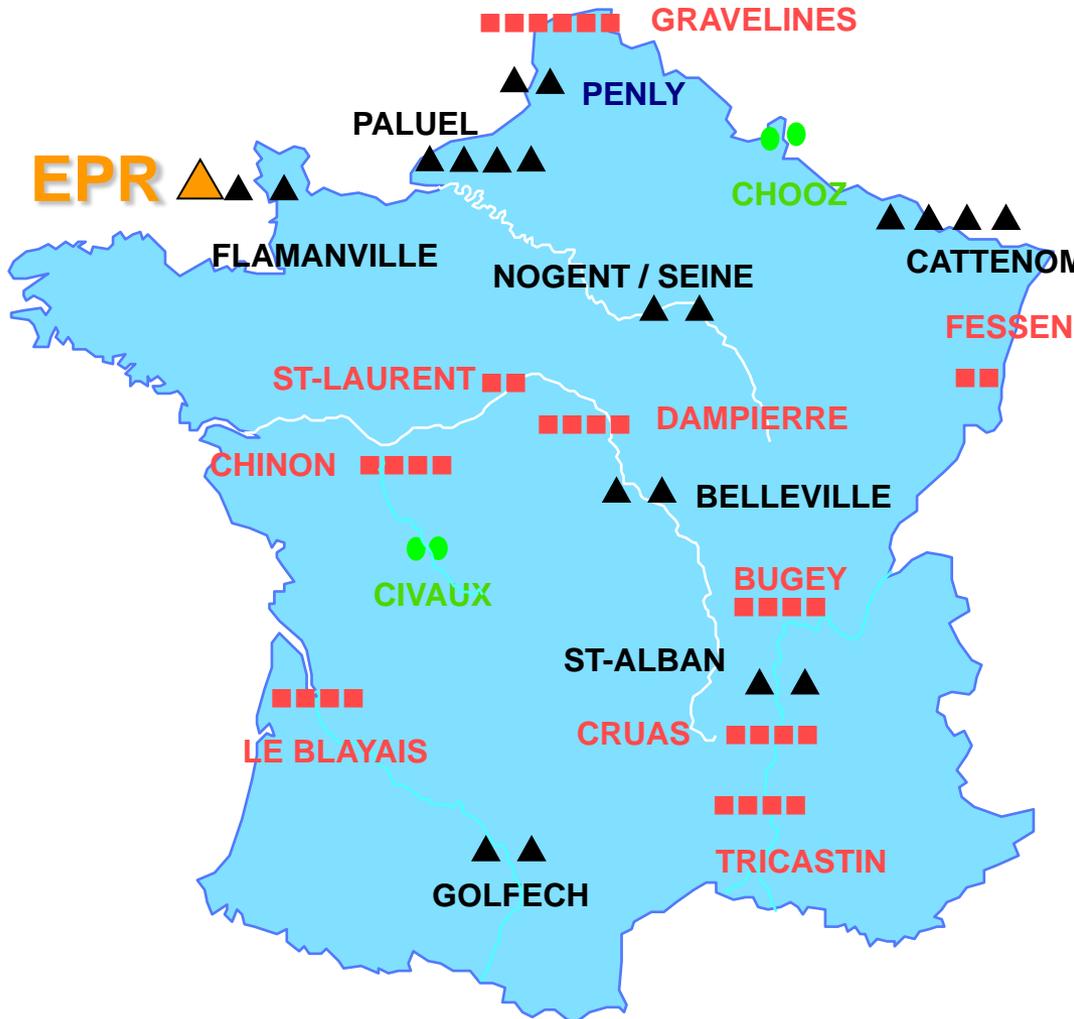
■ For the future :

↪ Optimization of current LWR operation and fuel cycle, preparation of Gen IV
and associated fuel cycle.

■ The ASTRID project.

■ Conclusion.

