



Nuclear Strategy and Nuclear Planning

MONTEL FRENCH ENERGY DAY

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This presentation has been prepared by Acousmatics for the Montel French Energy Day on 15 May 2024. It provides elements for a discussion of the French nuclear sector, and what the future may hold for this critical sector.





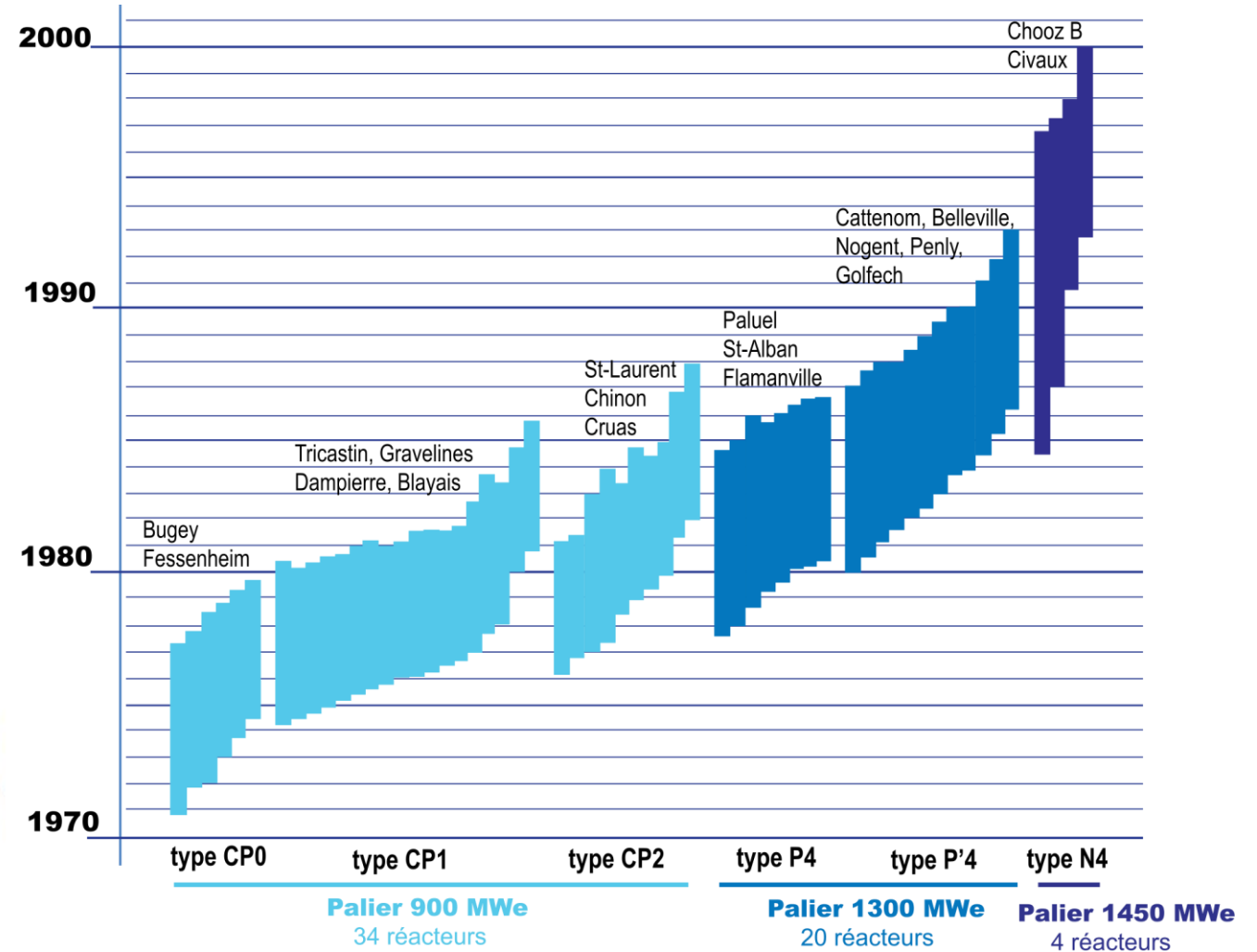
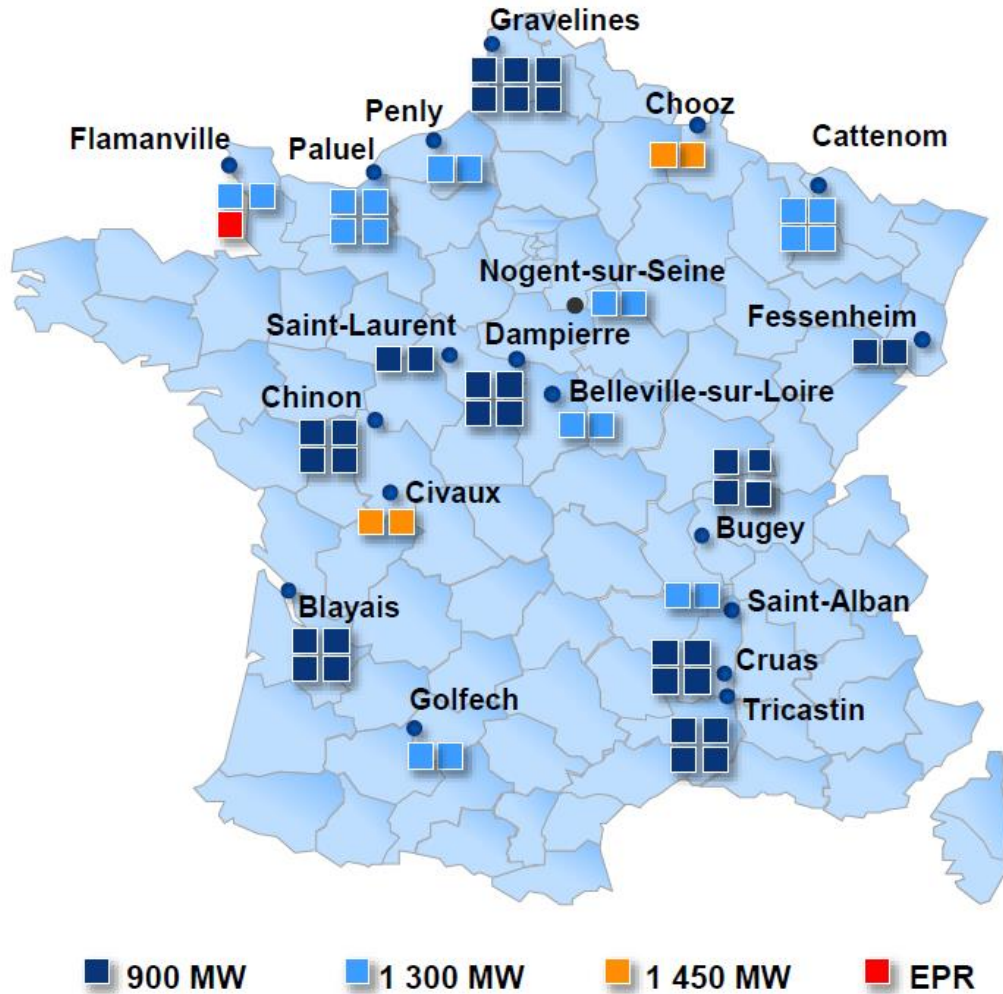
What does 'renaissance' look like?

