

THE INSPECTOR GENERAL'S
REPORT ON NUCLEAR SAFETY
AND RADIATION PROTECTION



20
25



FOREWORD

Our organisation is based on the duty holder's primary responsibility for nuclear safety and radiation protection. The EDF Group's safety policy makes this an overriding priority.

This report, submitted to EDF's Chairman, presents my assessment of the state of nuclear safety, radiation protection and occupational safety across EDF Group's nuclear activities and facilities in 2025.

The result of a collective effort with Bertrand de L'Épinois, Jean-Baptiste Dutto, Paul Wolfenden and Bertrand Vauchy, it draws on contributions from field teams, technical managers, staff representatives, industrial partners and internal and external regulatory bodies. I would like to express my sincere thanks to Paul Wolfenden, who is returning to his fleet on the other side of the Channel.

This report is intended not only for decision-makers within the company, but also for all those whose work has an impact on nuclear safety through their actions, attitudes and practices. It applies to all French and British production sites, engineering departments, subsidiaries and contract partners: technical rigour, transparency and accountability are essential levers for driving continuous improvement in safety.

More than ever, I emphasise the importance of change management: transforming organisations, adapting management, modernising practices, evolving know-how, digitalisation and technological innovations, so that nuclear safety is not just a requirement but a culture, a stimulus rather than a hindrance. The weaknesses identified in recent years regarding skills management, the operating rules

The Inspector General for Nuclear Safety
and Radiation Protection of the EDF Group
Admiral (Retd) Jean Casabianca



complexity, the industrial programme workload, the delays and burdens affecting spanner time, the consistency of the energy mix and operating experience make structural changes, individual ownership and collective commitment urgent.

My intention is that this report, beyond highlighting strengths and progress, identifies weak signals and areas of risk, and identifies areas for improvement. Its recommendations call for action and will be followed up by the Council for Nuclear Safety (CSN).

Safety cannot only come from rules: it is built day after day on individual skills and responsibility, on leadership and exemplary behaviour and, above all, on the collective will to improve.

This report is based on the three pillars of nuclear safety culture: a rigorous and cautious approach, a questioning attitude, and communication. It must therefore be widely distributed internally to encourage questions and challenges, which are key factors in the nuclear safety continuous improvement.

In full transparency, this document is available to the general public in French and English on the website www.ignr.com.

Paris, 15 January 2026



Introduction
to the report



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Cattenom power station

CHAP 1

RETROSPECTIVE, TAKING STOCK AND PERSPECTIVES

The year 2025 confirmed the renewal of nuclear power, with record production worldwide thanks to the new connections to the Chinese electrical grid and the restarting of Japanese reactors, which had been shut down since the Fukushima accident in 2011.

The Group's safety results remain stable, but incidents, the effects of which remained under control, must be used for operating experience.

Flamanville 3 (FLA3), the 4th EPR in the family, became one of 57 French reactors in operation. It is the 70th power reactor to be built in France.

Five years have elapsed since my first report in the middle of Covid and before detection of the stress corrosion phenomena (SCC). So much has changed, so much remains to be done, but one thing is for sure: nuclear power is an abundant, reliable and low-carbon energy source. An asset for sovereignty.

The men and women of the Group must continue to be accountable operators, conducting all activities in complete safety.

A SATISFACTORY SAFETY RECORD, SOME INCIDENTS TO BE ADEQUATELY ADDRESSED

Across the Group, while most safety indicators are satisfactory, the number of automatic reactor trips (RTs) due to internal causes has stabilised around 20 in France (24 for 57 reactors) and in the United Kingdom it has risen to a level rarely seen before (8 for 9 reactors). On both sides of the Channel, human factor and equipment failures are the main causes. In France, six atypical additional automatic RTs were due to external causes (lightning, jellyfish, grid, etc.).

This relatively stable safety record, with improved reactivity management that must be maintained over time, comes with higher production in France (373 TWh and 35 TWh of modulation) and slightly lower generation in the United Kingdom (32.9 TWh instead of 38.4 TWh forecasted). Improved outage management results from "Start 2025" plan, with greater rigour in meeting milestones. This brings EDF SA closer to its target of 400 TWh per year, confirming the recovery of the French nuclear fleet. The British fleet poorer performance is mainly due to equipment failures at a single station.

Beyond statistics and indicators, 2025 experienced events that deserve specific attention with respect to nuclear safety, and confirmed changes in the French energy mix.

