

Nuclear new build must be part of the French economic recovery plan

Introduction

Whilst the primary concern **remains the management of the COVID-19 health crisis, and successful easing of lockdown measures**, recovery of a severely impacted economy is also of major national concern. During the crisis, the French nuclear industry (through its representatives, the CSFN¹ and GIFEN²) encouraged an ongoing dialogue with the Government. The objective was to **ensure the continuity of the public service of electricity provision**, essential both for supplying hospitals and emergency service communications, as well as making teleworking for millions of French people and maintenance of essential services possible. It was also a question of guaranteeing, within the industry itself, the **safety of employees, and the economic health of many small companies across the supply chain**.

As the economy exits from lockdown, it is essential that the economy recover, and **governments are preparing ambitious recovery plans**. Many economists^{3,4}, several international organisations (World Bank⁵, International Energy Agency) and expert committees (French High Council for Climate⁶), have started discussing the criteria that these recovery plans must meet, including objectives to limit the economic and social consequences of the crisis, as well as paving the way for a ‘New World’ . **If this ‘New World’ is to align economic growth with climate objectives, nuclear power has a central role to play**.

As the third largest national industrial sector in France, well-established regionally and a strong exporter, **the French nuclear industry is one of the engines of recovery**. This is particularly true of EDF’s maintenance and investment programme for long-term operation of the nuclear fleet, known

¹ CSFN: French Nuclear Industry Strategy Committee

² GIFEN: French Nuclear Industry Association

³ Thinking post-crisis: reconstruction rather than recovery. P. Criqui and S. Treyer, The Conversation – 24 April 2020

⁴ After the crisis, the time for green money. Th. Piketty, Le Monde - 9 May 2020

⁵ Planning for the economic recovery from COVID-19: a sustainability checklist for policymakers. Stephen Hammer and Stéphane Hallegatte - 14 April 2020

⁶ Climate, Health: better prevention, better cure - accelerating a fair transition to strengthen France’s resilience to health and climate risks, French High Council for the Climate - April 2020

as ‘*Grand Carénage*’, which represents an essential source of activity for the sector with 4 billion euros per year⁷ and 1,000 companies involved. The sector also has several investment projects under development, as part of a nuclear sector deal signed in early 2019, in particular in the digital field (e.g. digital platform within the framework of GIFEN), as well as training and skills (e.g. ‘University of nuclear’).

In addition to investments in the existing fleet, the 2019-2024 French Multi-Year Energy Plan (*Programmation pluriannuelle de l'énergie - PPE*) has set up a work programme designed to inform decisions, by mid-2021, on building new nuclear reactors. These new constructions would gradually renew part of the current nuclear fleet from 2030 and secure a low-carbon, dispatchable source of electricity, alongside renewables, by 2050⁸. If opted for today, these investments would contribute significantly, right now and for several years and decades to come, to growth and jobs.

This SFEN position paper has been produced by the SFEN ‘Economy and Energy Strategy’ Expert Group to highlight how **the nuclear new build programme will contribute to the recovery plan**. In the electricity sector, where investments are essential in the long-term, the response of the American President Franklin Roosevelt to the crisis of 1929 provides much insight, as the New Deal “*sought to drive three areas of action: emergency intervention, recovery, and a profound change in the social project (relief, recovery, transformation)*”⁹. This position paper focuses on the last two objectives: recovery and transformation.

Summary

The decision to launch the proposed nuclear new build programme with 6 EPRs would be an effective stimulus for the French economy. Its effects would be significant from 2021 onwards, in line with long-term strategic objectives.

1. Construction of an EPR, a strategic infrastructure, would create many short-term jobs in the nuclear supply chain, where the share of French companies is estimated at more than 80%. This would mitigate the effects of the crisis in other industrial sectors. It would also consolidate sector skills, at a pivotal time for the industry with the commissioning of the first EPRs, where many lessons have been learnt, and trigger the series effects necessary to ensure the competitiveness of nuclear new build. Nuclear new build, with one of the lowest rates of imports in its value chain, would also have a strong ripple effect on the rest of the economy (in France, each euro invested in nuclear generates 2.5 euros in the rest of the economy), in particular at the local level where the plants will be constructed. The programme has already reached several key milestones towards enabling a decision to be taken by mid-2021.
2. In the ongoing debates on the ‘New World’ after the shock of COVID-19, nuclear energy ticks three essential boxes: it is one of the key contributors to achieving France’s climate objectives; it is essential for guaranteeing the resilience of the electrical system to future shocks; and it is the

⁷ EDF - 2019 financial results. The 4 billion is divided into 3 billion euros for routine maintenance and 1 billion euros for large-scale renovation works. Source: SFEN report on the production costs of the nuclear fleet - September 2018

⁸ SFEN report, ‘When to decide about the renewal of the French Nuclear Fleet?’ - April 2019

⁹ Thinking post-crisis: reconstruction rather than recovery. P. Criqui and S. Treyer, *The Conversation* – 24 April 2020

backbone of France's energy and industrial sovereignty. In addition, the nuclear industry will be the ally of European re-industrialisation strategies, providing competitive low-carbon electricity to 4.0 factories, as well as its technologies and expertise in industrial innovation.