- The challenge: finish Grand Carénage 1&2/ finish VD cycle, increase reliability, increase load factor
- Renaissance invoked
 - « Je souhaite que six EPR2 soient construits et que nous lancions les études sur la construction de 8 EPR2 additionnels. »
 - During his second term, Macron has called for a “nuclear renaissance” and announced a goal to build 14 (6+8) new reactors by 2050, implicitly targeting a sustained, very high share for nuclear in the power generation mix. BUT – Concerns have been voiced that such nuclear renaissance would hardly be feasible and spell slower growth for renewables.
- 6 nukes to 2050?
 - The French plan to build 14 new nuclear units by 2050 seems unrealistic. It is more realistic to aim for building an initial tranche of 2+2+2 new reactors, with 2035 as the earliest commissioning date.
- Double challenge: EDF “leader in low-carbon generation”, “major player in the energy transition” must follow up on ‘green’ vs renewable vs nuclear
 - « To build a net zero energy future with electricity and innovative solutions and services, to help save the planet and drive wellbeing and economic development »
 - Nuclear has the clear advantage to provide stable, CO2-free baseload generation for a long operational lifetime. BUT – It is not a renewable energy source (RES).
- Strategy vs planning: not strategic planning
 - Strategy shows the way, but it must be unambiguous as to the centrality of RES.
 - Planning is part of ‘getting the job done’.





