Société Française d'Energie Nucléaire

E3Modelling Energy Economy Environment

New Scenarios for Nuclear in the European Energy System

New results from the PRIMES model

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Chaire European Electricity Markets | 18/12/2018

Objectives of the SFEN scenario study

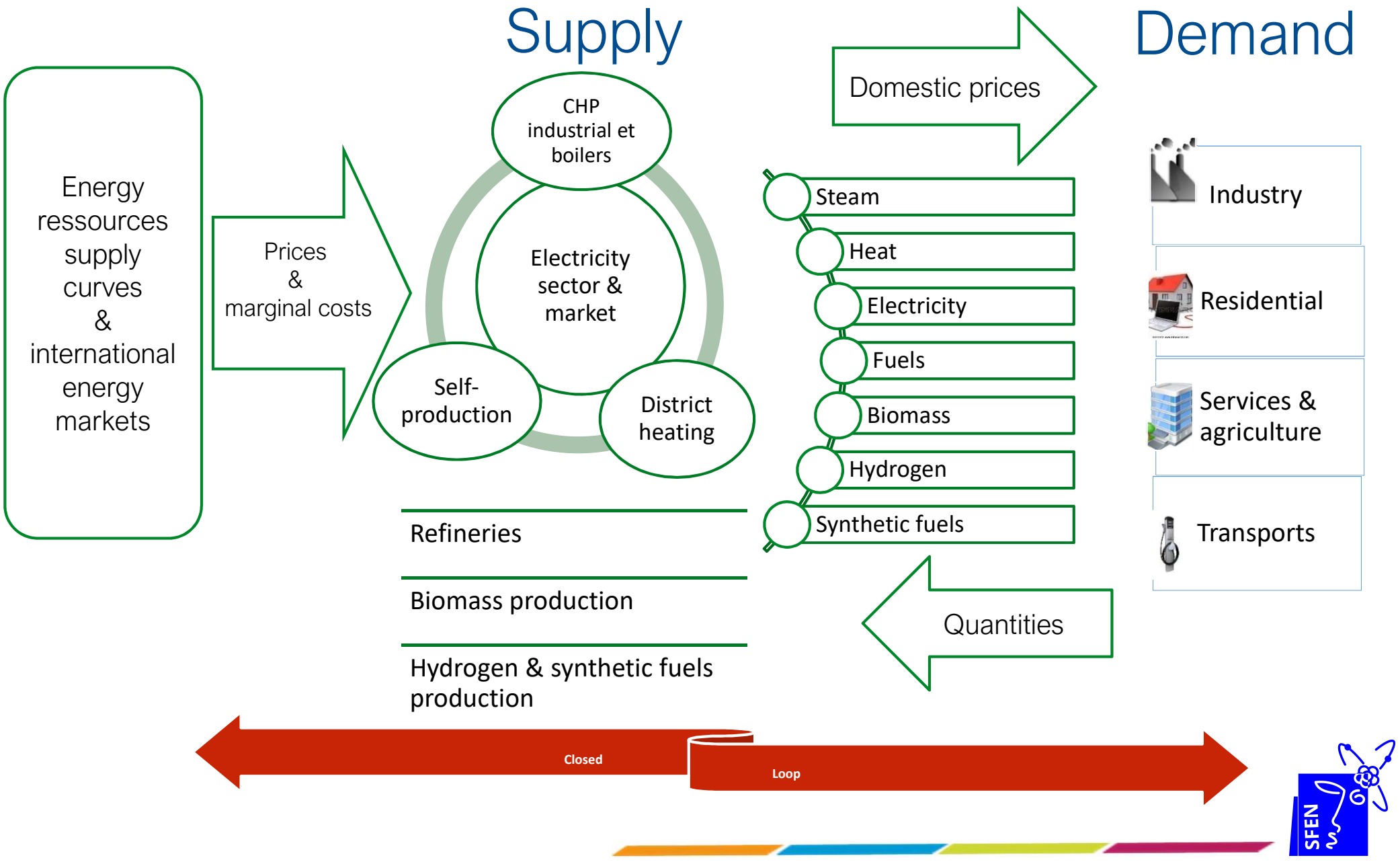
The study was decided last winter, in the context of the on-going debate about the future share of nuclear energy in electricity generation.

In line with France and the EU climate ambitions, the **SFEN and E3-modelling (PRIMES model) developed 8 new scenarios**

This study explores **3 dimensions to shed light on the decisions taken as part of the future French PPE**:

- The **energy mix** as a whole
- The **European** dimension
- The **long term** (2050 and even 2070)

The PRIMES model of the EU energy system (power module)



European policy frame of the study

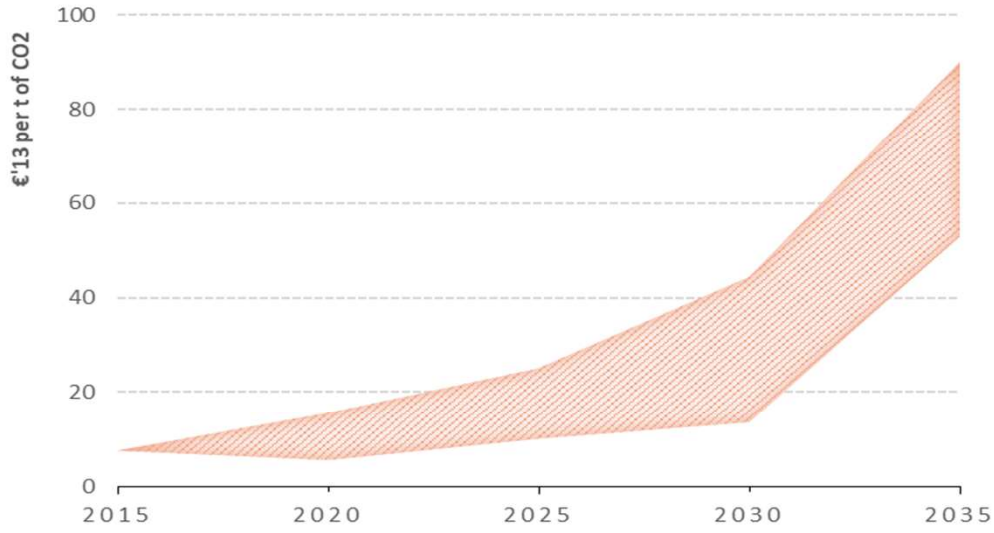
Based on the « **EUCO30 Scenario** » developed by the European Commission for the **Clean Energy Package**