The nuclear community is ready to mobilise and participate in the economic recovery efforts and, as such, contribute to the transformation of our society.

1. Launching a programme to build new nuclear reactors will be an effective tool for economic and social recovery from 2021

Foreword: strategic infrastructure has been at the heart of recovery plans historically; nuclear must play this role today.

Investment in infrastructures has been a key component of recovery plans from their inception. President Roosevelt's New Deal¹⁰ included the creation, in 1933, of the Tennessee Valley Authority (TVA), with many hydroelectric dams built on the river in the 1930s and 1940s. At the end of the war, TVA was the first producer of electricity in the USA, powering, among other things, aluminum production plants (electrolysis), and contributing to the development of the region (more than 1,000km of waterways were constructed, forests were replanted, and cultivation methods improved). The same was true of the Marshall Plan in Europe after the Second World War. Another example, in France, is the construction of hydroelectric dams at the start of the French 'Glorious Thirty' .

During the recovery plan after the 2008 financial crisis, the French State¹¹ invested 700 million euros in low-carbon transport infrastructure and energy efficiency, and 400 million euros in road programmes (renovation and new).

The nuclear fleet is one of France's key strategic infrastructures. The fleet of 57 operating reactors, across 19 sites, produces low-carbon electricity which is available on demand 24 hours a day. The nuclear fleet guarantees supply for urban areas (more than three quarters of the French population) and more than 250 industrial customers, representing 530 sites which are directly connected to the electricity transmission system operator (RTE). By providing stable electricity at affordable prices, it contributes to the competitiveness of French industry. In addition, its environmental impact is minimal relative to the energy produced (75% of the electricity of a large developed country), be it CO₂ emissions, noise or visual pollution, consumption of raw materials or land footprint.

The construction of new nuclear reactors is fully in line with a move towards economic recovery through sustainable infrastructure projects suggested by many organisations, including the French I4CE¹². **The programme under review includes the construction of a series of six EPRs, three pairs at three successive sites**, corresponding to the renewal of a production capacity of 10GW, or 15% of the current French fleet. To date, three French regions have volunteered to host these projects: Normandy (Penly site), Hauts de France (Gravelines site) and Auvergne Rhône-Alpes (several current sites).

The total annual investment cost of the programme for the whole community (private and public stakeholders), has been well estimated, in order of magnitude, at **2 billion euros per year¹³ during the**

¹⁰ Name given by President Franklin Delano Roosevelt to his interventionist policy to combat the effects of the Great Depression in the United States.

¹¹ Towards a recovery plan? Learning from 2008, I4CE. - Q. Perrier - April 2020

¹² I4CE - Investing in the climate will help us get out of the crisis. The Institute offers, alongside thermal renovation of buildings and construction of renewable energy installations, the construction of new public transport infrastructure, as well as the renovation of railway lines.

¹³ SFEN estimate on the basis of an average cost of 4500 €/kWe over twenty years (7 years of construction, with a 2-year lag between each reactor)

construction phase (for the record, public contributions to renewable electrical energy in France is estimated for 2020 alone at more than 5 billion euros¹⁴).

As such, the launch of the programme in 2021 would have **a double stimulus effect: for the nuclear sector, and for the rest of the economy.**

1.1 A ripple effect for companies in the sector

Several hundred million euros would already be mobilised annually in the early years focused on engineering studies, launch of equipment manufacturing and site preparation. More importantly, the prospect of a major construction programme over twenty years, and the setting up of framework contracts with several manufacturers, would provide the necessary visibility **for companies in the sector to invest in the supply chain and the skills required for the programme from 2021 onwards.**

1.1.1. An EPR project will create many jobs in France, in both the short and long-term

France has a fully integrated industrial sector comprising 3,000 companies¹⁵, which enables it to develop its expertise in the design and construction of nuclear power plants. As France's third largest industrial sector, it represents more than 220,000 direct and indirect jobs¹⁶.

According to PWC¹⁷, **the share of French companies in the construction of an EPR in France is 80%**, which is very high compared to other energy sectors. The French Ministry of Economy and Finance¹⁸ noted that at the end of 2015 the added value in France was 40% for installed wind farms, and 47% for ground-mounted solar power plants. In these sectors, France remains dependent on foreign stakeholders for key technologies, such as the manufacture of wind turbine blades and solar panels.

An EPR project creates 8,350 jobs (direct, indirect and induced) on average during the study phase and then the construction phase (around ten years on average). Many jobs are created upstream of the construction phase. The engineering teams complete preparations for the preliminary project and carry out the required on-site measures and investigations. Then, for the first five years, these teams continue their work on regulatory analysis, scale modelling, calculations and plans. The civil engineering team undertakes the excavation work, construction of water intakes, galleries and buildings. Equipment manufacturers and prefabrication teams are on-site (e.g. for piping) throughout the duration of the works. The same applies to the inspection and certification bodies, with a view to ensuring compliance of the activities carried out with the applicable regulatory requirements and industrial codes and standards. The construction and project management teams are also continuously present.