The setup in 2021

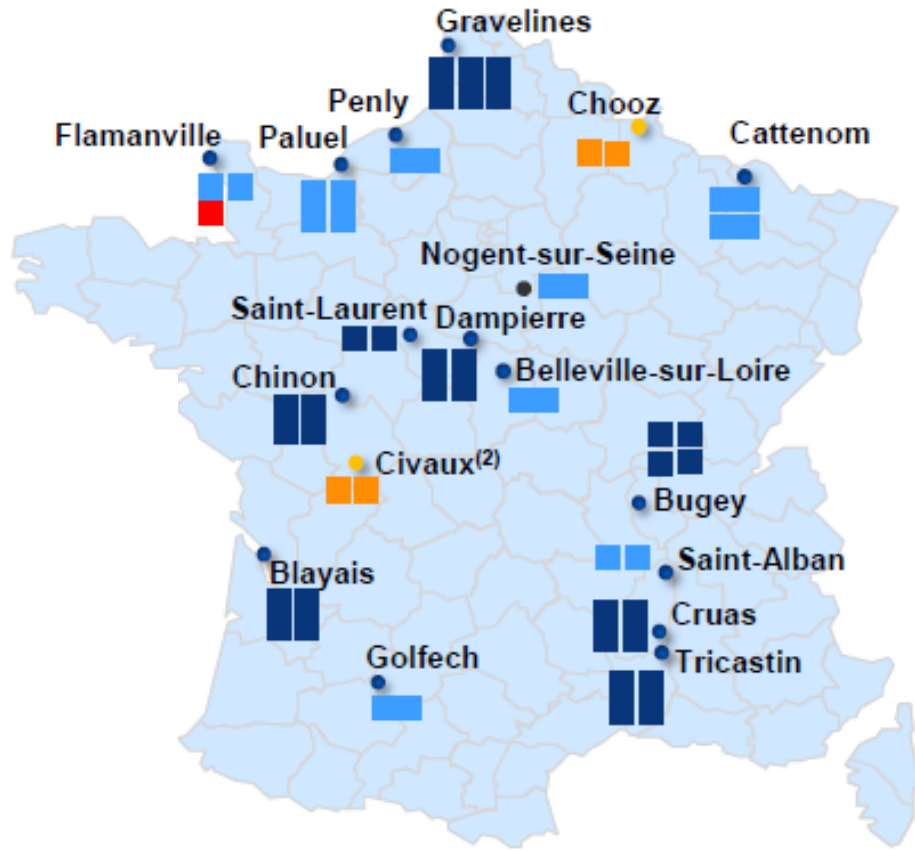


[2] Source: Acousmatics; EDF; IRSN (www.irsn.fr); ASN (www.asn.fr). Note: Fessenheim closed in mid-2020, Flamanville 3 EPR to commission in 20xx?