The first two incidents described below confirm that, in a context of weakening network balance, it is important to train for the loss of external power supplies and to ensure the reliability of emergency means. The recommendations in the 2023 report in its chapter entitled "Changes in the electricity system: anticipating instead of suffering" were the subject of an action plan and remain valid. The redundancy and resilience of our generating sources and grids contribute to reactor safety and reduce the risk of a cascade effect impacting countries (e.g. transport standstill, health services, telecommunications and public safety).

A third family of incidents is related to heat sink aggressions due to various causes, which are likely to become more frequent because of the climate change effects on the fauna and flora in our seas and rivers.

AN ENLIGHTENING IBERIAN BLACKOUT!

On 28 April, the total loss of the Iberian Peninsula grid for almost 24 hours was described by ENTSO-E, the association of European grid operators, as "the first blackout in Europe and probably in the world to be caused by a cascade of voltage surges". It caused disruption in south-west France and an automatic reactor trip at Golfech.

ENTSO-E published an interim report in October 2025. A final version is planned for spring 2026 including an analysis of the root causes, the behaviour of the players and the technical resources mobilised. It will give recommendations needed to strengthen the resilience of the European electricity system.

The Iberian Peninsula blackout highlights the greater robustness of the French grid and its generating means. In the event of a loss of external power, nuclear power plants have three lines of defence: household operation (self-supply of electricity by the turbine generator, a feature of the French fleet), internal sources (diesels, gas turbines), and then the possibility of restarting power plants and the grid (*blackstart*) thanks to controllable and diversified means of generation (one reactor backing up the other, use of hydroelectric dams or thermal combustion turbines). Thanks to the inertia and the control and regulation capabilities of its large rotating machinery, the nuclear power fleet stabilise grids considerably.

Operational coordination and periodic performance checks between generating sites and RTE's power system operating centres (COSEs) highlight the importance of the grid/generation interface. Finally, operation teams training and drills in houseload operation and re-energisation need to be regularly maintained.

In application of the *Emergency and Restoration* European code and its national implementation, RTE and EDF jointly ensure they can reconstitute the French power system within short timescale in the event of a widespread grid incident (blackout). The complementary nature of EDF's nuclear and hydroelectric plants is fundamental and must be preserved. It is a good thing that new contracts and connections for renewable energies now include specific rules to ensure that the balance and stability of the grid are not adversely affected.

LOSS OF POWER AT A UNITED KINGDOM SITE

At Hartlepool, the failure of a transformer caused the shutdown of a reactor at power due to the loss of external power supplies (the other reactor was in outage for scheduled maintenance). The gas turbines worked well as emergency generators and the safety of the two reactors remained under control. The work already completed by the fleet to improve the reliability of the gas turbines enabled to operate off-grid for an extended period.

The incident was caused by a manufacturing defect that was known and was being monitored. To be faced with this type of situation for almost five days is exceptional. The plant reacted well and benefited from the support of central services and industrial partners. The operating experience is to be used quickly, including a more detailed risk analysis of the external power sources redundancy prior to any work on the power supplies.

The incident also caused seawater to enter the secondary system. Two turbine rotors were replaced due to corrosion, with no effect on safety, but an outage extension and a significant impact on generation.



Golfech – Access to the industrial facilities

HAZARDOUS NATURAL ENVIRONMENT FOR THE HEAT SINK (SEA AND RIVERS)

During the summer, massive influxes of “clogging agents” adversely affected heat sinks at several coastal and riverside plants. Banks of jellyfish or filamentous algae carried by flood waters affected generation heat sinks, and in one case the safety heat sink was affected requiring reactors to shut down and extensive conservation work ([see Chapter 5](#)).

Comprehensive operating experience is needed, including the anticipation of these phenomena, warning systems, operating measures and associated equipment. The R&D of EDF is working with IFREMER, as part of the Iguazù project, focusing on the increase of jellyfish in the North Sea. In a field that is never static and is sensitive to climate change, it is essential to adequately take into account all possible external hazards.

NUCLEAR POWER'S FLEXIBILITY PUT TO THE TEST BY INTERMITTENT OVERCAPACITY

From the outset, the French nuclear fleet has modulated its electricity production to ensure a balance between supply and demand. Historically limited to nights and weekends, the need to adjust generation is intensifying with the ramp-up of renewable energies in a context of stagnating demand, with a solar peak in the middle of the day and irregular wind peaks.

By 2024, modulated generation had doubled to 31 TWh, leading to increased use of temporary reactor outages. In 2025, the fleet hit a new record with 35 TWh modulated.