Clean Energy Package
+ COP21 objectives

EC proposed climate and energy targets for 2030

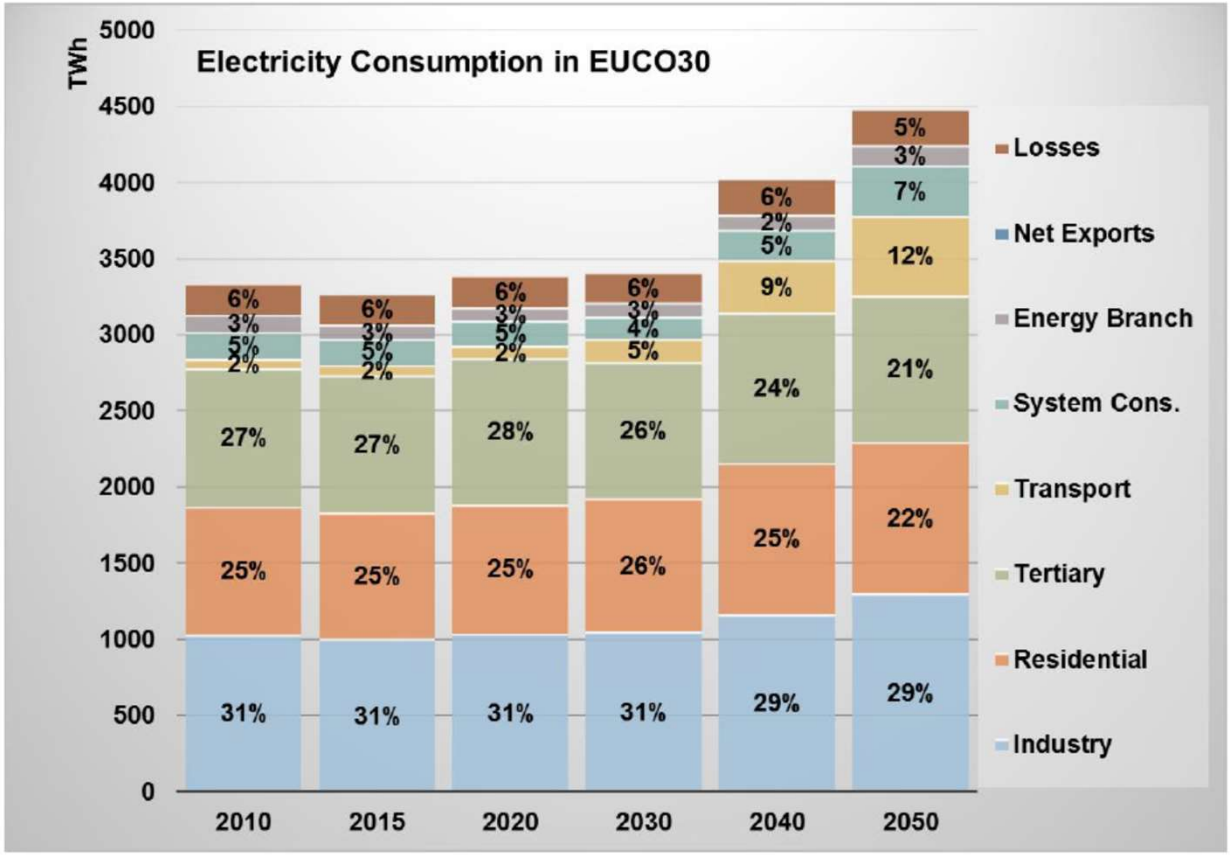
GHG	at least 40% GHG reduction (wrt 1990);
ETS/ESD	43% GHG emissions reduction in ETS sectors and 30% GHG emissions in effort sharing sectors (wrt 2005)
RES	at least 27% share of RES in final energy consumption
EE	**30% primary energy consumption reduction** (i.e. achieving 1321 Mtoe in 2030) compared to the PRIMES 2007 baseline

Key role of the CO2 price
(EU-ETS market) in order to achieve emission reduction objectives



Projected electricity consumption in Europe

- Electricity consumption hardly increases until 2030.
- The energy efficiency improvement drives electricity savings in the short/medium term, and energy savings overall
- Transport electrification and increased use of electricity for heat purposes add significant load, but only after 2030
- In the long term, electricity produces clean gas (methane) and H2 through electrolysis and a chemical process