THE CURRENT NUCLEAR POWER FLEET



- 34 900 MWe units ■
- 20 1300 MWe units ▲
- 4 1500 MWe units ●

58 PWR units
63130 MWe installed

416 TWh produced in 2014

energy independence rate :

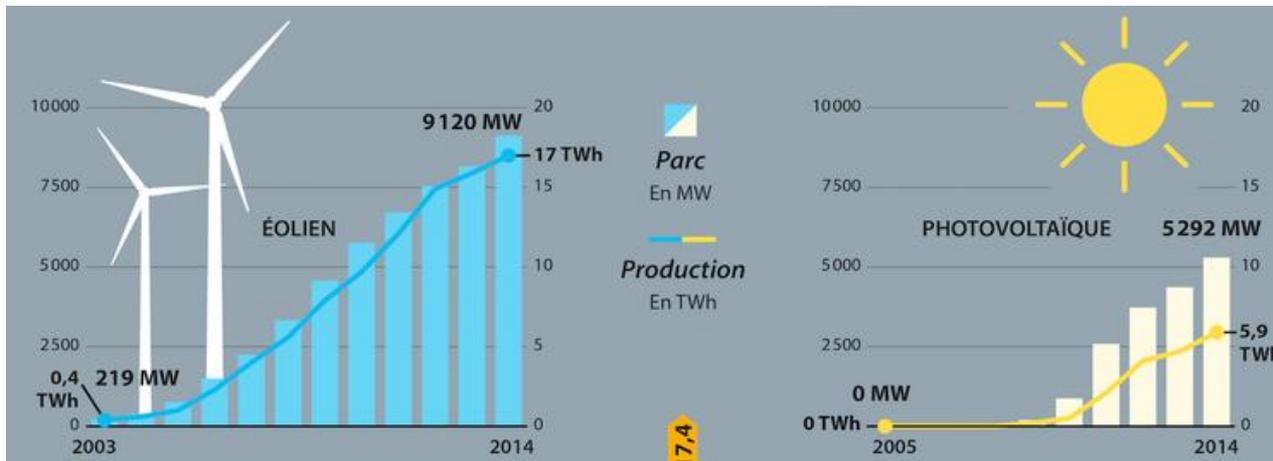
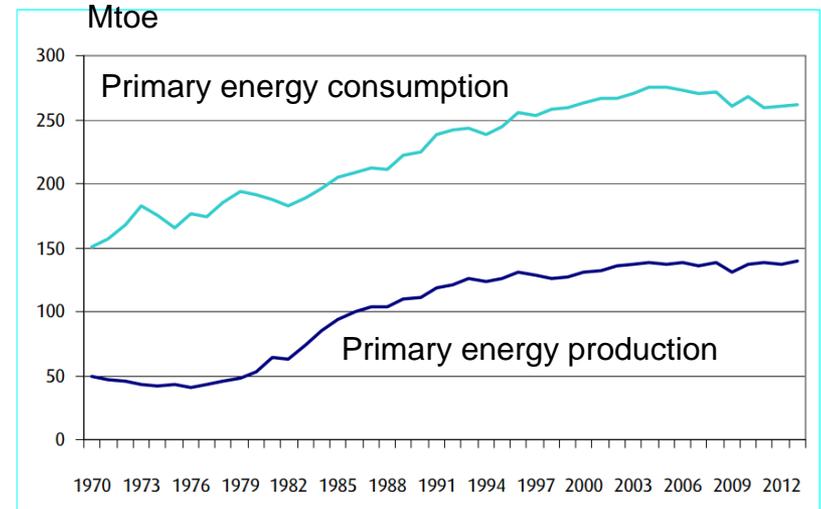
53 % in 2013

Connection to the grid :

- Unit 1 (Fessenheim 1) : April 1977
- Unit 58 (Civaux 2) : December 1999

SOME BASIC FACTS ABOUT ENERGY IN FRANCE

- Primary energy consumption is almost stable in France since 2000.
- Energy independence is around 50%.
- Around 75% of electricity comes from nuclear.
- More than 90% of electricity in France is CO2 free.
- The development of renewables :



2014 electricity production :

Wind power : 4%
PV : 1%

France keeps heading fixed by the European Climate-Energy Package in 2020

Reduction by 20%
of the consumption
of primary energy

Reduction by 20%
of GHG emissions
(compared to 1990)