I have already warned in two reports about the technical, human and organisational consequences of reactor control being increasingly subjected to external constraints, which tend to intensify. The conclusions of the wider global study carried out by EDF in 2025 corroborate my technical analysis and complement it with economic data. Modulation increases the number of transients experienced by the facilities; it entails additional studies to reestablish margins and could require replacing major components, in particular those brought to their design condition limits. In an already busy industrial context, modulation, even when it is well managed, makes work organisation more cumbersome, disrupts activity planning and complexifies operating conditions.

By 2030, modulation amounts could triple, which would suggest ill-fitted nuclear capacity. However, controllable, low-carbon resources provided by our plants are necessary to guarantee the stability of the grid and a response to seasonal needs for massive generation (harsh winters, with no sun or wind). Germany, which has a renewable energy capacity equivalent to three French nuclear fleets, modulates with gas turbines and coal. Its carbon footprint is still more than ten times higher than France.

Nuclear power plant safety and grid safety remain our top priorities. Two major levers are needed to reduce modulation and increase decarbonisation: accelerating the electrification of power uses and



HPB – Activity in the turbine hall

adapting the development of renewable generation capacity to the demand, using a non-dogmatic and dispassionate technical and economic approach.

NUCLEAR RENAISSANCE: THE GEOPOLITICS OF THE ATOM ARE BACK

The nuclear revival is entering the era of concrete achievements: global investment has soared by 50% in five years to over \$70bn. The return of the World Bank and the European Investment Bank is an institutional turning point. Europe and the United States are now placing nuclear power at the heart of their industrial and energy sovereignty. In addition to large-power reactor projects, momentum is being driven by the development of SMRs (*Small Modular Reactors*), electricity-heat co-generation, data centres, desalination and hydrogen production, and in the longer term, fusion.

Two decisions reflect a strategic move towards securing and regionalising nuclear fuel supply chains. In the United States, the NRC (*Nuclear Regulatory Commission*) has authorised Urenco to enrich uranium up to 10%, opening the way for a more efficient fuel suitable for future SMRs. In Japan, the aim is to count on 20% nuclear power in the electricity mix by 2030 (enabled by operation of 33 reactors that were shut down after Fukushima and the construction of three new ones), and to relaunch the Rokkasho recycling and enrichment plant in order to strengthen the country's autonomy, particularly with regard to Russia. This year at Onagawa, I visited the 1st BWR (*Boiling Water Reactor*) to be restarted and measured the full scale of the safety upgrade work that has been completed and staff training to emergency preparedness.

CHINA IS MOVING UP A GEAR

China's 58 nuclear power plants (57 GWe) produced around 450 TWh of nuclear power, i.e. 5% of electricity consumption. Around 30 units are currently under construction, and in 2025 ten more new reactors

were approved, mainly *Hualong One*. China is also innovating, with a high temperature gas-cooled reactor HTR-PM (GEN IV) which is almost in operation, and a sodium-cooled breeder reactor (CFR 600) ([See Chapter 9](#)). Advanced digital technologies (digital twins, AI) are integrated into the new facilities. China has demonstrated its ability to keep construction times under control (around five years).

THE AMERICAN NUCLEAR INDUSTRY, A POWER DOCTRINE

The United States is repositioning itself as a major player in civil nuclear power, a strategic pillar of energy sovereignty, technological superiority and geopolitical power. "Energy Dominance" is also designed as a counterweight to the Russian and Chinese nuclear export ambitions.

Beyond the extension of existing reactors and support for R&D, US clearly wants to transform the regulatory framework, to open up the sector to new technologies (SMR and GEN IV) and to make nuclear power an essential support for critical infrastructure (data centres, AI, military sites). The aim is to quadruple American nuclear capacity by 2050, which today is around 100 GWe, and to make it economically viable compared with shale gas. The American administration is requiring the *Nuclear Regulatory Commission* to reduce its approval lead-times (to 18 months for new reactors, and 12 months for existing reactors), to reconsider radiological exposure standards and to fast-track technologies already tested by the Defence industry. The risk of diluting safety standards, over-simplifying procedures and pressuring regulatory bodies raises questions. The government and the US group *Westinghouse Electric Company* have released \$80bn in support of ten reactors under construction by 2030.

RUSSIA AS AN EXPORTER AND DOMINANT FUEL SUPPLIER

Russia remains the leading exporter of nuclear power plants. It supplies 20 of the 59 reactors under construction worldwide, and holds over 40% of the world's uranium enrichment and conversion capacity. This gives it capacity for geopolitical influence across its sixty or so partner countries.