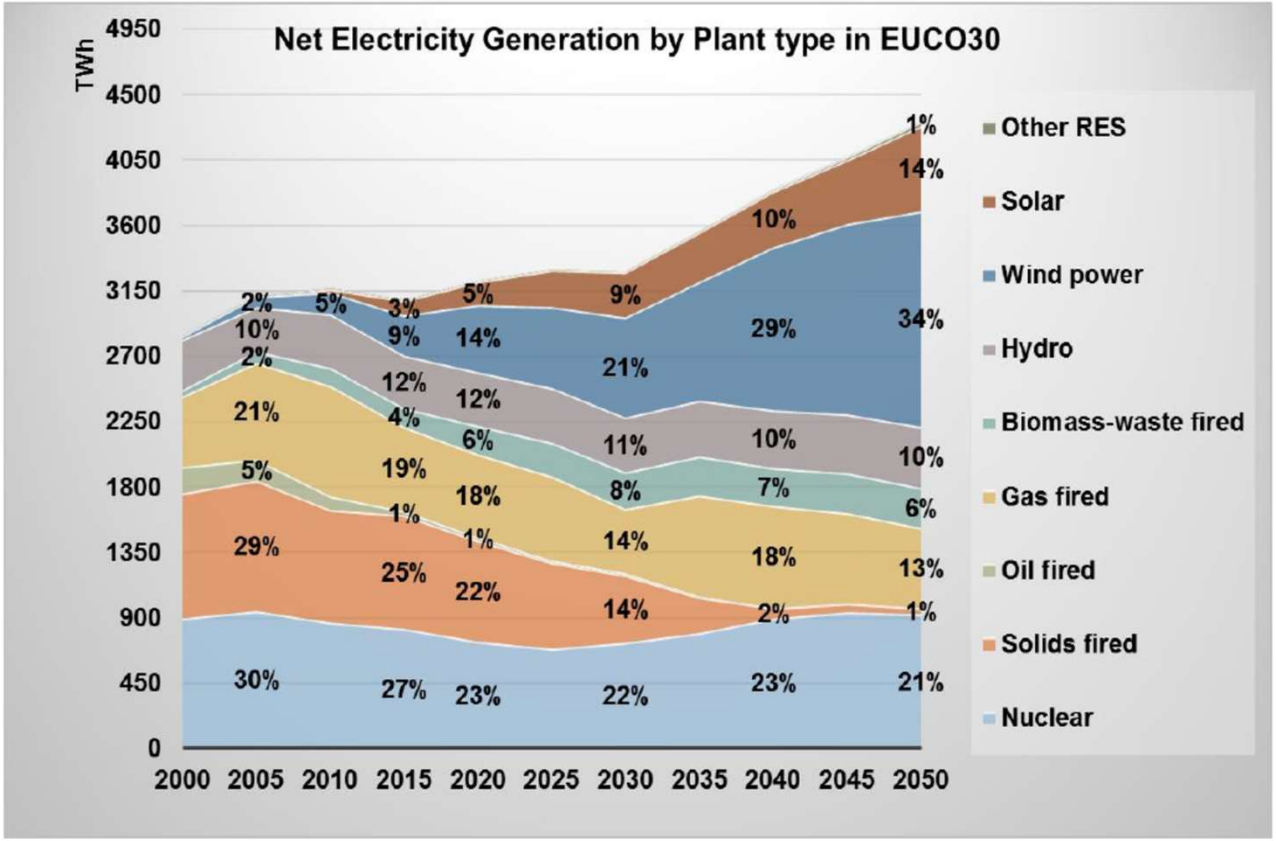


Professor Pantelis Capros, Vienna, 4 Sept. 2017

Projected energy mix in the EU power generation

The ETS prices drive profound transformation of power generation

- Solid fuels strongly decline
- Nuclear maintains a rather stable share
- Gas has a significant share and plays an important balancing role in the system
- Emergence of power-to-X storage systems in the long term reduces gas importance
- Hydro power and biomass are stable
- The variable RES (solar PV, wind onshore and offshore) is the strongly emerging power generation industry:
  - 30% of total in 2030 (50% all RES)
  - 50% in 2050 (65% all RES)



E3M - Lab 4 Sept. 2017

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Key hypotheses in the PRIMES model regarding technology costs

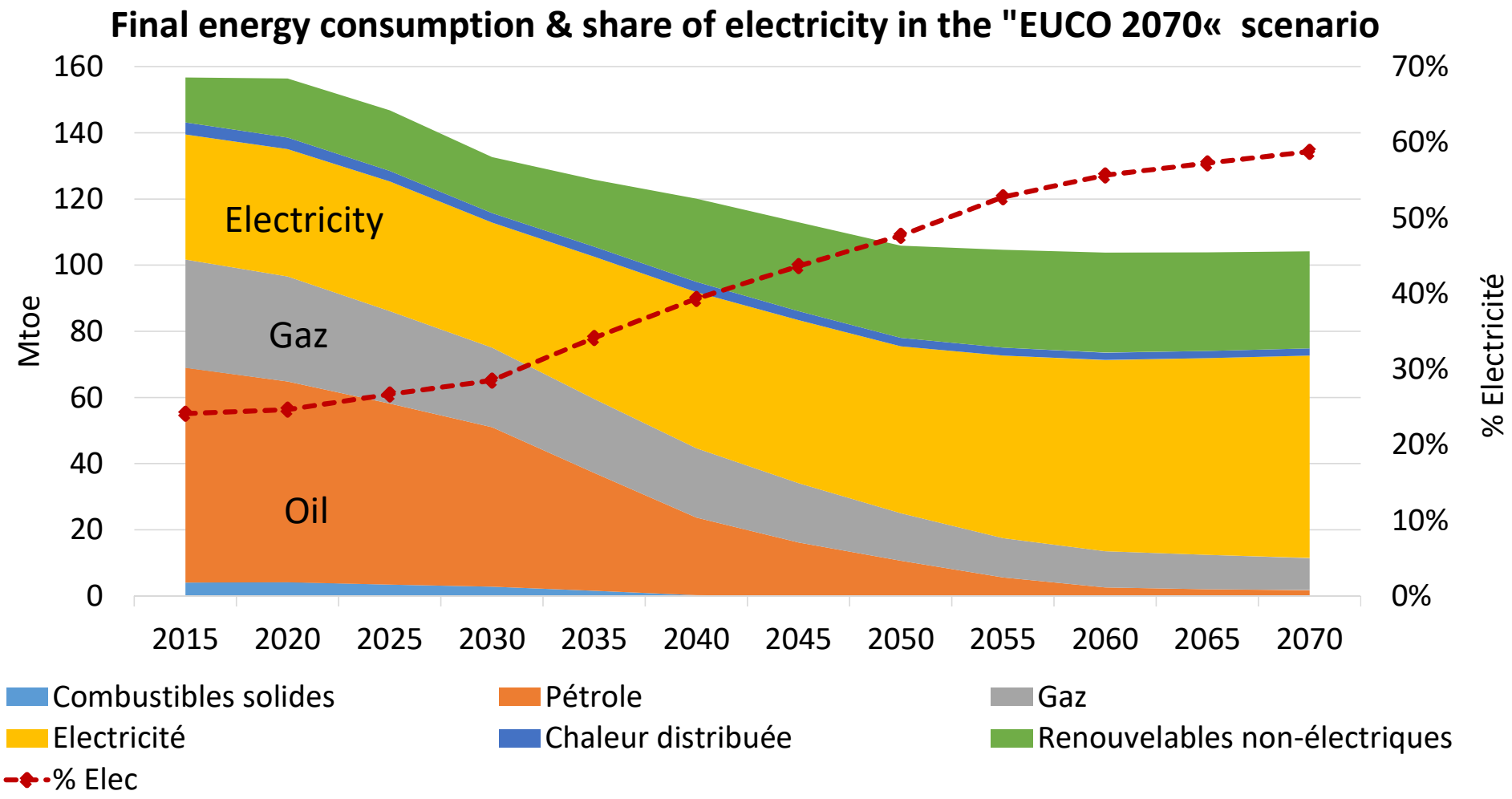
		Overnight investment cost Euro/kWe		
		2020	2030	2050
Offshore wind	for sites with medium availability	2 778	2 048	1 891
Onshore wind	idem	1 066	915	848
Solar PV	idem	814	663	554
Concentrated solar	idem	4 237	3 437	3 075
Tidal		6 100	4 704	3 100
Geothermal		5 370	4 870	4 010
Biomass	Biogaz	1 000	900	800
	Solid Biomass	2 650	1 950	1 800
Nuclear	Gen III France	4 500	4 500	4 500
CCGT	(high efficiency)	800	765	750