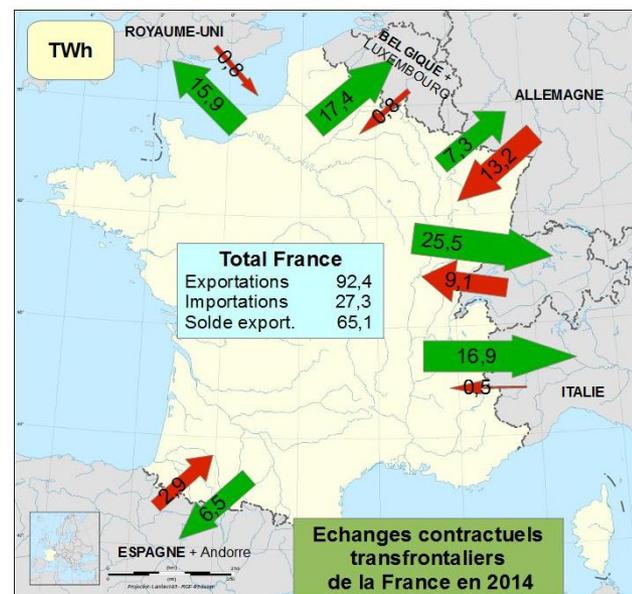
With a 20% share
of renewable energy
in the energy mix

Nuclear and Renewable :

- ❑ Renewable: intermittent supply
- ❑ Nuclear energy: base-load supply



France is integrated in the European grid : net exporter of electricity (65 TWh in 2014).



- **Control energy demand and promote energy efficiency and sobriety.**
- **Diversify energy supply sources, reduce the use of fossil fuels and increase the share of renewables.**
- **Involve all stakeholders : citizens, businesses and local territories.**
- **Ensure transparency and information, including energy costs and prices.**
- **Develop R&D in the energy field.**
- **Ensure energy transport and storage means adapted to the needs.**

- **Reduction by 2030 of the use of fossil resources by 30% and of GHG by 40%, and halve the overall energy consumption in 2050 compared to 2012 level.**
- **Capping the installed nuclear capacity to the current level (63 GWe), and decrease the share of nuclear electricity from 75% to 50% by 2025.**
- **Increase renewable energies share of final consumption to 23% by 2020 and 32% by 2030.**
- **Establishment of a Multi Annual Energy Plan (MEP), revised every 5 years, that sets the evolution of Energy mix.**

THE ACTUAL PROCESS OF DECISION

- **The law was voted on October 18th by the National Assembly (lower house).**
- **A modified version was voted by the Senate (higher house) on March 3rd :**
 - ↪ Nuclear capacity capped at 64,8 GW.
 - ↪ 50% of electricity from nuclear, but “in due time”.
 - ↪ 40% of renewable energy by 2030.

- **An inter house commission on March 10 could not reconcile the two versions of the law.**

- **The bill has to go again in front of the lower house for a final vote.**
 - ↪ Final version is unknown, even though according to the French constitution, the lower house has the final word on the higher one.

■ Declaration from Manuel VALLS, Prime Minister :

- ↪ « Nuclear is an energy of the future. It is essential for our sovereignty and to fight global warming »
- ↪ « ...Gen IV reactors will allow to multirecycle the fuel and strengthen our supply security. These reactors of tomorrow must be a priority for R&D works, especially in CEA.»



■ Statement from Ségolène ROYAL, Minister for ecology, sustainable development and energy :

- ↪ « the goal is to use the operational feedback of Gen III reactors (EPR, ATMEA1) and to prepare the Gen IV reactors, which will use less fuel, and will have integrated recycling capabilities, producing a lesser amount of less active radioactive wastes (CEA's ASTRID demonstrator). »