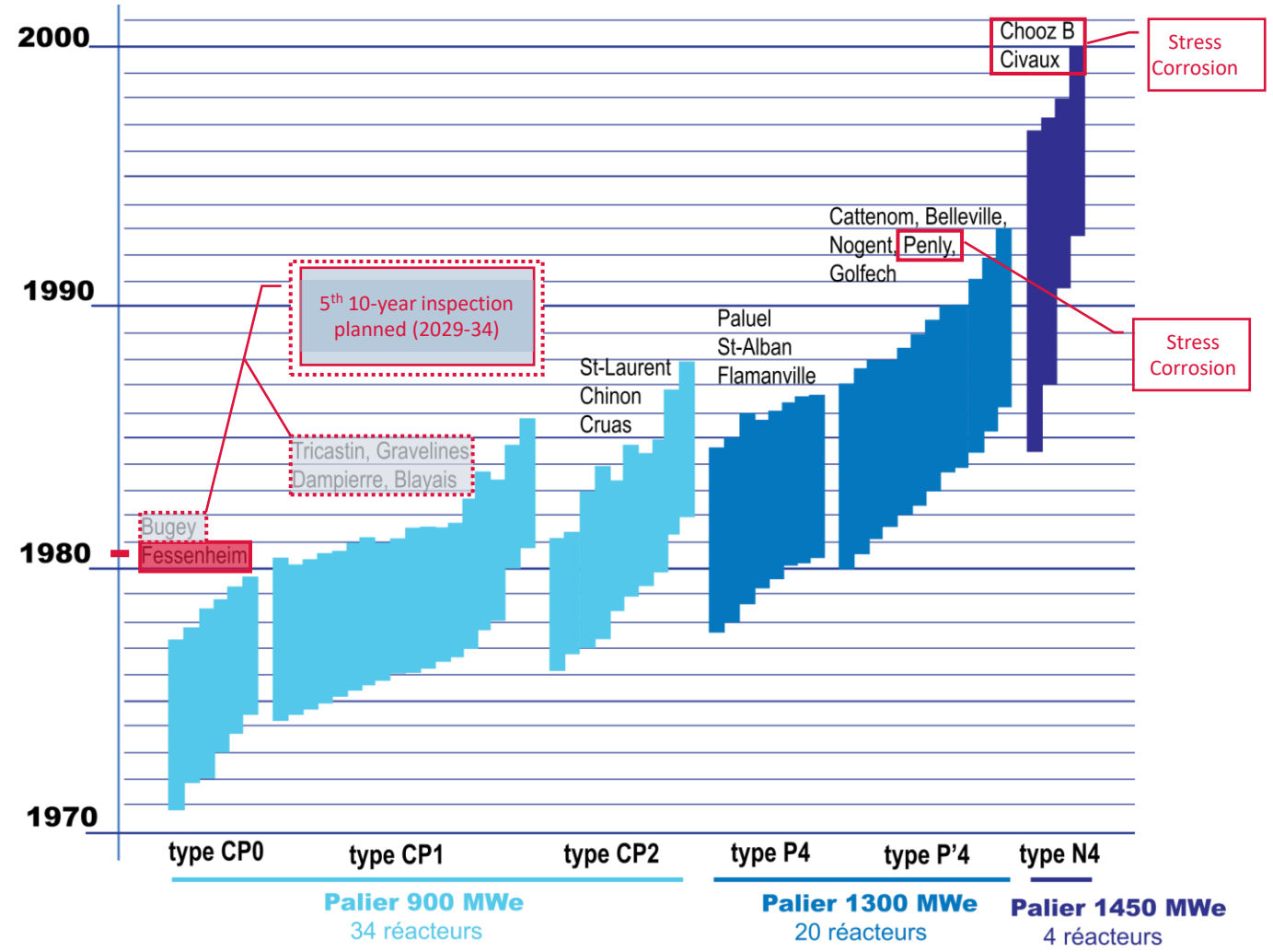


The setup in 2024



- 900MW
- 1,300MW
- 1,450MW
- EPR (1,600MW)

+ Flamanville EPR (2007-24)



[3] Source: Acoustics; EDF; IRSN (www.irsn.fr); ASN (www.asn.fr). Note: Fessenheim closed in mid-2020, Flamanville 3 EPR is commissioning in mid 2024

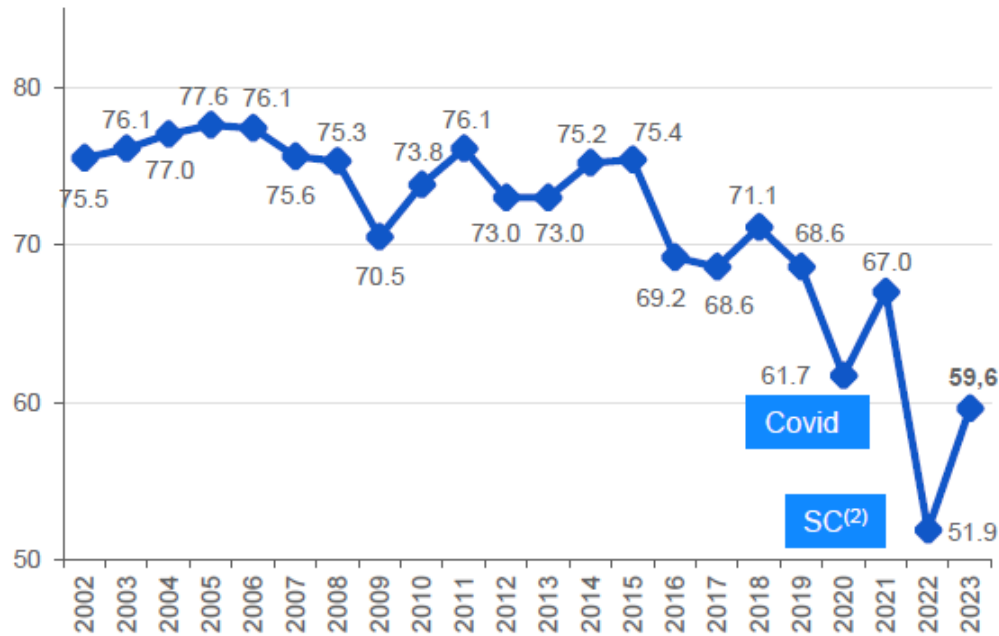




Output and LF have decreased ...