WACC = 7.5% real
governing investment in all power plants

Description of the new France scenarios studied

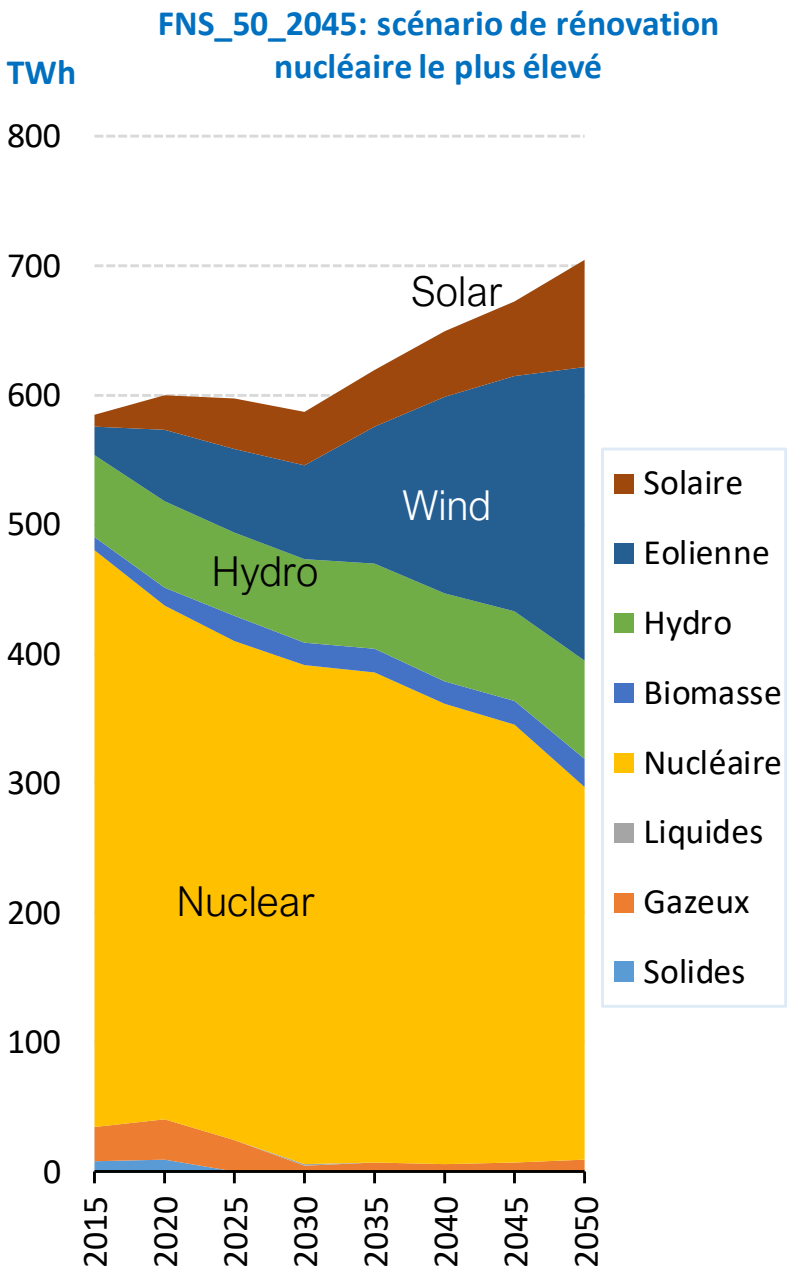
No	Scenario	Time horizon	Date 50% nuclear acheived	Detail
1	FNS_50_2045	2050	**2045**	The share of nuclear production in the French electricity mix reached 50% in 2045
2	FNS_50_2040	2050	**2040**	-//- in 2040
3	FNS_50_2035	2050	**2035**	-//- in 2035
4	FNS_50_2030	2050	**2030**	-//- in 2030
5	FNS_CONST_NU	2050	NA	Constant nuclear capacity of about **63 GW** maintained up to 2050
6	FNS_HIGH_ELE	2050	NA	Final **electricity consumption increased by 10% en 2030** compared to FNS_50_2045
7	FNS_2070	2070	NA	Extension of the **FNS_50_2045 scenario up to 2070**, with an increasing electrification rate
8	FNS_2070_SF	2070	NA	Similar scenario up to 2070, but with a **higher use of synthetic fuels and hydrogen**, produced with CO2 free electricity

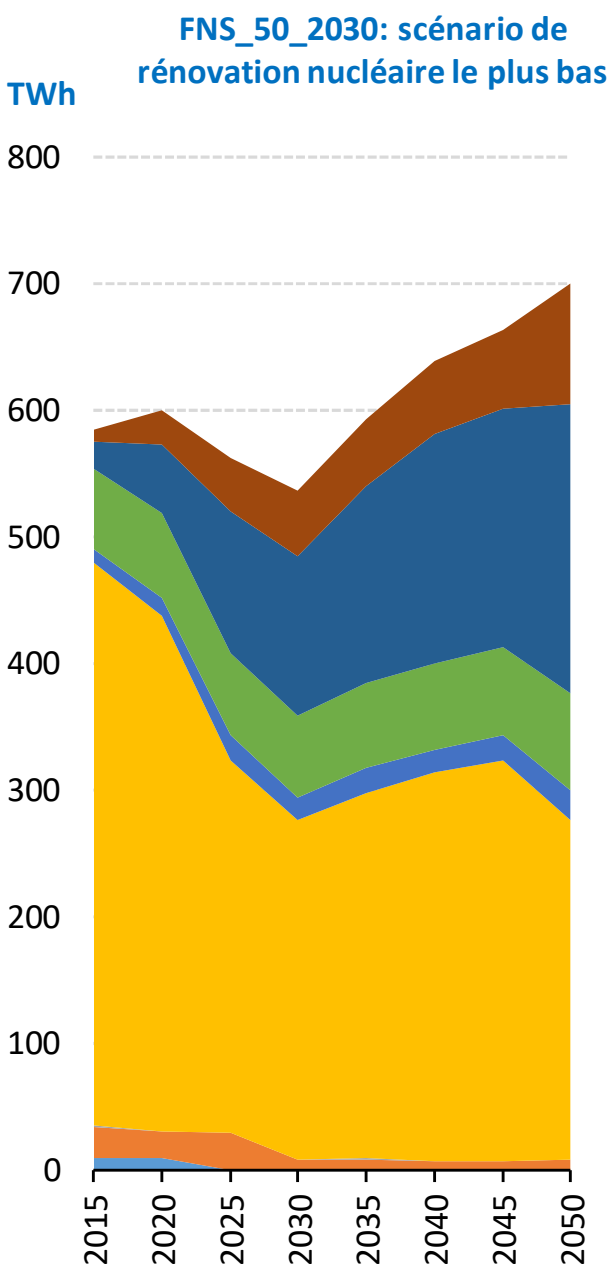
All scenarios show an increase in the share of electricity in the energy mix and a drop of the final energy consumption



Electricity must be used to decarbonize other sectors of the economy:
in particular by directly using the electrification of transport or indirectly the synthesis of biofuels