***NUCLEAR ENERGY WILL REMAIN
THE MAIN SOURCE OF ELECTRICITY
PRODUCTION IN FRANCE***

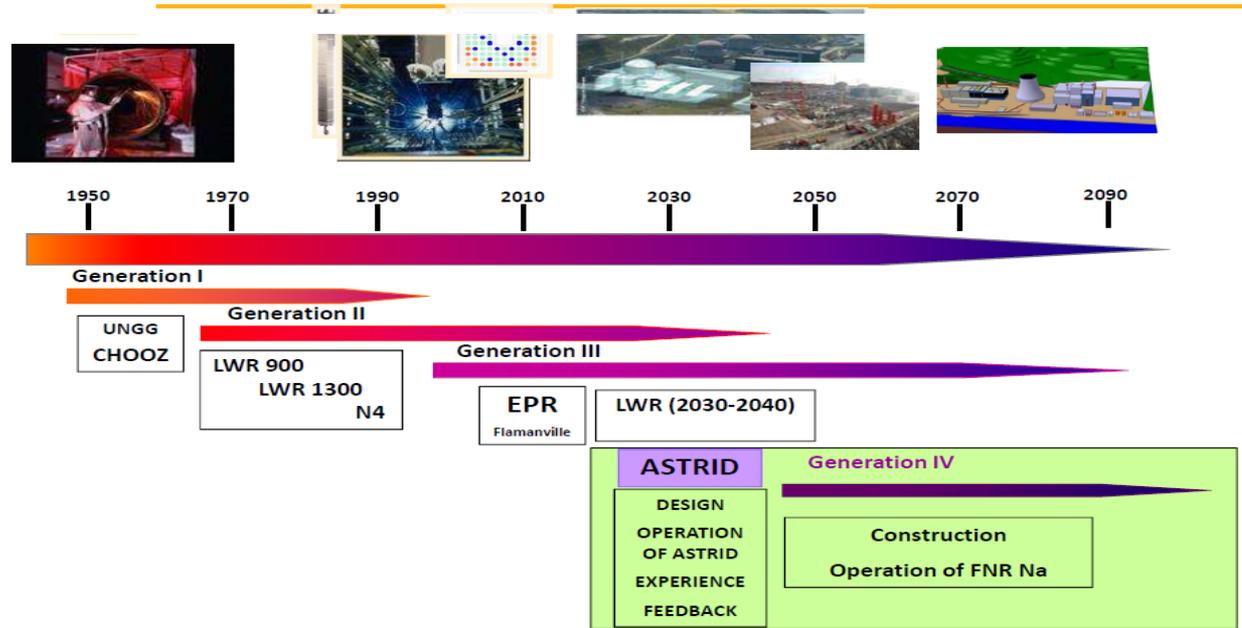


WHAT IS DONE TO PREPARE THE FUTURE ?

- **Increase LWR lifetime.**
- **Carry on with closed fuel cycle and optimize reprocessing.**
- **Prepare the future with a fast neutron reactor and its associated closed fuel cycle.**
 - ↻ To allow the multirecycling of plutonium.
 - ↻ To use all the energy potential of spent fuels.
 - ↻ To minimize waste volume and radiotoxicity of finale high level nuclear wastes, allowing a better use of the future geological repository.

NPP AND CYCLE FACILITIES GENERATION TIME FRAME

From LWRs to SFRs
 Gen III will remain the main contributor for decades
 But a need to prepare the future from now on



Cycle Technologies
 Current cycle technologies can bridge NPPs Gen III and IV
 But need adaptation for future plants



La Hague RPP



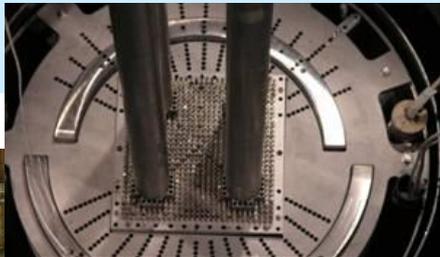
Rokkasho RPP



Melox

Reactors

- Extending the operating lifetime of nuclear power plants
- Improving their performance levels (availability, etc.)
- Increasing their nuclear safety levels



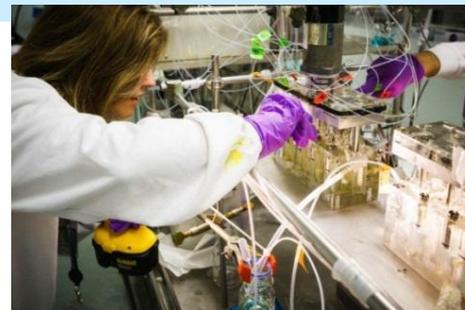
Studying the fluence absorbed by the 1300 MWe reactor vessels in EOLE



Investigation of irradiated materials and fuels at the Saclay centre

Cycle

- Meeting industry needs in a highly competitive market
- Supporting the recycling industry (La Hague & Melox), radwaste producers and Andra
- Preparing efficient new processes
- Promoting CEA developments in the international arena