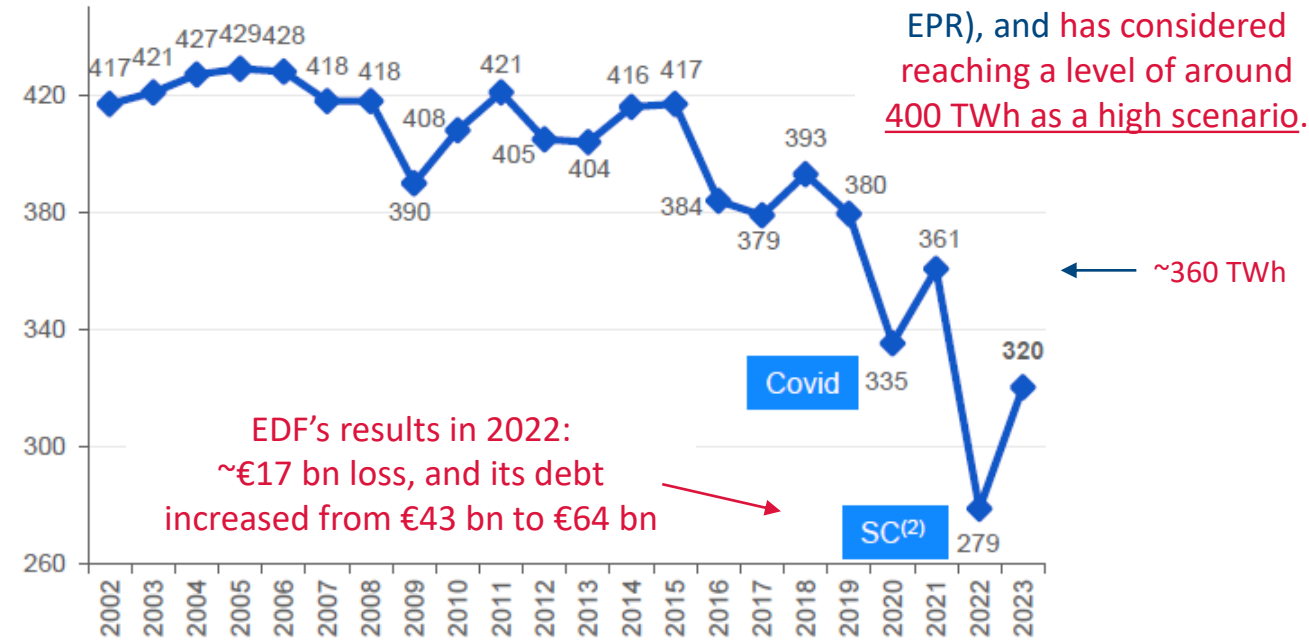
Annual load factor of nuclear fleet in France

Load factor (%)



Net output of nuclear fleet in France

TWh



In its most recent 10 year forecast exercise, RTE has relied on a quick return to an average annual production volume of around 360 TWh (including the Flamanville EPR), and **has considered reaching a level of around 400 TWh as a high scenario.**

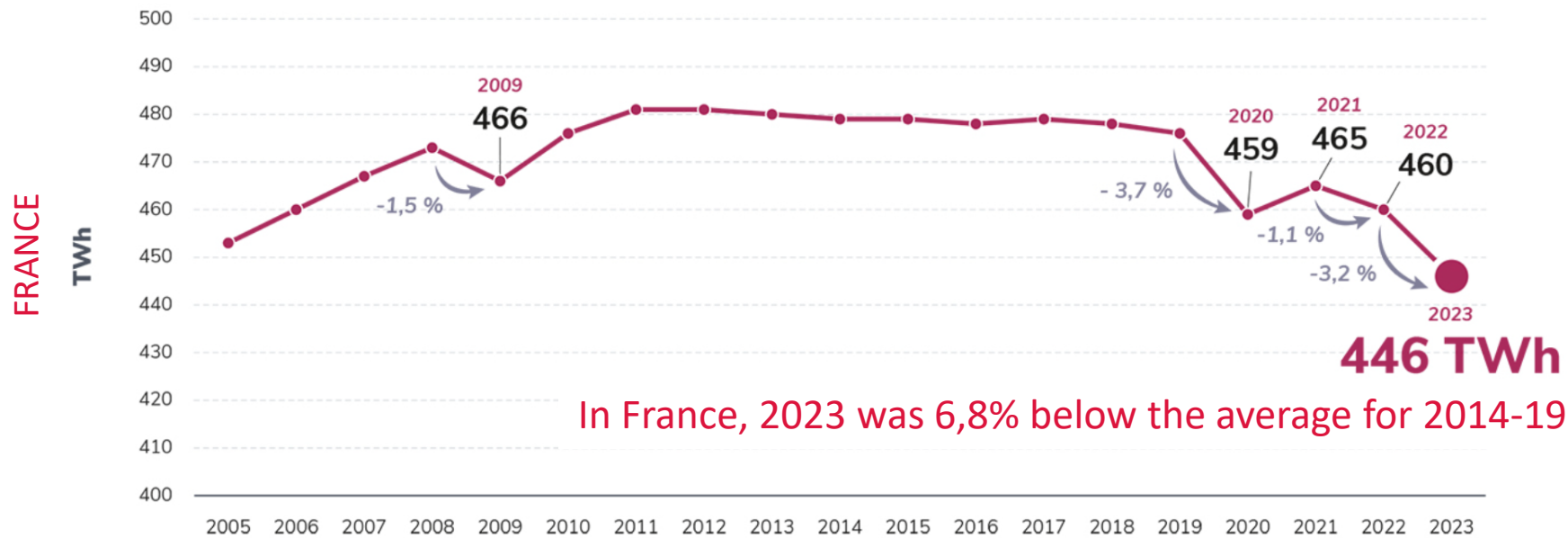
Nuclear output has experienced a structural decline compared to the peak reached in the early 2000s. The Fessenheim closure explains part of this decrease. Nevertheless, **the decrease in fleet availability between the 2000s and 2023 is equivalent to the closure of 14 x 900 MW reactors (RTE).**