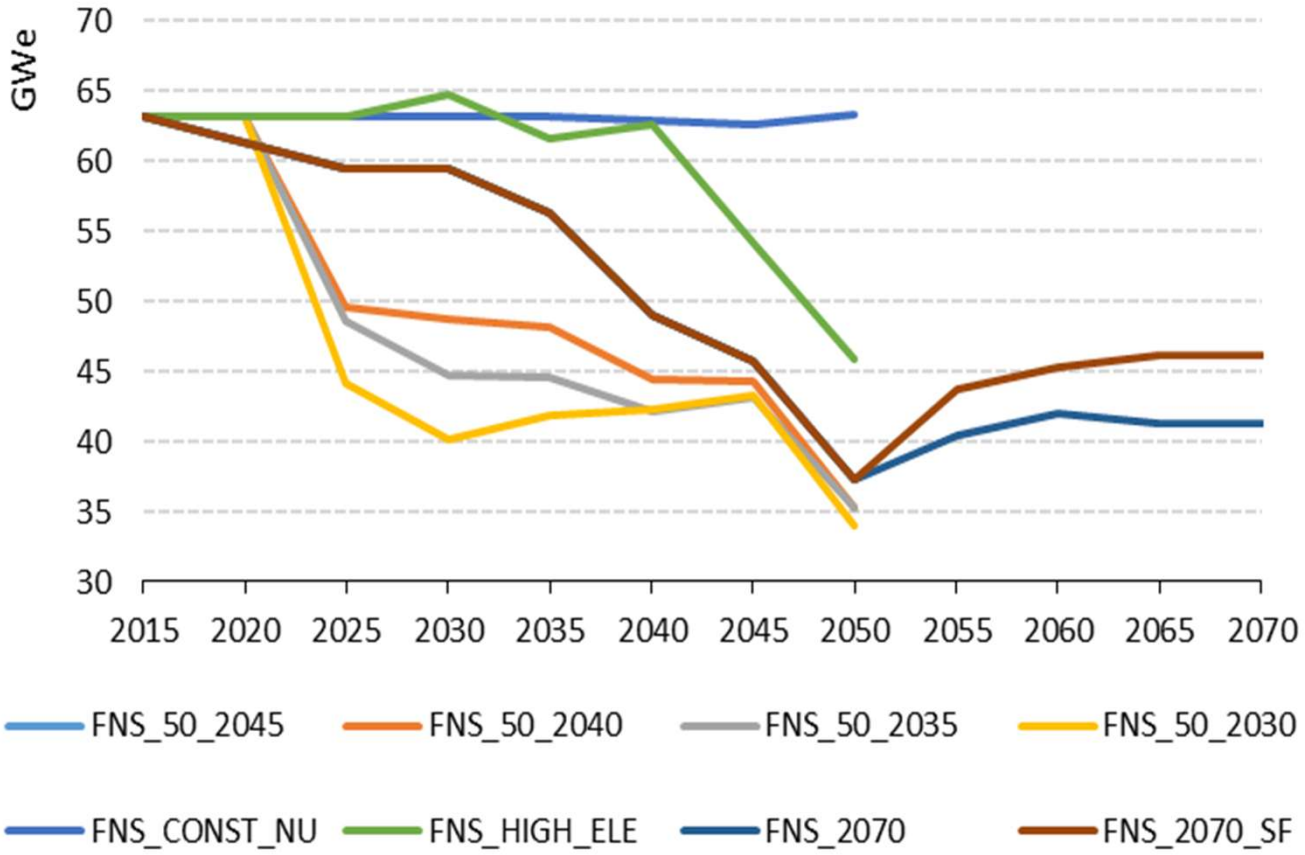
Electricity supply mix in different scenarios





- Strong growth of variable RESs. In 2050:
  - Wind = 225 TWh
  - Solar PV = 95 TWh.
- Hydro & Biomass relatively stable
- In 2050, Nuclear down to less than 300 TWh
- Gas is almost eliminated from the electric mix. However, gas power plants still needed to provide balancing and ancillary services.

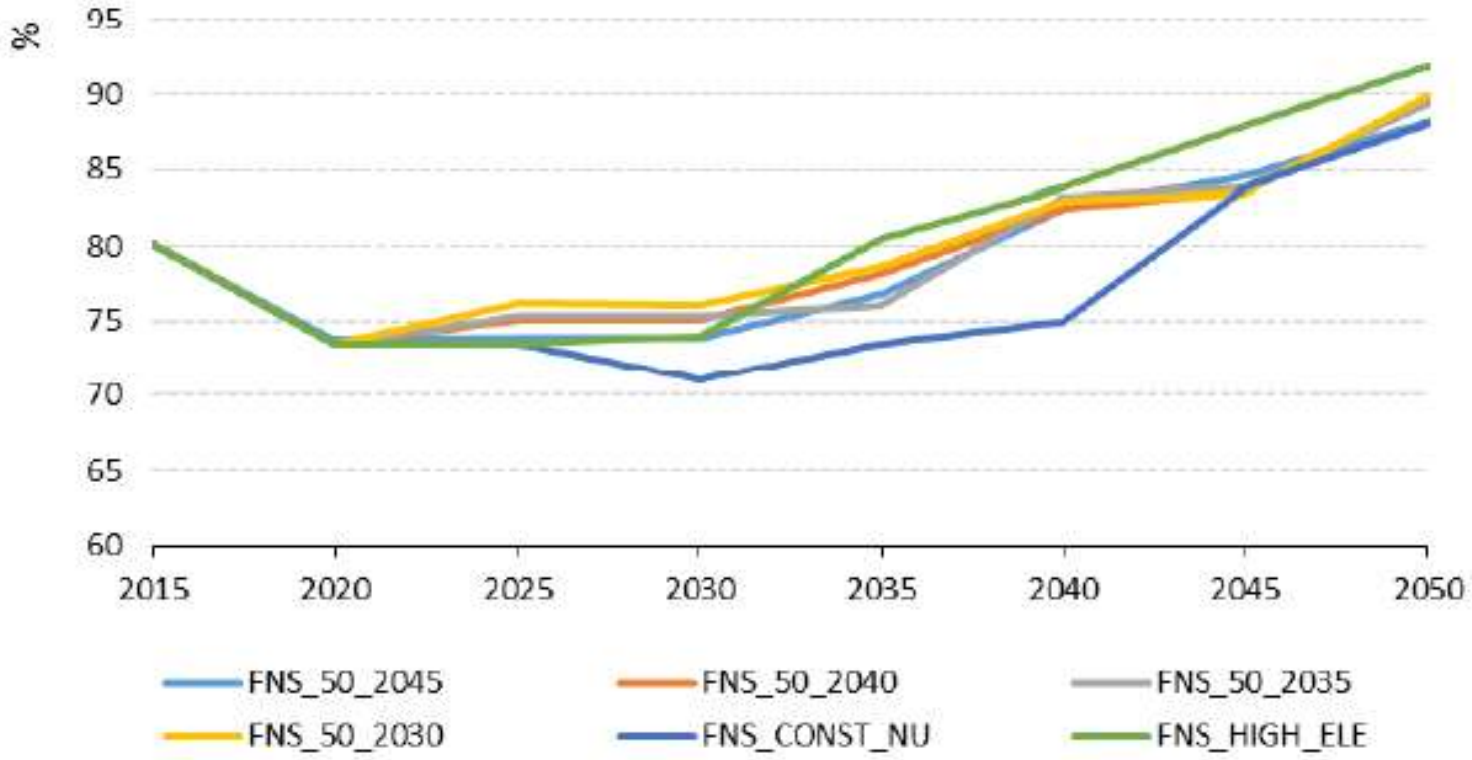
Derived nuclear installed capacity in each scenario