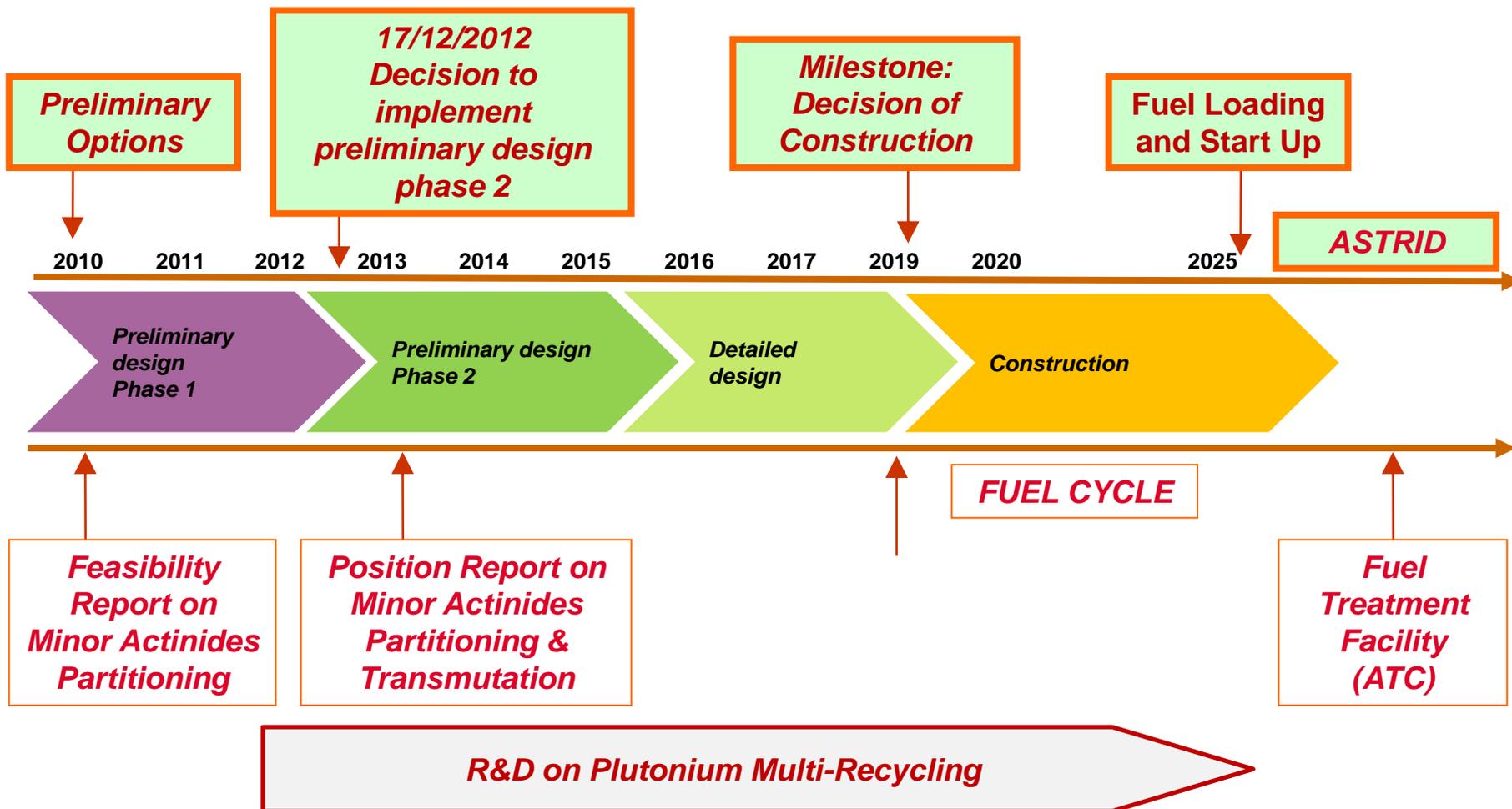
Platform of mixers and settlers to validate the performance of the selective uranium extraction process on a laboratory scale



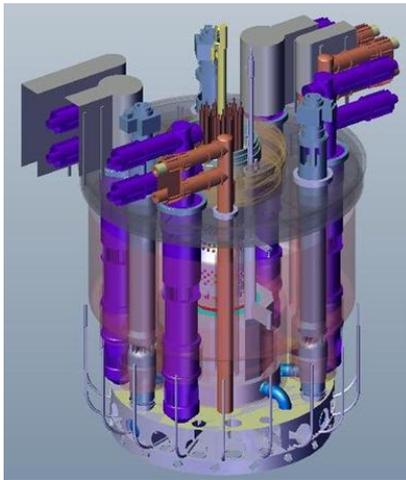
General view of the evolving vitrification prototype equipped with a cold crucible melter adapted for nuclear environments at Marcoule