... but demand reduction is common

Electricity consumption between 2005 and 2023 (corrected for weather and calendar effects)



The decrease in consumption between 2022 and 2023 (-3.2%) is one of the strongest ever recorded, second only to the decrease registered due to the health crisis between 2019 and 2020 (-3.7%).

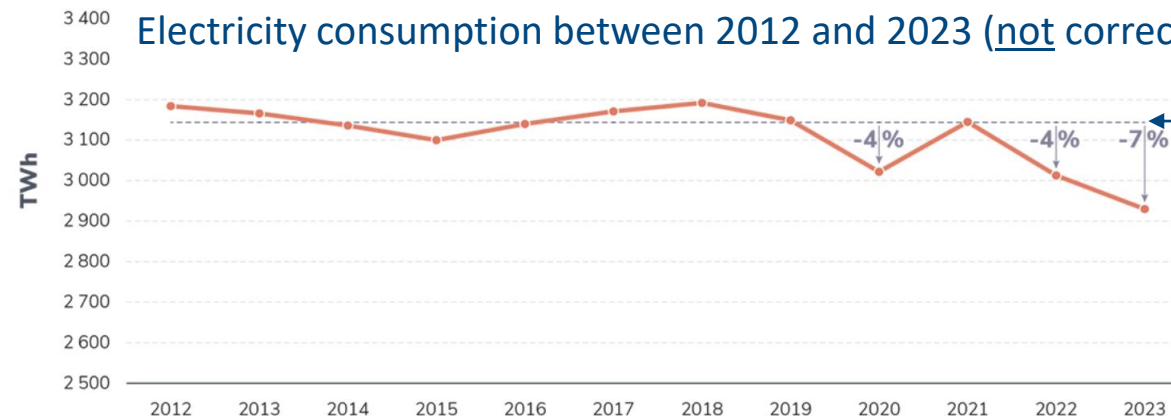
In France, 2023 was 6,8% below the average for 2014-19

After a COVID-related decrease in 2020, new reductions in 2022 and 2023 consumption were due to the worsening of the energy crisis that has affected the EU.

EUROPE



Electricity consumption between 2012 and 2023 (not corrected for weather effects)



Average 2014-19 (ENTSO-E + GB)

In Europe, 2023 was 7% below the average for 2014-19





What are the main risk concerns today?

Before undertaking any new reactor construction projects, these are the most critical risks faced by EDF Group, in its own words

This is a selection. The risks must be read in their entirety, as some of them may be interdependent.

3A – Changes in public policies and in the regulatory framework in France and Europe, in particular ARENH and post-ARENH

SUMMARY

Public energy policies and sectoral regulations are scalable, even on short notice, and expose the latter to a significant regulatory risk. These changes may impact, notably, in France, the market architecture, regulated sales tariffs, the tariffs for using the public electricity networks (Tarif d'utilisation du réseau public d'électricité - TURPE), or the taxation applicable to the company. They may also have an impact on the regulatory framework for energy saving certificates, CO₂ emission quotas or the mechanisms for financing the Group's investments through the European taxonomy.

The evolution of the architecture of the European electricity market is very advanced. It aims notably to reduce the dependence of retail electricity prices on fluctuating gas prices, and to create more favourable conditions for upstream investment (generation of low-carbon electricity) and downstream investment (electrification of uses).

The French State's guidelines on the post-ARENH market announced on 14 November 2023⁽¹⁾ could be included in a draft act to be presented in 2024.

The consequences of regulatory changes are potentially significant for the Group, insofar as they may affect its financial position, limit its ability to finance its strategy or meet its commitments to climate protection, or slow down its development in relation to its competitors.