¹⁴ French Energy Regulatory Commission (CRE), Deliberation N° 2019-172 - July 2019

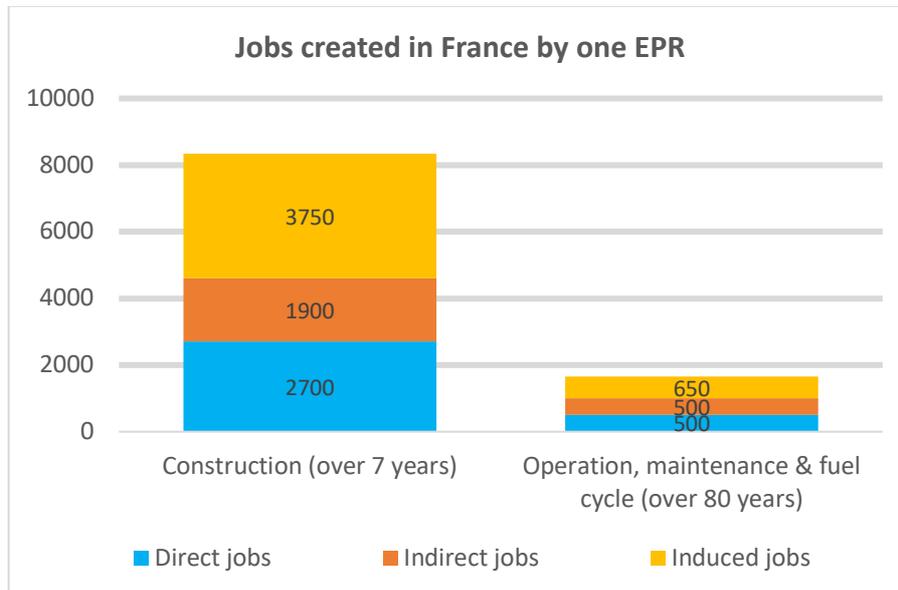
¹⁵ Source: CFSN 2019

¹⁶ GIFEN/CSFN Cartography – 2018 data

¹⁷ The socio-economic importance of nuclear power in France, PWC - May 2011

¹⁸ Industrial opportunities of the energy transition, CGE - February 2017

Beyond the construction phase (between 7 and 10 years), an EPR project creates jobs over the long-term: **the operating phase (at least 60 years) includes 1,600 permanent, qualified and non-relocatable jobs.**



1.1.2. The EPR construction programme would mitigate the effects of the crisis in other sectors

The nuclear industry relies on an integrated supply chain - more than 3,000 French companies, of which more than 80% are SMEs and mid-sized companies, which also work for other key industrial sectors: aeronautics, automotive, chemicals, shipyards, the steel industry and the Oil & Gas sector. Whilst the total cumulative turnover in nuclear power sector represents around 47.5 billion euros, its share varies from one company to another: if turnover represents around half of operator activity, the share is around 20% for large and mid-sized companies, and around 10% for SMEs. Nuclear construction activity would help mitigate the major crisis facing other industrial sectors today: in early May¹⁹ the car industry announced a drop in sales in France of more than 70% in March and 84% in April. In early May, faced with the collapse of air traffic and the threat of postponement of orders, the president of Airbus declared that "aeronautics is facing the most serious crisis in its history", and indicated to employees that the very survival of the company was at stake.

A nuclear site represents a strong demand for engineering resources: a 2019 study by the audit firm EY²⁰ indicated that the upstream labour requirements in large energy production capacities (nuclear, gas, offshore wind) increases with project complexity. The nuclear sector would also make it possible to draw on investments in continuous training for companies: it invests on average almost 9 days of training per year per employee, which is three times more than the French average. In addition, new nuclear projects would support investment in industrial capabilities through the visibility and long-term stability of their activity.

¹⁹ *Usine Nouvelle*

²⁰ Supporting the energy transition: inventory of employment and skills needs in engineering companies, EY on behalf of OPIIEC - September 2019

1.1.3. Taking a decision in 2021 is necessary to consolidate skills and strengthen the competitiveness of nuclear new build

Building nuclear reactors requires specific skills and capabilities that are different to those required for maintenance and decommissioning. The difficulties encountered on the Flamanville site, analysed in detail in the report produced by Jean-Martin Folz²¹ in October 2019, have highlighted the negative impacts on skills of the absence of any new nuclear construction for two decades in Europe. The nuclear industry adheres to very strict requirements in the management of large projects, safety studies, quality assurance, material properties, behaviour of equipment under irradiation, etc. It was, therefore, necessary to reconstruct the entire nuclear supply chain to build the EPRs for Olkiluoto OL3 and Flamanville FLA3.

