

The new nuclear

Preface

Joël Barre, Interministerial Delegate for New Nuclear

Introduction

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What is the need for a new nuclear programme?

Changes in demand for carbon-free electricity

Pierrick Dartois, Doctoral student in post-quantum cryptography at the Inria centre at Bordeaux University and **Marie Suderie**, Deputy Chief of Staff at the Directorate-General for Competition, Consumer Affairs and Fraud Control (DGCCRF)

Moving away from fossil fuels while reindustrialising France will require a significant increase in electrification between now and 2050. While there are alternatives to decarbonised electricity, such as biomass, their potential is too limited to cover future needs. According to our estimates, France's electricity consumption could reach 850 TWh by 2050. To meet this level of electricity demand, an ambitious revival of nuclear power is essential.

The decarbonisation of the aviation sector and the challenge of access to decarbonised energy

Thibaud Normand, Programme Director at Safran Nacelles

In 2021, the aviation sector adopted the goal of carbon neutrality by 2050, and rapidly converged on the decarbonisation levers required to achieve this objective. However, this decarbonisation requires the massive and rapid development of a sustainable aviation fuel industry. Alongside biomass, whose resources are fraught with uncertainty, decarbonised electricity appears key to the production of synthetic fuels. The French aviation sector could account for indirect electricity consumption of around 150 TWh by 2050.

The development of a new, highly electro-intensive industrial sector for the production of synthetic fuels represents an opportunity for a new use for nuclear electricity. However, new nuclear power will have to be competitive with centralised renewable electricity sources in the global market for Sustainable Aviation Fuels (SAF).

Financing new nuclear power and risk management in carbon-constrained economies

Jan Horst Keppler, Senior Economic Adviser at the OECD Nuclear Energy Agency (NEA)

As the only low-carbon power generation technology that can be scaled up or down at will, nuclear power is set to play an important role in achieving the net-zero emissions targets to which a growing number of OECD countries have committed. However, achieving the level of installed nuclear capacity needed over the next few years and decades will require the ability to raise significant amounts of capital at competitive rates.

To this end, the NEA is presenting a new framework for analysing the financial risks associated with the construction of new nuclear power plants. Minimising the cost of capital depends on optimising financial risk management. The framework proposed here leads to two key conclusions. First, in a carbon-constrained world, the real capital costs of nuclear power and other low-carbon generation sources are lower than generally assumed because of their ability to offset systemic financial risk. Incorporating investments in low-carbon generation can therefore reduce overall portfolio risk. Secondly, there are effective policies and measures to radically reduce the economic and financial costs of other components of risk, such as construction risk, price risk and political risk.

These conclusions apply equally to private and public investment. However, governments also have an important role to play. Firstly, they must ensure credible and effective commitments to the goal of zero net carbon emissions by 2050. They must also implement the necessary measures to eliminate or reduce the economic costs associated with construction risks, price risks and political risks. Finally, governments can intervene as direct project promoters in the event of market failure when private players fail to recognise the true economic value of a nuclear project. Beyond reducing financial risk, governments then have a role to play in establishing effective project management structures for large, complex projects such as new nuclear power plants, as well as in macroeconomic stability.

If the measures outlined below are fully implemented and new nuclear power plant projects are fully de-risked, private and public investors will compete for the benefits of low-carbon, controllable electricity, reducing the required return on capital to rates significantly lower than today.

Reducing consumption and decarbonising: the two pillars of France's energy and climate strategy

Sophie Murlon, Director General for Energy and Climate at the Ministry of Energy Transition

In line with the Paris agreement on climate and our international commitments, France enshrined in law in 2019 the objective of achieving carbon neutrality by 2050. This commitment for climate requires an acceleration of the decarbonization of our economy and lifestyle, a reduction in energy consumption as well as a redefinition of our energy system, which is still dependent on fossil fuels for about 60%, by developing low-carbon energies: renewables and nuclear. This transition must also ensure security of energy supply and reduce our dependence on imports, preserve the competitiveness of our economy and protect French consumers. It is a major industrial challenge.

Rediscovering the path to industrial mastery and technical excellence in the nuclear industry

Following the difficulties encountered on Flamanville, EDF's excell plan

Alain Tranzer and **Anne-François de Saint Salvy**, EDF Group

After Flamanville 3, EDF's excell plan.

On December 11, 2019, EDF decided to implement a major plan, engaging EDF and the entire nuclear industry to regain the level of quality, rigor and excellence that presided over the construction of the French nuclear fleet. The excell plan has three main pillars: industrial quality control, skills, and governance of major projects.

The operational implementation of the excell plan began in June 2020 with the arrival of Alain Tranzer at EDF's Executive Committee. It is organized according to five axes: Project governance, Skills, Manufacturing and achievements, Supply Chain, Standardization and Replication, completed by the Welding plan.