Criticality: ■■■ High

1B – Failure to comply with the objectives for operation and/or for extending the operating life of nuclear power plants (France and United Kingdom)

SUMMARY

The Group may not be able to meet its nuclear power fleets' operating objectives in terms of safety and availability, notably in the case where controls or defect detection would lead to modifications on the nuclear French fleet. It may also not be able to continue operating its reactors beyond the current planned expiry date, or even be authorised to operate them until that date in both France and the United Kingdom. In addition, the Group may not be able to control the costs and deadlines for modifying its operating fleet to continue its operations (Grand Carénage in France), which constitutes a major risk for the Group.

Criticality: ■■■ High

Potential inability to meet operating objectives/extend the life of the nuclear fleet, lack of control re: meeting budget and timing deadlines for the above

Large exposure to regulatory outcomes in FR and EU





EU: Frenemy?

As of January 2023, nuclear power generation became eligible for green investments (i.e., those that contribute to curbing climate change) under the EU taxonomy, which promotes sustainable economic activities.

At the IAEA Nuclear Summit in March 2024, President von der Leyen said:

- “Nuclear technology can play an important role in the clean energy transition, [...] a reliable anchor”

But then she added that

- “the reality today, in most markets, is a reality of a slow but steady decline in market share [for nuclear generation]”

<https://www.youtube.com/watch?v=bM-ZmElrTEY>





Planning for six new EPR2 units by 2050?

In 2023 nuclear energy rebounded, to supply 320 TWh or 65% of total electricity production (495 TWh) in France.

- RTE – the decrease in fleet availability between the 2000s and 2023 is equivalent to the closure of 14 x 900 MW reactors. 400TWh of production in 2030 is considered a high case in RTE's planning (it includes Flamanville).
- The VD outlook for 2024-2030 sees 30 inspections in total, across multiple units, sites. In 2031 and 2032 alone there are 14 VDs planned (9x900MW, 3x1300MW, and 2x1450MW for a total of nearly 15GW, across the three types of units (900MW, 1300MW and 1450MW), comprising a set of 3rd, 4th and 5th VD inspections.

Applications have been submitted for approval, and an initial deal signed with Framatome, to build the first pair of EPR2 reactors at the Penly site. However, it will be a compelling challenge to build 2+2+2 new EPR reactors on time, on budget, in addition to the efforts to complete the VD cycles and the Grand Carénage program. A couple of 'dependencies' to note:

- Dependence on financing for decision making – building ambition requires accelerated investment and financing. *Estimated* EPR2 costs €10 bn apiece, total = €60 bn ; no positive cash flows for 10-15 years.
- Dependence on market, regulatory outcomes may impact the ability to finance strategy – remuneration of the contribution made by nuclear is key.



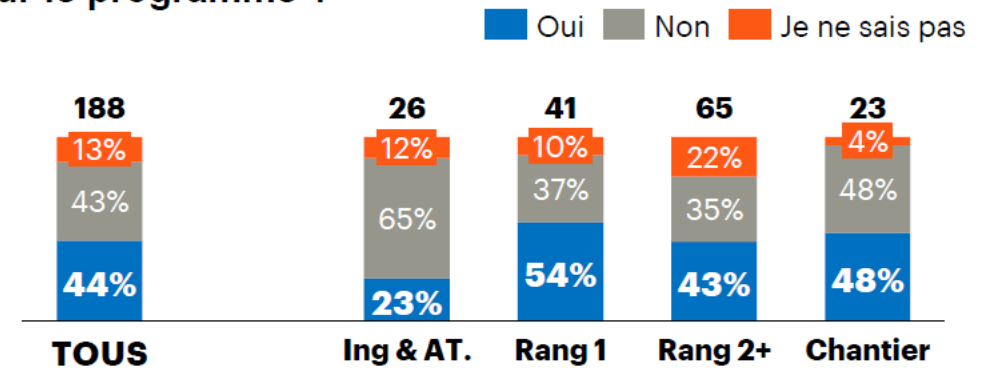
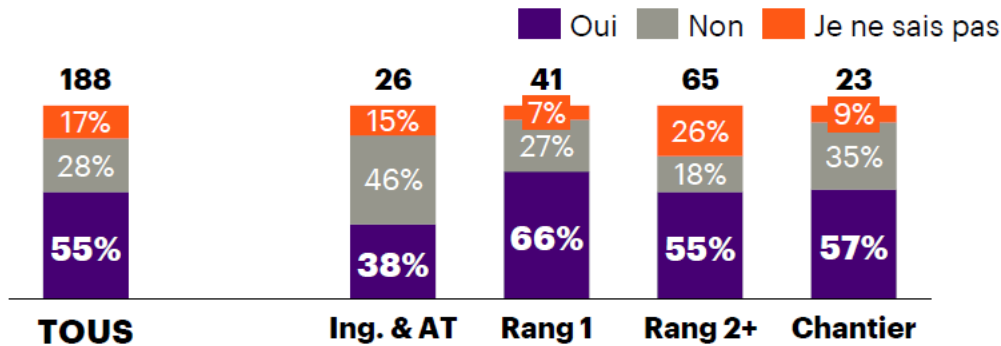