A study carried out by BCG for the SFEN²² interviewed companies in the sector in mid-2018. It showed that the sector has regenerated its construction skills because of Flamanville. However, in the absence of a decision on nuclear new build, these companies were tempted to redirect their teams to other sectors, including Oil & Gas. These sectors are currently in difficulty, which highlights the challenges at stake for French industry.

As such, even before the crisis, the SFEN emphasised the need for a firm decision regarding a nuclear new build programme, in order to support industrial investment and commitment of the required resources, in particular in terms of recruitment and training, and to be able to build on time and with the expected level of performance. It also emphasised that there must be a commitment to the construction of at least three pairs of reactors, with an optimised timing, **in order to fully benefit from the expected series effects (competitiveness gains)** and guarantee a low-carbon, long-term and affordable electricity supply for France.

1.1.4. The new construction programme has already achieved several key milestones

One of the key criteria in recovery plans is the ability to support short-term economic stimulus. This is the case for the French nuclear new build programme, which has achieved several key milestones.

The nuclear new build work programme has already made significant progress for several key milestones:

France has its own technology: the sector has a third generation reactor model that has now demonstrated its industrial performance: the two Taishan EPRs are in commercial operation in China (the first since December 2018), and the Flamanville site has successfully completed its hot tests. In order to capitalise on the lessons learned from the first projects, the French industry is working on a simplified and optimised EPR, the EPR2. This reactor will enable, with comparable and even additional safety requirements, the integration of industrial constraints at the design stage making it simpler and more economical to build.

²¹ 'Construction of the Flamanville EPR', Jean-Martin Folz's report (submitted to Bruno Le Maire and Jean-Bernard Lévy) - 28 October 2019

²² SFEN report, 'When to decide about the renewal of the French Nuclear Fleet?' - April 2019

The EPR2 is already the subject of a first review by the French Nuclear Safety Authority (ASN)²³, which issued an initial assessment in July 2019.

- **The nuclear supply chain is ready:** in the context of the French and Finnish EPR projects, EDF and Framatome have qualified more than 600 suppliers of equipment and services at the ‘nuclear quality’ level. The nuclear industry adheres to very strict requirements in the management of large projects, safety studies, quality assurance, material properties, behaviour of equipment under irradiation, etc. Many companies have invested in skills, through recruitment or through internal training programmes.
- **The sector is investing in quality standards and performance:** the challenges encountered during the construction of the Flamanville EPR were the subject of several audits (see report by Jean-Martin Folz, October 2019). From December 2019, the 100 million euros ‘Excell’ plan, for 2020-2021, is being implemented so that the industrial sector, now grouped within the GIFEN, can work point by point on the three key issues identified: industrial quality, skills and governance of major projects.

In parallel and in addition to the aforementioned points, numerous actions have been taken to reduce the costs of future reactors. A recent SFEN report²⁴ focuses on this subject. It summarises the lessons learned and highlights new prospects: stability and predictability of safety regulation, re-organisation of the supply chain, integration of lessons learned from recent projects, implementation of new techniques and methods for re-optimising concepts, new organisation of contractual arrangements so that each type of risk is carried by the most suitable stakeholders. The report also highlights that, as with historical projects, other cost reduction drivers will play a role: twin projects as compared to single projects in Olkiluoto 3 and Flamanville 3, and series effects, derived from the visibility and pace of construction of a new build programme. The report shows that the objective of a cost reduction of at least 30% is achievable. In terms of cost per kWh, this would imply a production cost of about 70 euros/MWh, with very low system costs compared to other means of production.

1.2 A ripple effect on the rest of the economy

1.2.1 At the national level

According to a recent study by Deloitte²⁵, **in France, each euro invested in nuclear power generates 2.5 euros in the rest of the economy.** In 2019, the share of the French nuclear industry in GDP can be estimated at 48 billion euros, leading to a total (direct and indirect) impact on the economy of about 175 billion euros, i.e. more than 7% of GDP. This macroeconomic impact results from the combination of several specific factors:

- The high level of localisation of the nuclear supply chain in France.