On the domestic front, two new licences have been issued. Nuclear power accounts for around 20% of Russia's electricity mix, with a target to increase to 24% by 2042. Funding, availability of specialised labour and the effects of international sanctions are all adversely affecting the ability to deliver.

HAS THE EUROPEAN UNION WOKEN UP?

The European Commission is allocating a record budget of €9.8bn to the Euratom programme (2028-2032). The priority on fusion is confirmed with €4bn to the ITER project, a global technological showcase, and €1.3bn to research and innovation to build a European industry. In addition to the funds allocated to the Commission's research centre (JRC), only €590m is earmarked, through public calls for proposals, for the fission sector, to strengthen safety, radiological protection and preserve skills.

The EU has also updated the Nuclear Illustrative Programme (PIN) provided for in the Euratom Treaty, which sets out the development of nuclear fission in Europe. For the first time, based on contributions from Member States, the volume of GWe installed in Europe is expected to grow between now and 2050 (from 98 GWe in 2025 to 109 GWe in 2050, taking into account the closure of reactors at the end of their operating life and the construction of new ones). At the end of 2024, 101 reactors were in operation in the EU, representing 23% of European electricity production.

The Commission launched the Industrial Alliance for SMRs. Nine SMRs and AMRs were selected on the basis of their contribution to

the economy and European ambitions. This support for new reactor projects is a first in the EU in over 40 years.

The Commission forecasts a doubling of electricity demand, whilst half of the current infrastructure is more than 40 years old. Grids must therefore be redesigned to support electrification of power uses, integrate renewable energies, reduce storage requirements and guarantee more competitive prices via an enlarged market. The European Court of Auditors estimates the financial need at nearly €1900bn. France has already committed nearly €200bn over 15 years to adapting networks. Each country must be able to import the equivalent of at least 15% of its production by 2030. Many still have a long way to go, and barriers remain: high costs, development times (more than a decade) and regulatory constraints.

Germany will invest more than €2bn by 2029 in the *Fusion Action Plan* to make nuclear fusion a pillar of its energy strategy and asserts it will achieve energy autonomy, carbon neutrality and global leadership by 2040. Meanwhile, above all, Germany plans to build around 71 gas-fired power stations to make up for a shortfall in controllable production and guarantee the stability of its electricity grid. Meanwhile, France is helping it to de-carbonise its electricity production by supplying it this year again with a significant share of the 92 TWh exported (new record after the one hit in 2024).

On 28 February 2025, Italy, Europe's leading electricity importer, passed a bill opening the way to a return to nuclear power after the ban resulting from the referendums of 1987 and 2011.

In Belgium, the exit from nuclear power is being delayed by the operation extension at the Doel 4 and Tihange 3 reactors until 2035, despite the shutdowns of Tihange 1 and Doel 2.

In Spain, a gradual shutdown of power plants is scheduled between 2027 and 2035. It is possible that the recent *blackout* may lead to a rethink.

Elsewhere in Europe, Sweden, the Netherlands, Finland, the Czech Republic, Slovenia, Slovakia, Hungary and Poland have decided to



Cattenom – Walkdown in the turbine hall

maintain or develop nuclear power, in particular through new reactors including SMRs or AMRs.

EDF GROUP COUNTRIES

In February 2025, the United Kingdom modified its regulatory framework in order to relaunch construction of nuclear reactors, particularly SMRs: planning rules were revised to speed up these projects.

Following the decision in 2024 to extend the four AGR reactors at Heysham 2 and Torness until March 2030, work is progressing to extend the operating lifetime of the Sizewell B pressurised water

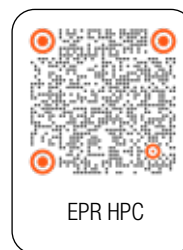
reactor (PWR) until 2055. The four AGR reactors at Heysham 1 and Hartlepool will generate power until March 2028, i.e. a year more than initially planned. The Sizewell C EPR project was given the green light in July 2025, with the final investment decision and the United Kingdom government becoming the major shareholder.

In addition to graphite cracking, which is the subject of core inspections and dedicated safety cases, extending the operation of AGRs means controlling degradation of the boilers and ageing of the facilities. Equipment reliability, particularly in reactors whose design has a lower level of redundancy and defence in depth, remains the priority. The British fleet has to catch up for an investment programme that was reduced a few years ago due to the impending closure of AGRs.