Financing the filière (ex recruitment)

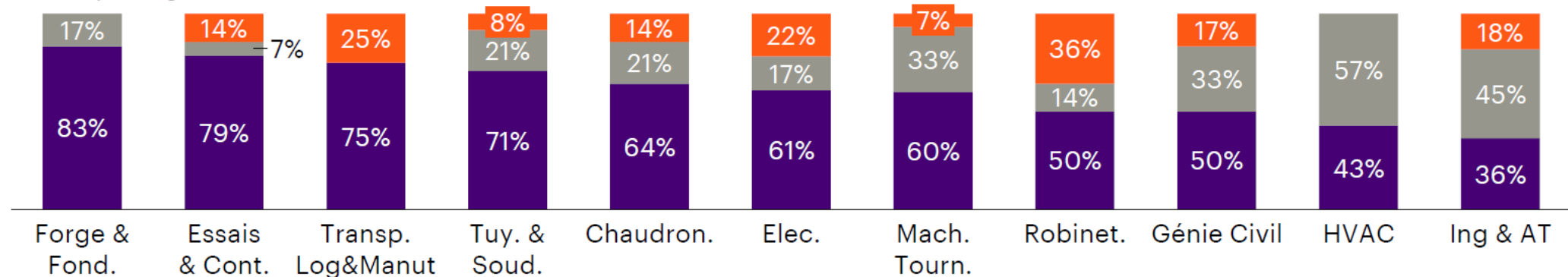
The increase from 6 to 14 EPRs is not integrated into *their* industrial plans to date

Aurez-vous besoin d'augmenter la capacité de vos outils industriels pour le programme ?

Aurez-vous besoin de moderniser vos outils industriels pour le programme ?



Résultats par segment





A matter of *strategy*

EDF is rooted in France's national energy and industrial policy and its evolution ...

- There is a lot of built-in inertia, where emphasis and concern are skewed towards nuclear and system safety at the expense of production and efficiency. Logic of partnership.

... but nuclear industrial vision must not distract from RES ambitions

- Present/future strategy must not neglect to focus on RES, given the competition for investment resources.

Electricity output in 2023

467.6TWh produced, broken down as follows:

- Nuclear: **78%**
- Hydropower: **9%**
- Other EnR: **6%**
- Gas: **6%**
- Coal: **0.1%**
- Fuel Oil: **1%**

95% of investments in accordance with carbon neutrality target

€19.1bn invested, broken down as follows:

- Nuclear maintenance (France, Belgium and UK) including Grand Carénage: **5.3bn**
- Networks: **4.9bn**
- New nuclear (including HPC, Flamanville 3 and EPR2): **4.5bn**
- Renewables: **2.5bn**
- Framatome: **0.4bn**
- Services: **0.6bn**
- Other: **0.9bn**





Strategy vs Planning

A strategy specifies a competitive outcome which involves other actors (eg consumers, suppliers, competitors, regulators). There is no 'control' of the outcome. STRATEGY tag: *going somewhere, with purpose*

- <<To build a net zero energy future with electricity and innovative solutions and services, to help save the planet and drive wellbeing and economic development>> (EDF's stated raison d'être)

Plans typically have to do with a set of activities, with the resources one is going to spend. PLANNING tag: *getting the job done*

- "At end-2023, the 30 commitments of the Excell plan have been finalised and anchored in operational practices ." (EDF)

... will there be enough know-how, capital, strategic vision, time to develop RES as well as new nuclear (on time, on budget)?





Summarising some of the most important issues impacting nuclear renaissance

Financing/operational/regulatory

- The financing, then building, then operating of six new EPRs and the impact of this aspect of 'nuclear renaissance' on future electricity prices.

Financing/strategic

- The exact role to suit EDF, whose nationalization is complete, but whose financial fragility is evident.

Operational/technical

- The capacity for the nuclear industrial sector, which is recovering from several years of underperformance, to raise to the challenge and succeed (on a technical level, being on time, on budget).

Strategic/regulatory

- The co-existence of the 'nuclear renaissance' goals and constraints with the strong need for a faster development of RES in France and elsewhere.





So, what does Renaissance look like?

1500-1504
Master
Perugino



1504
Pupil
Raffaello Sanzio





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ANALYTICAL

RELEVANT

SURPRISING