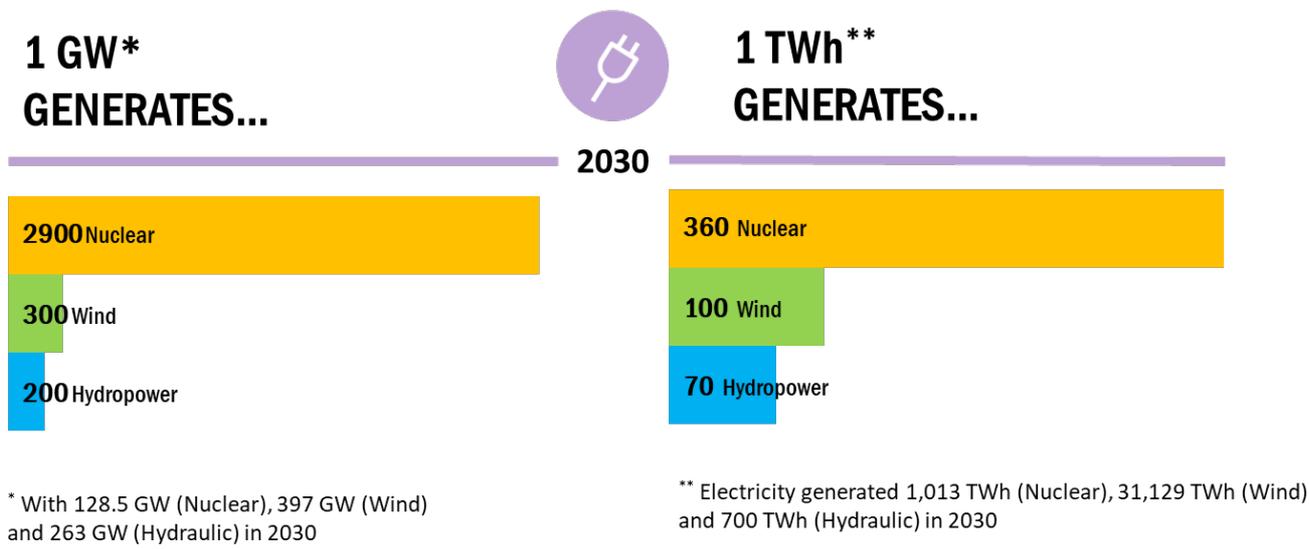
²³ Opinion N° 2019-AV-0329, French Nuclear Safety Authority -16 July 2019

²⁴ SFEN report, ‘The costs of new nuclear in France’ - March 2018

²⁵ Investing in low-carbon nuclear generates jobs and economic growth in Europe, FORATOM, - April 2019

- The contribution of the nuclear fleet - along with hydropower - to the competitiveness of industrial and household electricity prices. As a reminder, in 2019 household electricity prices were more than 70% higher in Germany than in France²⁶.
- The high level of qualification which results in higher incomes compared to the rest of the power sector (and industry in general). It is estimated that the level of qualification within the nuclear industry is up to twice as high as the industry average.

An investment programme in new reactors would further strengthen this macroeconomic impact in the immediate future. In a scenario of renewal for the European nuclear fleet, alongside the development of the wind industry, the Deloitte study estimates that by 2030 the European nuclear sector will have a spillover effect per TWh 3.6 times greater than wind. By this time, each nuclear TWh will contribute 360 million to GDP, compared to 100 million to GDP for wind power²⁷. This result is again explained by the high level of localisation of the nuclear supply chain within the European Union.



Contribution of nuclear, wind and hydro to European GDP in millions of euros (per GW of capacity and TWh produced)

1.2.2. At the local level

Generally speaking, nuclear power plants and the activities of companies in the sector are well distributed across all French regions: facilities are often located in regions with economic challenges. A nuclear power plant also generates indirect and induced local jobs. A study carried out for the Fessenheim (Haut-Rhin) power plant showed that the latter supported, during operation, more than 5,000 people.

²⁶ Eurostat 2019

²⁷ The impact is more limited for hydropower since there are no plans to build new dams (or replace existing ones)

The local impact of nuclear power is even more important when it comes to new build:

- A study²⁸ carried out in 2017 by the Normandy Chamber of Commerce and Industry shows that the Flamanville EPR construction site reached, at its peak in 2016, **up to 4,600 on-site employees**. The key ‘*Grand chantier*’ site-work programme, which was launched in the summer of 2008, the year of the financial crisis, made it possible to train 1,000 job seekers in the region and helped to recruit and train local workers.
- Following the crisis, whilst between 2008 and 2015 there was an increase in job seekers at the national level, from 2 to 3.5 million, and a fall in employment contracts, **the Cherbourg (Manche) region was spared, with a stable number of jobs over the period**. In particular, industrial employment, which recorded a decline of 10% over the 2008-2013 period at the regional and national levels, was maintained in the Cherbourg region, where it represents almost 20% of total employment.
- Interviews carried out by the Normandy Chamber of Commerce and Industry with a panel of Cotentin industrial companies reveal that the site, which on average represented more than 10% of their turnover, enabled half of the companies to consolidate their financial structure at a time when they were weakened by the drop in activity on other sites. It also contributed to 60% of the companies being able to create new market opportunities.

2. Renewal of the nuclear fleet is part of the long-term transformation objectives

Beyond the need for ‘recovery’, many economists and institutions stress the importance, when it comes to stimulus packages, of incorporating long-term transformation criteria. It is about *"rethinking our economic and social system in a world under the threat of other crises, isolated or combined, whether health, social or climatic"*²⁹.

These recommendations generally cover three main issues: commitment to climate objectives, the requirement for technical resilience, and the imperative of industrial sovereignty. **Nuclear power responds favourably to all three of these issues.**

2.1. Renewal of part of the nuclear fleet is essential to achieve French and European carbon neutrality objectives by 2050

In April 2020, the French High Council for the Climate³⁰ stated that *"in order to respond to the economic, social and financial shocks that are looming, the end of the crisis and the recovery must integrate the climate*

²⁸ Economic impact study - ‘*Grand chantier*’ large EPR project, carried out by the Normandy Chamber of Commerce and Industry - 2017

²⁹ Continuity, resilience, sobriety: the horizons of a world in crisis. Patrice Geoffron and Benoît Thirion, La Tribune - 6 April 2020

³⁰ Climate, Health: better prevention, better cure, French High Council for Climate - April 2020

emergency". The Council also clarified that investments must be directed towards "*resilient infrastructures favouring low-carbon uses*", and that "*the essential sectors and creators of long-term transition jobs must be prioritised*".