- The scenario that assumes a +10% increase in electricity demand in 2030 supports the 63 GW capacity until 2040 and would offer an opportunity for new nuclear investments before 2030 (+ 4 EPR)
- Otherwise decreasing towards 35-40 GWe in 2050 – however new investments take place after 2030
- Beyond 2050, the increasing electricity demand and scarcity of best performing wind and PV resources would drive a rebound of nuclear capacity

The French nuclear fleet, dispatchable and flexible, supporting RESs in France

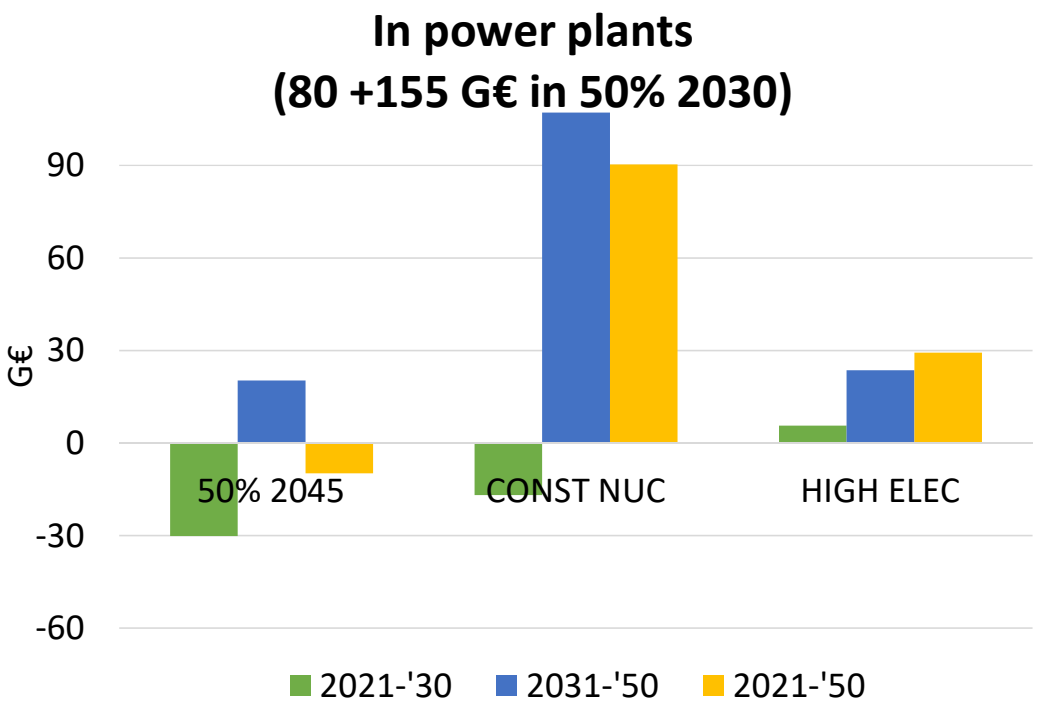
Average load factor of the French nuclear fleet

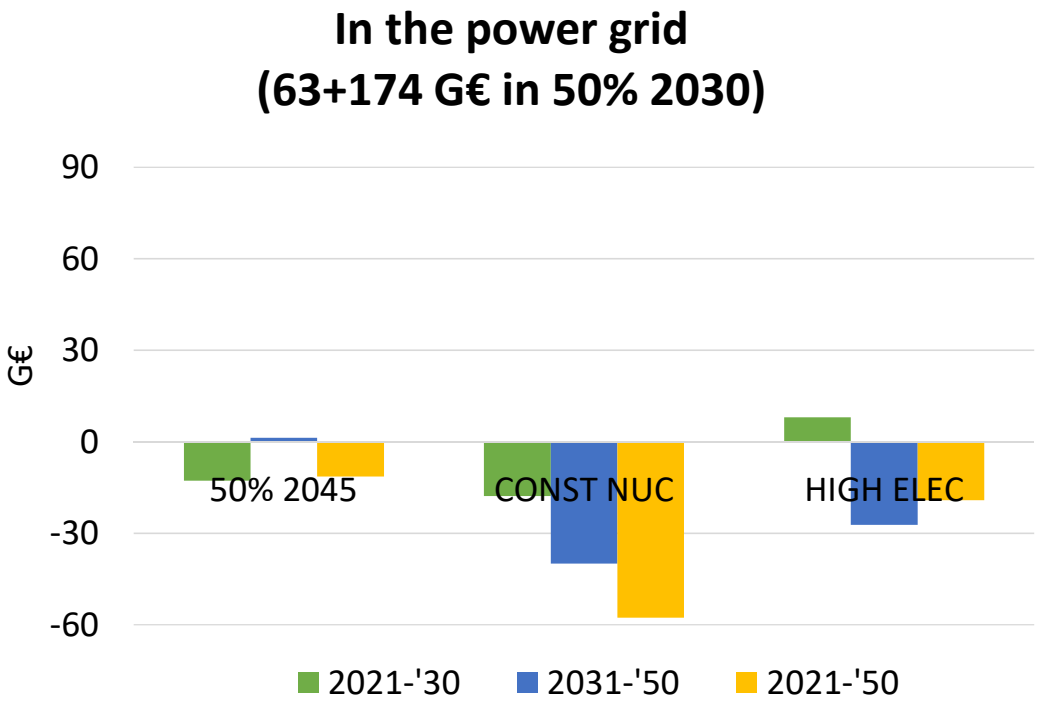


Decrease of the load factor to facilitate the arrival of RESs

Return to high load factor and higher profitability of nuclear power driven by the electricity demand