Two years after the launch of the excell plan, 90% of the commitments made have been met. The dynamics created have become the rule within EDF and in the nuclear industry. Its impact on the results of nuclear projects is monitored in a quarterly dashboard with ambitious targets.

Strengthening industrial quality at Framatome

Bernard Fontana, Chairman of the Management Board and CEO of Framatome

For over 60 years, Framatome has contributed to the development of safe, low-carbon and competitive nuclear solutions in France and around the world.

After the end of new construction in France and the associated loss of skills, the nuclear market is now dynamic again, driven by its strong integration in future low-carbon electricity mixes and the reinforced need for energy independence.

Framatome has been pursuing a program of skills and quality enhancement for several years, in order to meet the diverse demands of the French and inter-

national markets and achieve ever-higher levels of performance.

Improving the constructability of the EPR2 to gain competitiveness

Gabriel Oblin, EDF Group EPR2 Project Director

The EPR2 is an optimized and industrialized version of the EPR. It capitalizes on the strengths of the EPR: the same power, and the same safety and environmental performances among the highest in the world. It also takes into account lessons learned from previous EPRs and the fleet in operation, to facilitate construction; lessons learned both by EDF and France's nuclear industry mobilized towards a return to excellence, via its "excell plan".

The difference with the EPR therefore lies mainly in the fact that the EPR2 will be easier to build, within optimized deadlines and therefore more competitive. Construction will be facilitated by:

- simplifying the design;
- standardizing equipment;
- strengthening prefabrication in factories;
- involving suppliers as early as possible;
- adapting organizations and addressing the issue of skills;
- profoundly transforming and digitalizing EDF's engineering.

EDF aims to start the first work on the Penly site (Normandy) in mid-2024. The following projects are planned in Gravelines (Hauts-de-France) and Bugey (Auvergne-Rhône-Alpes).

MATCH or how the nuclear industry is looking to the future

Olivier Bard, General Delegate of the French Nuclear Energy Industry Group (GIFEN)

The announcement of a new nuclear program in France is a first after more than 50 years. It will contribute to reindustrializing our country while fighting against climate change and strengthening energy sovereignty. For this program to be successful, the nuclear industry has equipped itself with a robust tool, led by GIFEN and developed collectively with more than 100 companies: the Match program.

The Match program aims to ensure the adequacy of the capacities of the sector with its industrial and human needs. It gives a visibility over 10 years, which will be updated on a yearly basis and it drives the required action levers based on three main pillars: mobilization of resources, operational efficiency to optimize their use and economical and financial sustainability of companies in the nuclear industry. Match is designed to help the nuclear industry to "do it right the first time" and to strengthen its collective production capacity over time.

Relaunching the nuclear industry: a Marshall Plan to secure skills

Hélène Badia, President of the Université des Métiers du Nucléaire

The question of skills is crucial for the nuclear industry, and is first and foremost a question of safety. In addition to the specific technical skills they need to acquire, all new recruits have to integrate safety-related requirements and behaviours, an acquisition of skills that takes place over a “long period”. The resource requirements arising from future large-scale industrial projects also explain the importance attached to skills development by industry players, who have set up the Université des Métiers du Nucléaire in 2021. The revival of the nuclear industry has reinforced the need for a structured action plan that brings together all the players involved. This action plan, submitted by the Université des Métiers du Nucléaire to the public authorities in June 2023, is based on an analysis of the 20 sensitive professions in the industry and highlights the fact that the creation of new training courses must be supplemented by measures to enhance the visibility and attractiveness of existing training courses and target new recruitment pools.

HEFAÏS, welding training par excellence

Corentin Lelièvre, HEFAÏS

HEFAÏS, Haute École de Formation Soudage, is a unique welding school in France designed by and for industrial businesses as a response to the lack of highly qualified welders that are needed to work on major current and future industrial projects.

This high-end industrial school was founded by four leading industrialists located in the Cotentin (Normandy) – EDF, Naval Group, Orano and CMN (Constructions Mécaniques de Normandie) – with the ambition to train the best welders in France for both the nuclear and naval industries.

Supported by several local institutional partners, HEFAÏS offers modern innovative training methods and environments that allow the welders to learn or improve their skills in near-real conditions.

HEFAÏS offers training of excellence to metalworking industry employees as well as to jobseekers who are interested in the welding industry, whether they are beginners or experienced workers, men and women, from Normandy or elsewhere.