In France, electricity production infrastructure is already low-carbon: French average CO₂ emissions are less than 50g/kWh³¹, well below those of the neighbouring countries (e.g. around 400g/kWh for Germany and 260g/kWh for Italy). This performance is largely due to the production of the nuclear fleet, combined with renewables (hydropower, solar photovoltaic, and wind).

Nuclear energy is one of the energy technologies that helps to decouple economic growth from CO₂ emissions: between 1980 and 1985, France experienced a decrease in its CO₂³² emissions of 20%, despite GDP growth of 8% in constant terms. In the ten years which followed the commissioning of the Fessenheim nuclear power plant, France had in fact succeeded in reducing, owing to its nuclear programme, the share of fossil energies in electricity production from 55% to 10%. The Executive Director of the IEA³³ recently highlighted that in 2019³⁴, global CO₂ emissions stabilised, despite growth of 3%. The electricity sector has been a key contributor, with a decrease in its emissions linked to the development of renewables (mainly wind and solar), the replacement of coal by gas, and the growth of nuclear production (Japan, Korea and China).

Developing electric solutions to reduce the consumption of fossil fuels (oil, gas, coal) is a means to further decouple economic growth and CO₂ emissions. The French National Low-Carbon Strategy (SNBC) sets a long-term trajectory for the French energy mix by 2050, and already foresees an increase in electricity consumption of around 30% compared to the current level: by then essential household uses and individual transport must be based on electricity. It should be noted that currently, many of the measures proposed in the recovery plans are already based on carbon-free electricity, whether these are new means of heating (heat pumps), mobility (train, urban transport, electric vehicles) or the development of the hydrogen vector (which is currently produced from fossil fuels). This issue is of primary importance as we expect to make extensive use of renewable energies, whose role in the electricity system will increase significantly. At the same time, we will have to maximise synergies with nuclear power.

For low-carbon electricity to play its role in decarbonisation in the long-term, France must decide without further delay to launch a nuclear new build programme. By 2050, the vast majority of the existing nuclear fleet will have reached 60 years of age, with a possible 'cliff-edge effect' in the early 2040s, linked to the very rapid pace of construction of the fleet in the 1980s. We will have to renew them with new low-carbon and renewable, as well as nuclear production capacities. Even if technical and economic progress is expected by 2030-2050, we do not currently know the feasibility, the robustness, the cost or the exact limits of a system combining exclusively, or in very large quantities, variable renewables, new storage technologies, biogas, and/or fossil fuels with Carbon Capture and Storage (CCS). To date, the leading international organisations (OECD/IEA, EU, IPCC) believe that all low-carbon technologies – renewable, nuclear and CCS – must be implemented to

³¹ The European Power Sector 2019 Agora Energiewende

³² World Bank: CO₂ emissions from 505Mt in 1980 to 401Mt in 1985, increase in GDP over the same period from 1.48 **1012** to 1.60 **1012** in \$ 2010

³³ Now is the time to plan the economic recovery the world needs, IEA - 27 April 2020

³⁴ IEA - Global CO₂ emissions in 2019 – February, 2020

achieve a deep decarbonisation of the electricity sector by 2050. It is difficult to see why it would be otherwise in France, which is a world reference for the use and industrial performance of this technology.

Delaying the decision (or the absence of a decision) on the launch of nuclear new build programme would expose France to **the risk of having to urgently launch the construction of new gas-fired power plants, with a significant impact on greenhouse gas emissions**. We have observed this recently in Japan, with the slow restart of nuclear power plants, in the United States in New Jersey and in State of New York³⁵, and possibly soon in Belgium³⁶.