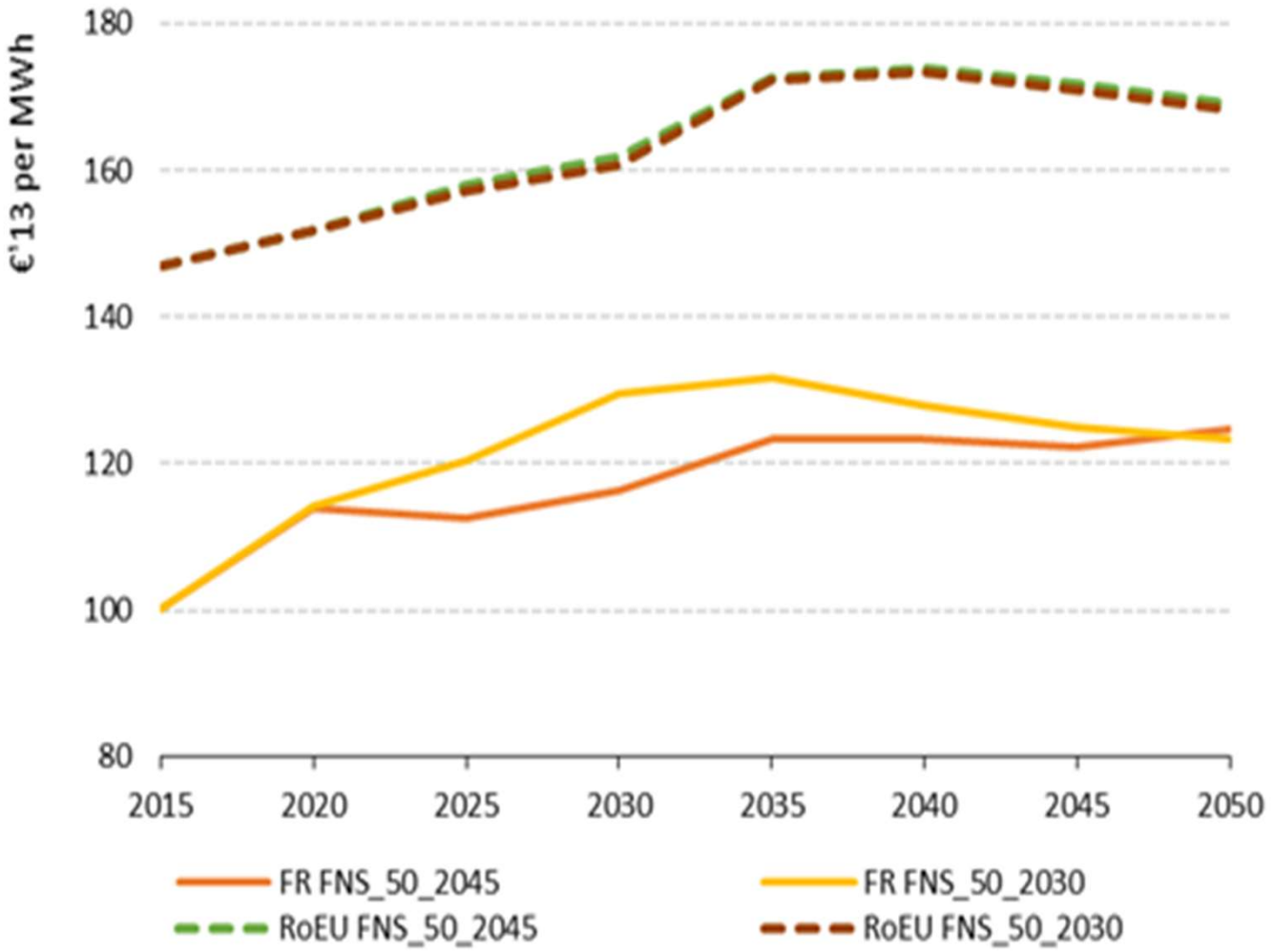
Economics/1: Scenario investments as compared to the « 50% in 2030 » scenario





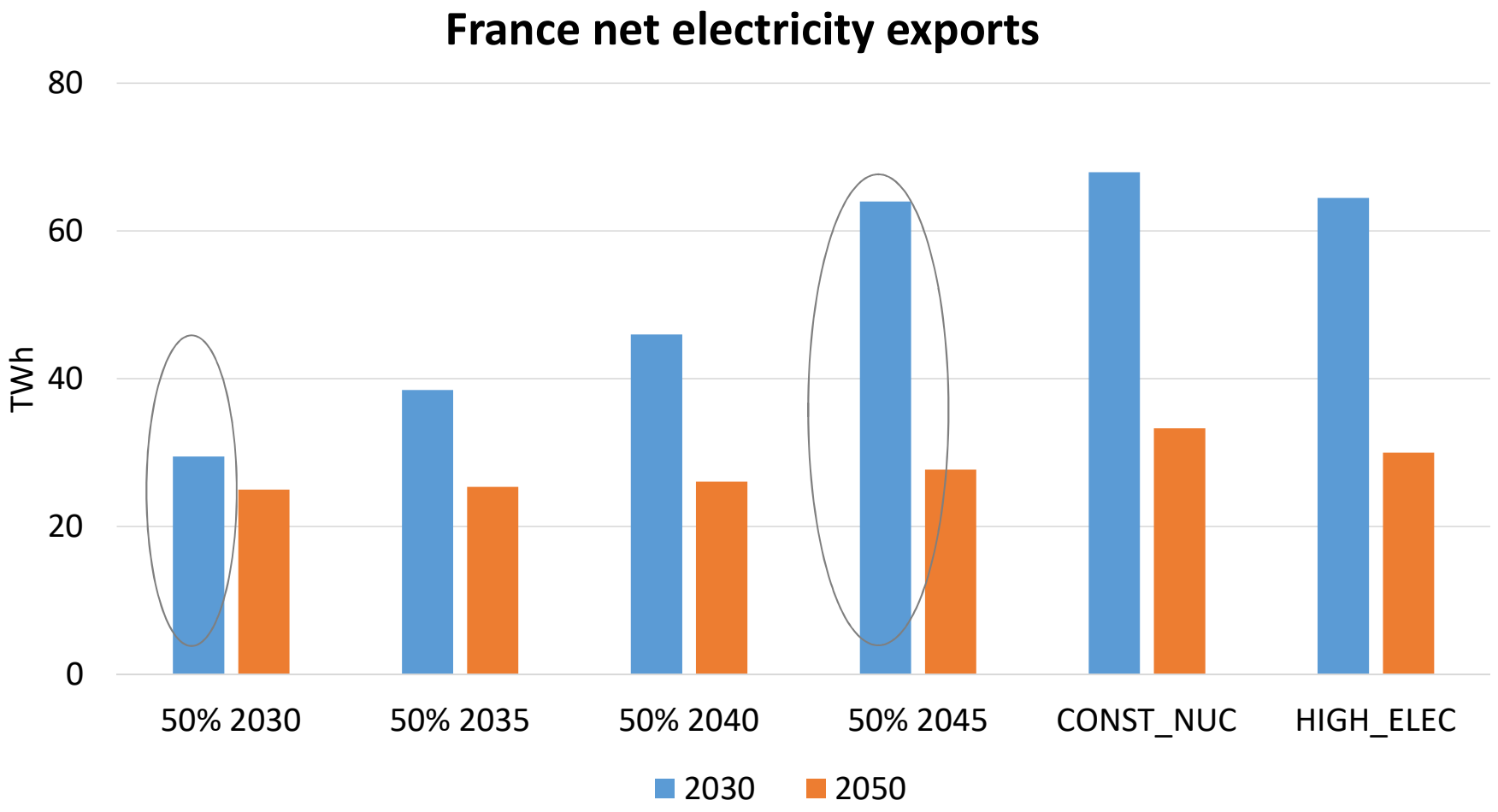
- Scenario “50% 2045” Grand Carénage investments for the LTO of the existing nuclear fleet allow **significant savings until 2030 (43 billion €, plants + grid)**
- Scenario “Constant Nuclear” is the most demanding in investments
- Scenario “High Elec” drives more investments in the plants but less in the grid
- Keeping a nuclear base makes it possible to limit network investments linked to the integration of renewables.