New nuclear power to help reindustrialise the country

Nuclear power to help re-industrialise France

Hubert Virlet, Project Director in the Industry Department of the Directorate General for Enterprise

France is facing massive growth in its need for stable, competitive electricity generation to meet the dual

challenge of decarbonisation and re-industrialisation. Nuclear power is a strategic asset in this context, with electricity price regulation enabling consumers to reap the benefits. The revival of nuclear power is also in itself an industrial opportunity for the country, whether it be the EPR2 programme or the development of innovative reactors.

Successfully decarbonising French industry through the competitive advantage of nuclear power

Nicolas de Warren, Chairman, Union des industries utilisatrices d'énergie (Uniden)

The historic partnership between nuclear production and electro-intensive industries has structured the French industrial landscape, with the former needing large, stable and predictable consumers and the latter needing abundant, safe and competitive electricity. Renewing this partnership today would meet two challenges: firstly, that of decarbonising industry, nuclear being the low-carbon energy par excellence and industry being called upon to multiply its electricity consumption by 1.5 by 2035, and by 2 or 3 by 2050 in order to decarbonise. Only nuclear power can meet these needs. Then there is the challenge of competitiveness, with nuclear power guaranteeing the availability of resources over the long term, independence from the impact of energy crises on prices, as long as it is not subject to the uncertainties of the wholesale market, and a reasonable production cost, as the existing nuclear fleet has been written off.

Orano, leader in the fuel cycle, could double or even triple its investments to support the nuclear revival

Claude Imauven, Orano

Orano, as a global industrial expert in the fuel cycle, is ideally positioned to support and strengthen French energy sovereignty as well as to support the development of nuclear power around the world. The group has never stopped investing, whether in mining, conversion or enrichment, with the renewal of factories over the last decade.

In order to support this recovery in France first, then in Europe and in the world, Orano could double or even triple its investments in the cycle. While the project to extend the Georges Besse II plant, which was approved by the group's Board of Directors last October, will be mostly self-financed, financial support will have to be found if the group wants to be able to deploy other major projects such as the renewal of mining capacities or recycling facilities, for which decisions will have to be taken by the end of 2023.

How to strengthen the innovation dynamic in the French nuclear industry?

Jean-François Debost, Managing Director of the Nuclear Valley competitiveness cluster and **Bernard Salha**, GIFEN Innovation Commission, Chairman of SNETP, CTO and Director of R&D at EDF

The civil nuclear industry is restarting around the world, providing many opportunities to position an ambitious French technological offer. With 67 years of experience in civil nuclear power and the accelerated innovation projects of the « France Relance » and « France 2030 » plans, France is racing at the forefront of global nuclear power. In the face of competition, we will have to accelerate innovation and bring our SMEs' and startups' technological solutions to market. This will require significant support from public authorities over time, as well as strengthening the equity of our ETIs - SMEs, which are strongly capital-intensive industries. Finally, Europe will have to protect the industrial and economic interests of its member countries in the already highly competitive market for new nuclear power.

Is the New Space model the future of smart modular reactors?

Antoine Chesne, Engineer and economist

The nuclear industry is currently experiencing a period of great excitement, given the development of small modular reactors (SMR) and the emergence of innovative start-ups. Also, the nuclear industry shares similarities with space industry. Both sectors have experienced common origins and have been developed in parallel, with rapid growth in the 1960s and 1970s, followed by a period of relative stability from the 1980s to the 2000s. However, over the last decade, the space industry has been turned upside down by what we refer to as the "New Space" revolution. Today, this transformation is inspiring the rise of the SMRs driven by the "New Nuclear" trend, whose technical, economic and political inspiration comes directly from the New Space. By adopting its codes: miniaturisation, replicability, reusability, by attracting its entrepreneurs, and by pursuing similar public policies, the new nuclear is seeking to replicate the success of the New Space and is aiming to find the path that will enable it to play a leading role in the energy transition.

Governance and social acceptability of nuclear power

Changes in public opinion on nuclear power in France and Europe

Henri Wallard and **David Lévy**, Co-founders of NewCovalence

Nuclear energy, an invisible and relatively recent source of power, has had a tumultuous history marked by its dual civil/military nature and three accidents with global repercussions. Ideology and politics have often taken precedence over economics and technology.

In Europe, after 30 unproductive years, the situation changed in 2022. This shift appears to be more connected to the war in Ukraine and concerns about shortages than to the fight against greenhouse effect.

Around the world, many countries are relying on nuclear power to decarbonize their electricity generation. And voices of young environmental activists are starting to advocate for nuclear power, contrary to historical doctrines.

The new nuclear era will require a high level of professionalism in the deployment process and an impeccable democratic framework, similar to what has been established for deep storage sites.

Insufficiently prepared announcements and plans could make some projects much more challenging despite this favourable environment.