2.2. Renewal of the nuclear fleet will be necessary to guarantee the resilience of the power system to future shocks

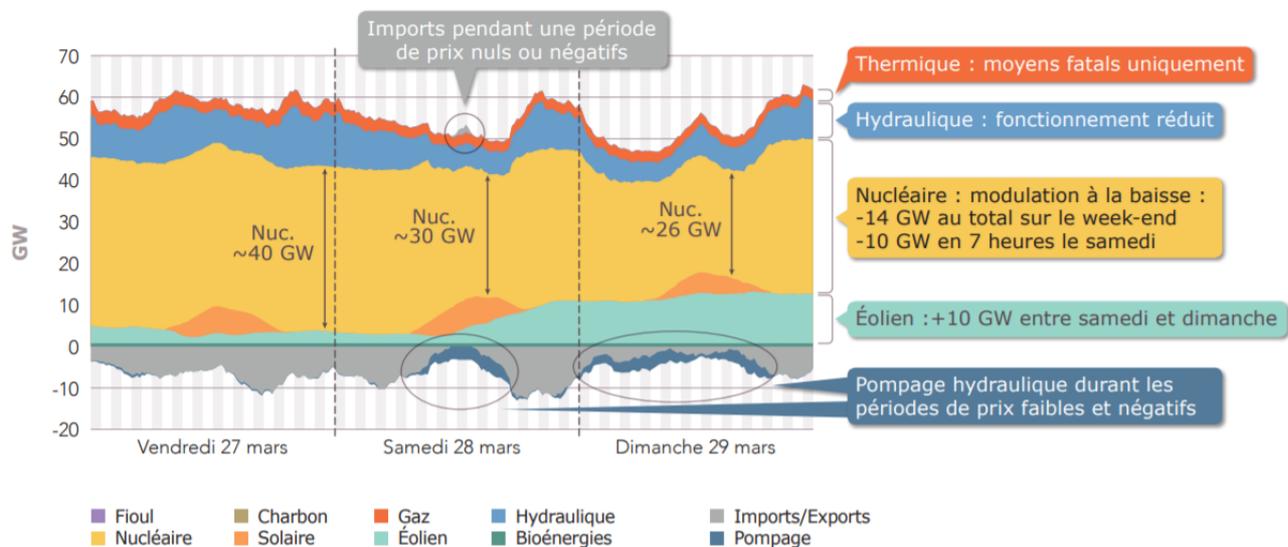
Faced with these multiple and emerging uncertainties, it is relevant to focus on the notion of resilience in the face of unexpected shocks and in particular on the first two key criteria: **robustness** to resist external shocks and **flexibility** in adapting its organisation. In addition, it is necessary to **make the distinction between the resilience of a given production infrastructure and the contribution to the resilience of the electricity system as a whole**. In this second case, the key factor is what services this infrastructure brings to the resilience of the system as a whole.

Throughout the COVID-19 crisis, **the nuclear fleet was able to demonstrate a significant robustness and a high flexibility to adjust very quickly to a new situation and to maintain the security of electricity supply**. The industry rapidly adapted its organisation and processes (limitation of the number of employees present on sites, priority given to teleworking) and modified the plants' schedules, guaranteeing, under the control of the French Nuclear Safety Authority (ASN), a very high availability of the nuclear fleet. The fleet was able to adapt to an unprecedented situation of declining electricity consumption, and operate within an electrical system in which the share of variable renewables (wind and solar), with priority access to the grid, was much larger, to the point of causing an increasing number of episodes of negative prices. Throughout the period, the nuclear fleet has been able to constantly adjust its production according to variations in demand and the production of renewable energies. For instance, in France, during the last weekend of March 2020, the nuclear fleet load-followed by 14GWe (out of 40GWe of available nuclear capacity at that time), primarily in response to the variability of solar PV and wind power in France and its neighbouring countries. The IEA highlighted³⁷ that, during this period, **nuclear energy was one of the main sources of flexibility in Europe. This remarkable (and often overlooked) capacity makes it the ally of renewables: it is the very concept of the *new nuclear core supply*, which allows development of other low-carbon energies, together with hydropower.**

³⁵ RGN 27/04/2020 - In the middle of Coronavirus, closing Indian Point is a mistake

³⁶ Les Echos: Engie and Eneco prepare for the post-nuclear era - 17 April 2020

³⁷ IEA Global Energy Review 2020



Electricity generation mix in France from Friday 27 March to Sunday 29 March, 2020 (source: RTE)

By 2050, the electricity system will face significant challenges and unprecedented uncertainties.

Beyond the challenge of decarbonisation, the share of dispatchable means of production, which has always guaranteed the security of electricity supply, is set to decrease in favour of an increasing share of variable renewables: the grid will therefore be faced with a real paradigm shift. At the same time, France will face a very strong increase in uncertainties at three levels:

- **Uncertainties over the strategy of France’s neighbours and the development of interconnection capacities**, which now have a very strong impact on the security of electricity supply of France, and more generally Europe. According to consulting firm FTI-Compass Lexecon, decisions to exit coal in Europe should reduce the available dispatchable capacity by 110GW. Several of France’s neighbours have also announced closures of nuclear capacities.
- **Uncertainties about electricity demand and citizens' expectations.** The French low-carbon strategy expects a 30% increase of electricity consumption by 2050, largely linked to the electrification of uses in the mobility and housing/tertiary sectors, but also to support the development of other energy vectors (hydrogen by electrolysis in particular). With respect to societal changes, there remain significant uncertainties regarding changes in lifestyle, and expectations of citizens. In addition, electrical solutions may be all the more necessary since there are significant uncertainties about other low-carbon solutions, in particular biomass.
- **Technological and industrial uncertainties:** uncertainties about the long-term potential of renewable energies in France, about the development of intraday and weekly electricity storage and inter-seasonal energy storage, in particular via Power to Gas, and about the development of interconnection capacities.