I reiterate the recommendation of my predecessor who in 2019, faced with the risks of successive incremental extensions in a constrained energy context, felt it was necessary to emphasise the importance to define investments on the basis of the most distant deadline envisaged (*see Chapter 4*).

In France, civil nuclear power is at a strategic turning point. While the revival of the industry is under way with the programme for six EPR2s, the lack of integration into a new multiannual energy plan (PPE) is creating uncertainty and could hold back investment. This vagueness complicates the task for EDF and the industry, and contributes to higher costs due to the risk provisions.

The French Nuclear Safety and Radiation Protection Authority (ASNR) approval for continued operation of 900 MWe reactors beyond the age of 40, and its decision on 1 July with regard to the conditions for continued operation of 1300 MWe reactors, are positive news. The *Cour des Comptes* (French National Audit Office), in its November 2025 report, confirms that extending operating life would be “*a beneficial option for the French electricity generation system*”. However, on the long term, this life extension is no substitute for a coherent and stable



EPR HPC

energy strategy. France's experience and homogeneous fleet is an industrial and strategic asset, provided that the government rapidly re-establishes a clear and sustainable vision for its energy future. This is also a question of nuclear safety.

The Flamanville 3 (FLA3) EPR reactor, connected to the grid at the end of 2024, reached full power on 14 december and in 2025 supplied 2 TWh. The ramp-up has continued, with some unplanned events under control but causing delays. FLA3 must now definitively switch from project mode to operational fleet, while preparing for its first outage (VC1) scheduled for autumn 2026. This is not the least of its challenges (*see Chapter 8*).

FIVE YEARS AT THE HEART OF NUCLEAR SAFETY

After five years at the helm of the IGSNR, a unique structure, I am in a position to capture some key elements for improvement in safety from my visits and interviews in the field.

My guiding principle has remained clear: nuclear safety is the overriding priority and the prime responsibility of the operator of competitive, environment-friendly and low-carbon nuclear power, for a renewed industrial ambition.

NUCLEAR SAFETY CANNOT BE DECREED; IT MUST BE EMBODIED, PRACTISED AND MAINTAINED

The nuclear industry must demonstrate exemplary standards and transparency, which are essential for public confidence and industrial legitimacy. Safety requires everyone to adopt exemplary behaviours.

Nuclear safety can never be taken for granted, and there may be a high price to pay for any deviation. It is based first and foremost on

the quality of the teams who design and then operate the facilities. It must be seen not as a state but as a dynamic: it is cultivated by being demanding, questioning, competent, and by learning individually and collectively.

As professionals in charge of complex systems, each person has a responsibility to their fellow citizens to guarantee nuclear safety, industrial and environmental risks management, as well as the health and safety of our employees. It is in this capacity that I have continued the work of my predecessor against addictions, in order to preserve the nuclear safety of our facilities, the employees' health and the Group's reputation.

Compliance with rules is a major factor in accident prevention but is not sufficient to guarantee excellence in nuclear safety. It is not a fixed state or a static standard. It cannot be decreed; it must be embodied, practised and maintained.

The industry's strength not only lies in its technologies, but in the alliance between man and machine, conscience and technique, high standards and competence. It is a state of mind, a constant tension between know-how and a questioning attitude, between confidence and doubt. In design, people plan, analyse, innovate and calculate. In operations, they act, control, correct and protect. In the process of transmission, they train, share, teach and help others to grow. In a crisis situation where it is not sufficient to just adhere to procedures, they know how to adapt and innovate.

This human continuity brings to life the rigour of nuclear safety, the demands of industrial safety and respect for health, which represent the shared foundation and priorities of a responsible industrial operator.

PROFESSIONALISING TEAMS, A CALL FOR SAFETY

I am convinced of the key role of the managers' leadership, the strength of teamwork and skills as the first lines of defence. People are the first nuclear safety line of defence and sometimes the last resort. They



Flamanville 3 EPR

need to be aware of this and prepared for it. It is their responsibility as part of collective performance relying on individual skills.

Leadership is based on professional and human qualities that are recognised and nurtured. Management in the field helps to develop them, because nothing is innate. It is therefore necessary to devote time first and foremost to the essential tasks: knowledge of facilities and people, training, analysis of operating experience, awareness of the operational reality.

Skills are acquired through training, apprenticeships, coaching and practical experience, both in design and operations. It is essential to check qualifications and skills. Leaders must be demanding without being rigid, help people to progress without being complacent, and show managerial courage to assert and reinforce their choices.