A new nuclear dynamic in the EU

Pierre Jérémie, Chief engineer of the Mines

Upholding the balance between European energy and climate targets and the sovereign competence of Member-States to define their energy mixes that was enshrined in TFEU Article 194 has been a sensitive topic over the past months. European cooperation in the field of nuclear energy was at the core of the European project in the 1950s, within the framework of the Euratom treaty: it since the 1990s has focused on the most consensual aspects of nuclear energy, such as waste management, workplace safety, and general principles for nuclear safety.

Since 2020, European energy policy evolves in a dramatically changed landscape. Our joint climate targets have been moved forward at an unprecedented pace, fossil energies are becoming increasingly scarce and expensive following the Ukraine invasion, and access to capital has become more difficult in a higher-for-longer rates environment. This has revealed renewed tensions between the main Member-States energy choices, between market prices and national system costs, between the total costs of the leading low-carbon energies. It is in that new landscape that a growing number of Member-States have coordinated together to defend jointly a strict vision of technological neutrality and subsidiarity, within the Nuclear Alliance: this has allowed key advanced, that will be built upon in the next European Commission mandate.

Legislative changes to speed up nuclear projects

Anne-Cécile Rigail, Head of Legal and Regulatory Affairs at the Interministerial Delegation for the New Nuclear Power Plant, and **Pierre Guillot**, Head of the Technological Risks Department at the Directorate-General for Risk Prevention

The French law n°2023-491 promulgated on June 22nd 2023 is part of an ambitious program for building new nuclear facilities. It aims at facilitating and legally securing the construction of these new units. This very technical legal text achieves three main objectives: removing the legal obstacles to launching a new nuclear program, especially any ceiling for nuclear power in the energy mix, speeding the administrative procedures for building new units next to existing nuclear sites, and speeding the litigation process, while legally securing

some technical aspects of the project (right to build on the sea shore, endangered species special provisions). This law paves the way for constructing six new EPR units, as wished by the French President of the Republic in his Belfort speech on the decarbonation of the French power mix.

The safety implications of a revival of nuclear power in France

Julien Collet, Deputy Director General of the French Nuclear Safety Authority (ASN)

The relaunch of a major nuclear power programme is a challenge for the French nuclear industry, which must rebuild its capabilities, particularly in terms of skills. The ASN is drawing attention to the risks associated with the very rapid start-up of the EPR2 programme and is adapting its control accordingly.

At the same time, projects for small modular reactors are multiplying, with ambitious objectives, including in terms of nuclear safety. Most of these projects are at an early stage of development and have yet to prove their worth. The ASN has put in place appropriate procedures for discussion and work with these projects, which raise new questions or call into question current safety doctrines.

Responsible and sustainable management of radioactive waste in France

Pierre-Marie Abadie, Director General of the French National Radioactive Waste Management Agency (Andra)

Nuclear energy is the largest producer of radioactive waste in France (ahead of research, defence, the non-electronuclear industry and the medical sector). This waste can present risks for humans and the environment, and needs to be managed according to its level of radioactivity and lifespan. The long-term management of this waste has been entrusted to Andra, the French national radioactive waste management agency.

The vast majority is stored in surface facilities. This is very low-level or short-lived waste, which accounts for more than 90% of volumes but a very small proportion of total radioactivity.

On the other hand, high-level and long-lived intermediate-level waste, which comes from the reprocessing

of spent fuel and the operation of nuclear power plants, represents very small volumes but concentrates 99% of total radioactivity and cannot be managed in surface facilities. They are destined to be stored in Cigéo, the deep geological repository project for which Andra has applied for authorisation in early 2023.

New nuclear power, participation and decision-making: a difficult balancing act

Michel Badré, Chairman of the National Commission for Public Debate on EDF's EPR2 reactors

The "New Nuclear" project presented by EDF, involving a pair of EPR2 reactors at Penly as part of a programme of six reactors of the same type, was the subject of a public debate in 2022/2023.

The announcements made by the public authorities concerning a decision that was understood to have already been taken, and the scarcity or absence of information on a number of key issues, made it difficult to exercise the constitutional rights of every individual to be informed and to participate in the preparation of decisions.

Some thirty unanswered questions have been recorded in the minutes of the debate. Only the answers to these questions will enable us to assess the usefulness of our contribution to the exercise of these rights.

What are the conditions for a sustainable revival of nuclear power in France?

Yves Bréchet, Associate Professor at Monash University (Australia) and McMaster University (Canada), Scientific Director of Saint-Gobain and Chairman of Framatome's Scientific Advisory Board.

This article sets out the conditions for a sustainable revival of nuclear power, as well as the need to put in place a strategy for sustainable nuclear power. These conditions are both political and organisational. They include making the industry attractive again, developing a pool of training courses, and relaunching the fast neutron industry without delay, which is essential if nuclear power is to be a sustainable solution in a world of high geopolitical tensions.

Issue editor:

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