ASTRID SCHEDULE CONSISTANT WITH FUTURE DEPLOYMENT

Start up in mid-2020 for enough feedback in mid-2030



ASTRID – COOPERATIONS



R&D Institutes	Industrial partners	Countries
EDF	JAEA + MHI + MFBR	Japan
AREVA	AREVA	Russia (Rosatom)
PSI	EDF	USA (DoE)
CNRS (NEEDS)	COMEX Nuclear	
IGCAR	ALSTOM	
DOE	TOSHIBA	
ROSATOM	BOUYGUES	
NNL	ROLLS-ROYCE	
JAEA	JACOBS	
EURATOM (European projects)	ASTRIUM	
	ALCEN	



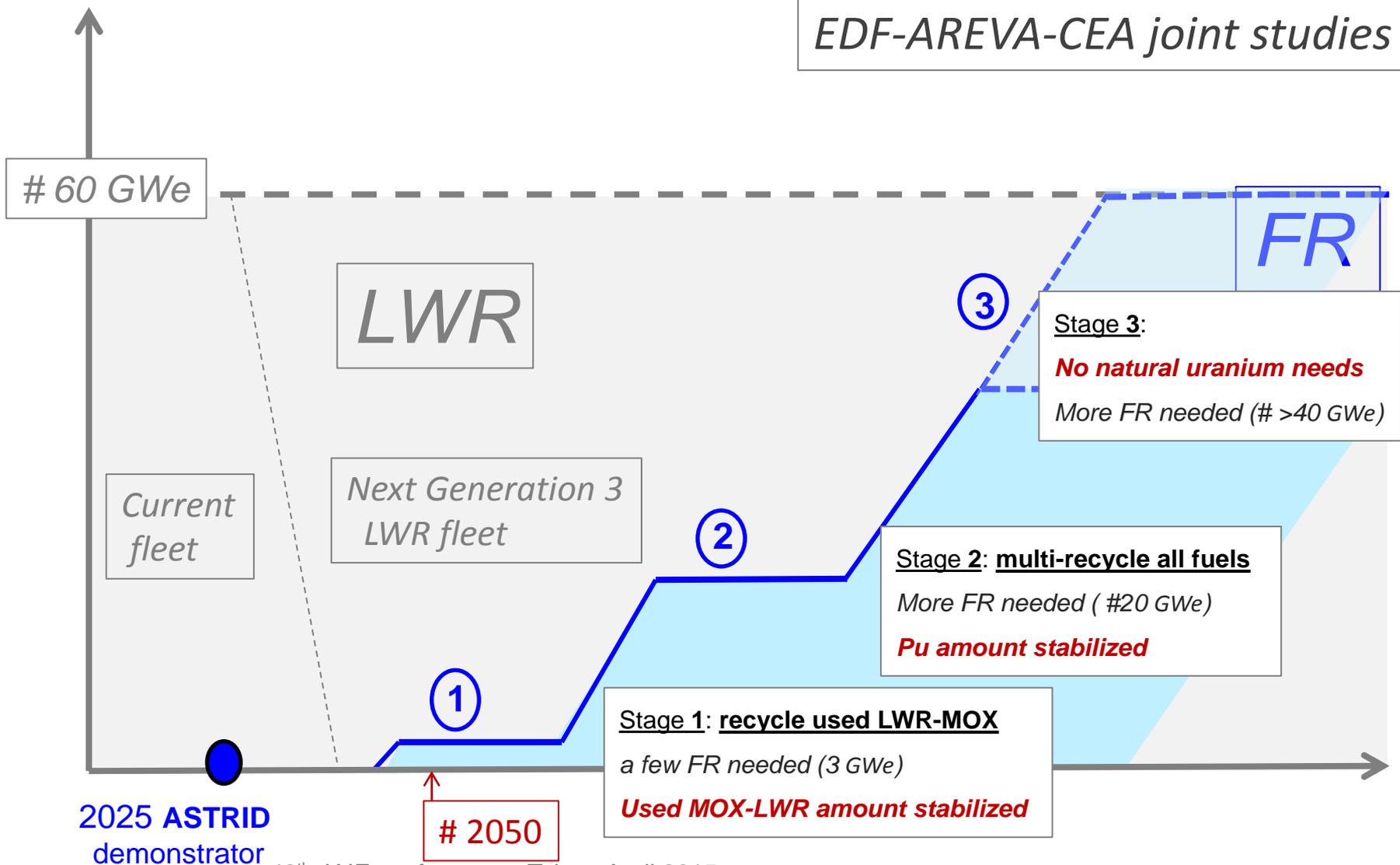
↑
- about 250 staff
- 28% of preliminary design