Economics/2: Average prices of electricity for end-users in France and in the rest of Europe (excl.taxes)



"Smoothing" the 50% target from 2030 to 2045 for the nuclear part of the electricity mix makes better use of installed nuclear competitiveness and limits electricity prices for end-users

Economics/3: x2 of French electricity exports to 2030, beneficial for our trade balance and for decarbonising our neighbors'mix

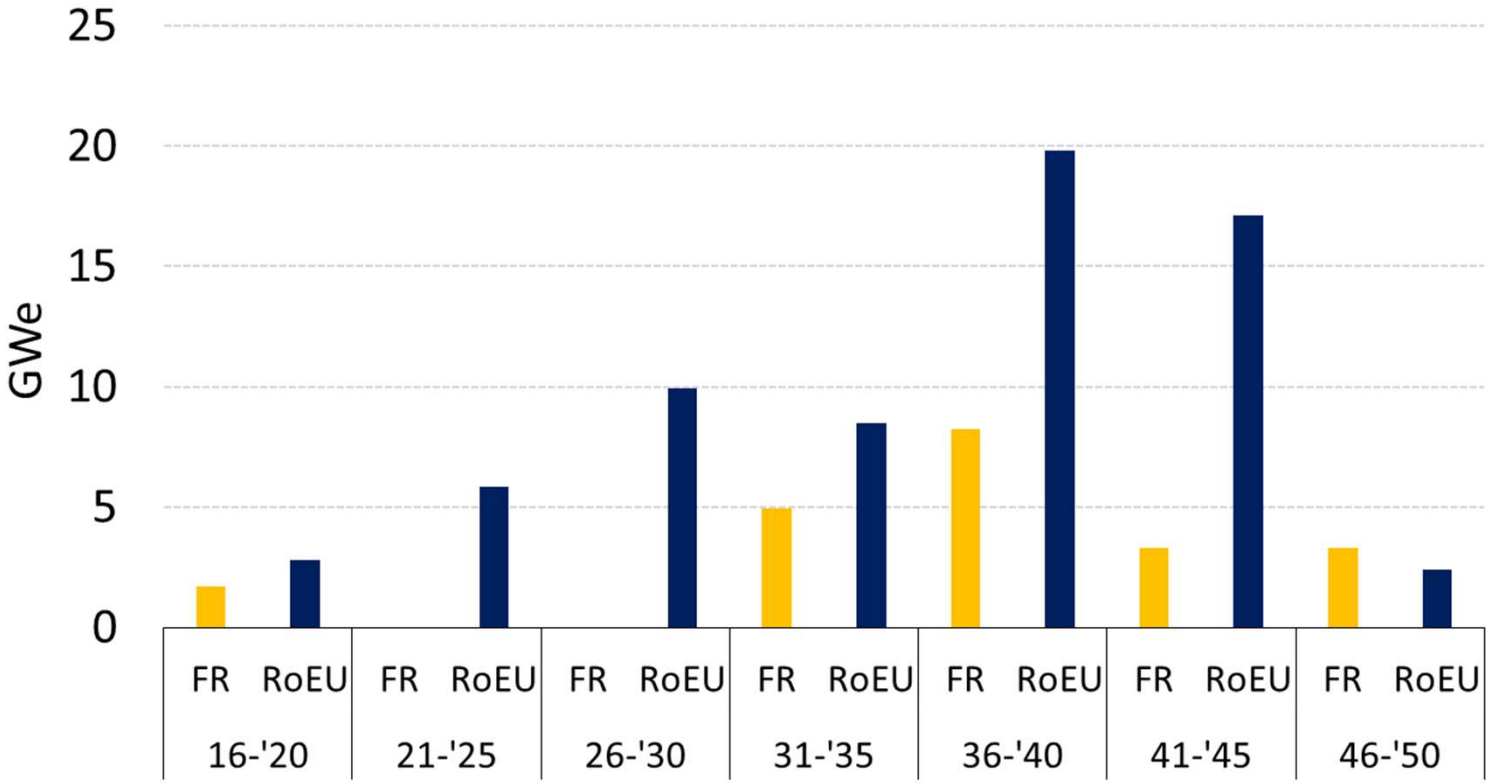


The European Union benefits from a significant amount of low-carbon French electricity production.

Currently, **France exports 10% of its production for about 2 billion € per year**

In the scenario "50% in 2045“, about 80 GWe of nuclear new build projected in 12 EU countries

Investments in new nuclear capacities, in France: around 20 Gwe and in the rest of Europe (RoEU): around 60 GWe



- The reference scenario 2016 of the European Commission foresees an installed nuclear capacity of nearly 110 GWe in 2050, instead of 120 GW currently.
- The share of France in the EU nuclear fleet would drop from ½ in 2016 to 1/3 in 2050.

Conclusions : the role of nuclear for the decarbonation of Europe

1) **In all the considered scenarios, a strong growth of wind and solar capacities is projected.** Keeping nuclear constant would be too expensive. Nuclear capacity in France would decline down to 35-40 GWe in 2050.
2) **Delaying the 50% objective for the share of nuclear from 2030 to 2045 is the best solution from an economic standpoint.** A reduction of the share of nuclear should be based on the dynamics of other low carbon energy sources and not *a priori*.
3) **In the longer term, (French) nuclear will remain an essential backbone of the EU electricity mix** in order to meet climate objectives. The electricity vector is expected to play an increasing role, with a marked increase in final electricity demand possible beyond 2050, inducing a rebound of nuclear capacity.

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THANK YOU FOR YOUR ATTENTION