The scenario work carried out by FTI Compass-Lexecon for the SFEN shows that not taking the decision to renew the nuclear fleet in good time is likely to expose France to very significant risks in terms of ensuring electricity security:

- **Wind and solar will be pushed to their limits:** available sites will be saturated in the coming decades, while at the same time recent years show, in France as in Germany, that these projects can be limited by acceptance constraints.
- The management of flexibility needs would be based on **a major gamble on technologies yet to be proven at technical and industrial scales:** this is particularly the case for Power to Gas technologies, which would offer a long-term storage solution, but which remain at the technological demonstration phase.

In addition, the risks for the electricity system are increased by the convergence of national electricity mixes at the European level. The modelling work shows that giving up the nuclear option would worsen this situation. The renewal of the French nuclear fleet is an industrially mature solution to guarantee France's electricity security from 2035 onwards. The proposed new build programme offers France the option of having, by mid-century, a nuclear capacity of 30% and 50% of the electricity mix (in energy). This is therefore far from advocating a policy of 'all nuclear'. Rather, its aim is to keep the option open, with a low-carbon technology that has demonstrated its industrial performance and will continue to support the resilience of the electricity system.

2.3. Renewal of the nuclear fleet in Europe is essential for maintaining France's energy and technological sovereignty

Nuclear energy is the backbone of France's energy sovereignty:

- It has allowed and still allows France **to protect itself from the uncertainties of the world energy markets and associated geopolitical risks:** oil shocks and counter-shocks, the rise of gas and – more recently – shale oil. In 1970, two-thirds of French electricity was produced using fossil fuels (coal, oil, gas). Thanks to nuclear power, this share is now only 7%. It should be noted that France imports almost all of the hydrocarbons it consumes: in 2016, France spent 32 billion euros on oil and gas imports.
- The cost of producing nuclear electricity is very predictable as the impact of uranium prices is marginal: it represents only **5% of total production costs**. In addition, the uranium market is different from that of other raw materials: the geopolitical risks are low (more than 40% of current uranium reserves are in the OECD, excluding unproven resources in seawater), and the majority of transactions are covered by long-term contracts over several decades.
- **France has an extremely robust uranium supply chain:** in the short term, EDF has a stock of uranium in France corresponding to 2 years' of electricity production. In comparison, hydrocarbon reserves represent less than 6 months of French annual consumption. France is also reducing its dependency on natural uranium by recycling its spent fuel: 10% of French

nuclear electricity is produced from recycled materials. In addition, France has a strategic stock of depleted uranium which can be substituted at any time for 5 years' worth of natural uranium consumption by using modern domestic conversion and enrichment capacities. In the medium-term France has, through Orano, a portfolio of uranium reserves representing 30 years' of consumption. In the long-term, proven uranium resources represent 130 years of world consumption and up to 250 years if we include speculative resources.

Nuclear energy is **the backbone of French industrial sovereignty and, more generally, European industrial sovereignty:**

- France has a **fully integrated national industrial sector** which enables it to develop its expertise in the design and construction of its own facilities for the production of electricity, uranium enrichment and fuel fabrication, including recycling.
- **Nuclear is a low-carbon energy sector where France enjoys an international competitive advantage.** France's interest in consolidating its competitive advantage in nuclear power is even more important considering it is a world leader in this field. EDF, the world's leading operator of nuclear power plants, is recognised and sought after by its peers (China, South Africa, United Arab Emirates, etc.) for its experience in both operation and safety. This is also the case for Orano in the fuel cycle and Framatome for the manufacturing of key components. More than 50% of companies in the sector are involved in exports, and the sector as a whole exports around 5 billion euros in goods and services each year.
- **The industrial capacity to build new reactors is not only a strategic asset for French technological sovereignty, but also for European sovereignty.** According to the European Commission's EUCO30 decarbonisation scenarios, the Union will need 110GW of nuclear power in 2050, including 70GW of new nuclear outside France, to achieve its objectives. France is the last country in Europe to have an integrated supply chain. However, France has not yet been able to use its capacity for serial construction of 3rd generation reactors, due to lack of an industrial programme. In contrast, Russia's Rosatom has commissioned 15 new reactors over the past 14 years, and has around 30 projects in progress internationally.
- **Beyond the nuclear sector, nuclear energy is a key infrastructure in the context of French re-industrialisation and for 'industrial sovereignty'** . It guarantees future low-cost electricity supplies to future 4.0 industries. It is also a key source of expertise and innovation with significant spillovers with other sectors.

As the French think tank IFRI pointed out ³⁸ in a 2019 report on energy transition, *"the nuclear industry is a huge asset in terms of sovereignty, control of the value chain, employment and value creation."*

³⁸ The strategic dimension of the energy transition: challenges and responses for France, Germany and the European Union, by Marc Antoine Eyl-Mazzega and Carole Mathieu, IFRI - April 2019



About this content

This position paper is the outcome of discussions between the members of the SFEN ‘Economy and Energy Strategy’ Expert Group (ST8) during the months of April and May 2020.

Contact – sfen@sfen.org