48th JAIF conference – Tokyo, April 2015

FR REACTORS DEPLOYMENT: CURRENT SCENARIO STUDIES

EDF-AREVA-CEA joint studies



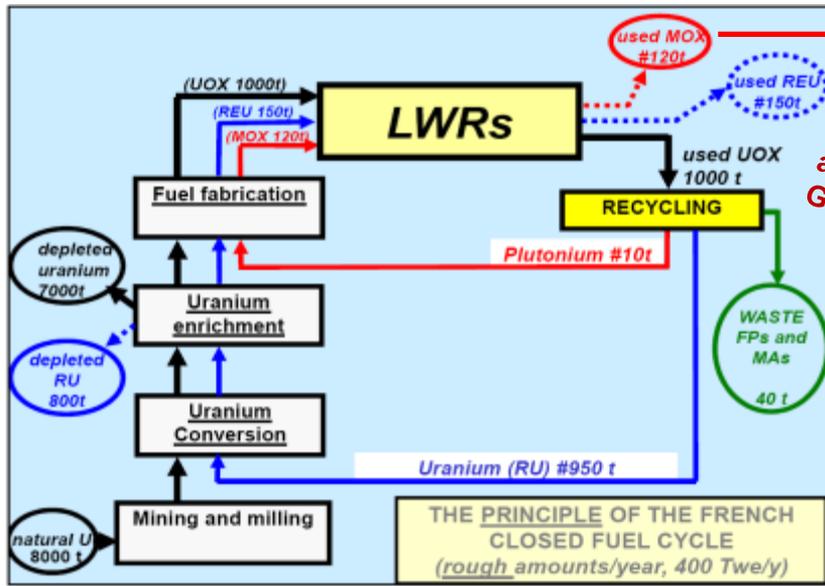
2025 ASTRID
demonstrator

2050

48th JAIF conference – Tokyo, April 2015

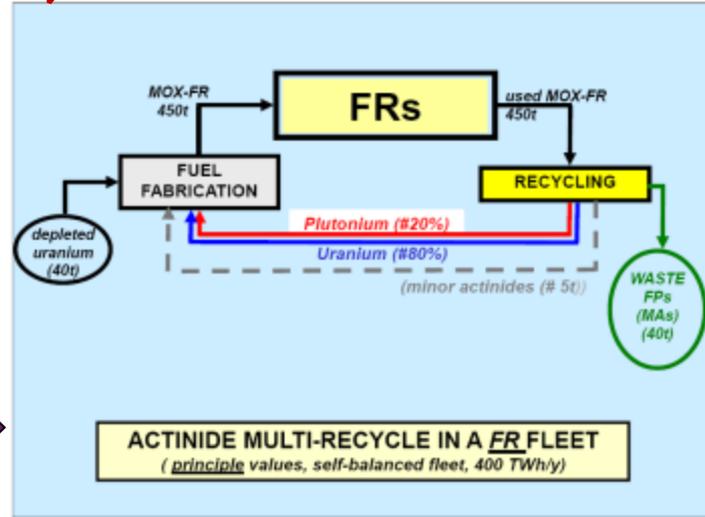
FROM LWRs RECYCLING TO FRs RECYCLING

DECADE OF EXPERIENCE IN HYDRO PROCESS & SFR MOX FUEL
SFR CYCLE NEEDS ADAPTATION, NOT BREAKTHROUGH



Current technologies:
a bridge between
GEN II/III and GEN IV

Pu stored in MOX Spent Fuel recycled in MOX SFR to start the SFRs deployment



Scenario can be flexible
Both systems can coexist during a transition phase

SFR merits as regards to fuel cycle

No front end steps and no enrichment technology / Use depleted U; Use Pu included in MOX Spent Fuel

Multi-recycling of Pu / Possible recycling of Minor Actinides

CONCLUSION

- NUCLEAR ENERGY REMAINS ONE OF THE PILLARS OF THE FRENCH LOW CARBON FUTURE ENERGY MIX
- CLOSED FUEL CYCLE IS ONE OF THE TWO KEYS FOR THE SUSTAINABLE NUCLEAR ENERGY DEVELOPMENT
- FNR DEVELOPMENT IS THE KEystone TO SUPPORT THIS STRATEGY IN THE LONG TERM
- COOPERATIONS WITH FOREIGN COUNTRIES ARE OF UTMOST IMPORTANCE

Thank you for your attention