Nuclear safety not only depends on procedures, but also on how they are used. It derives from an understanding of the whole, as well as attention to detail and a refusal to trivialise risk. The corollary is that this safety imperative is a source of industrial performance.

I have often quoted Michel Crozier, who wrote *“Professionalise people instead of sophisticating structures and procedures”*, and that is maybe because I was seeing the opposite.

Finally, although the young generations are well versed in the new technologies, their scientific and technical level and mindset must also remain equal to the challenges. To compensate for the shortcomings of the education system, additional training for new recruits is urgently required.

The return of international momentum in favour of atomic energy is reflected in the revival of new nuclear power. The enthusiasm it generates is a key driver of attractiveness, but faces the Group with the challenge to recruit on a massive scale while ensuring a high level of skills. In addition, the digital transformation and performance plans must be careful not to dehumanise the work, at the risk of undermining safety. We need to make sure that new ways of organising work, which do not favour friction of ideas, and the new digital tools and

AI capabilities, do not undermine what remains custom practice. Opportunities to pass on knowledge, in particular discussions with experts, must be preserved.

KEEPING MAN AT THE HEART OF SAFETY

In the design phase, human intelligence combines science, technology and responsibility. People not only create safe machines, they also anticipate technical contingencies or natural hazards and possible errors. The aim of each plan, each diagram and each calculation must be to provide protection, to demonstrate today and, above all, to facilitate the task of those who will be building and operating tomorrow. Engineers must design systems that are easy to operate, reliable and robust, and designed with margins in mind, while guaranteeing the health and safety of the personnel implementing them. Rigour is not limited to compliance: every design decision has an impact on the future. Designers must integrate, i.e. be aware of, the human dimension, the people who will be working on site and those who will be living nearby, in the long term.

In operations, nuclear safety becomes a living, shared behaviour. People are simultaneously the sensors, interpreters and correctors of the industrial system. They are the guardians of a daily life where every action counts, every decision can make a difference. An observation shared with Edgar Morin, for whom *“man is both man’s greatest danger and man’s best protection”*. Every operator, technician and engineer knows that their rigour is the first line of defence against incidents. Safety is no longer just a set of rules, but a way of working.

Independent nuclear safety oversight (INSO) acts as a watchdog, assisting management and supporting the imperative that design, construction and operation choices never infringe on safety. To be in a position to inform decisions, the role of managers is to ensure that independent nuclear safety oversight is given the adequate role, access to all information, and serenity. The final decision always rests with the manager, provided that the challenging debate occurred.

Lastly, health and environmental protection are not incidental: they form the foundation for nuclear power's social legitimacy. Radiation protection, ergonomics and worksite industrial safety are all tangible proof that people and their lives are at the heart of all our decisions.

ANTICIPATING AND ADAPTING WITHOUT REGRESSING

Recognition of the central role of nuclear power in de-carbonisation policies comes with a warning: the revival is no excuse for complacency on the part of either long-standing operators or newcomers. Improvements in production and industrial control do not overshadow the emerging challenges: energy transition, controllability in a more intermittent mix, operating lifetime extension and renewal of the existing fleet, climate change adaptation and waste management. I also call for vigilance with respect to technical phenomena (stress corrosion cracking is a reminder to remain humble).

In the previous report, I could have devoted a chapter to the new collective challenges: climate change, re-industrialisation, securing of national supply chains, economic and political instabilities, health and safety risks. They will undoubtedly disrupt our societies. However, I decided to devote it to the organisational and human challenges over which we have control: generational and organisational mismatches, complexity, performance of design and engineering, the role of digital technology and artificial intelligence, and the commitment of individuals and teams.

Despite its valuable expertise, EDF's integrated organisation can also create complexity and slowness. For each field there must be a legitimate person in charge who is clearly identified and able to make decisions. In design and construction, a strong technical authority and contracting authority, as well as a project management team with a clearly defined scope of work, are crucial to underpin future programme successes. In operation, global project management in maintenance (long term plan, outage, on-line) is featuring results. The keys to efficiency, savings and safety are to better integrate engineering and operations, share best practices between peers and capitalise on

synergies between fleets, work more closely with industrial partners and optimise operating experience.

Professional mobility must be organised and discipline silos avoided. In particular, the operations sector, with its experience and skills in the field, needs to feed into the training, nuclear safety and engineering.

CONTINUOUS IMPROVEMENT: TARGET INVESTMENTS

The creation in 2025 of the French Nuclear Safety and Radiation Protection Authority (ASNR) is an opportunity to improve the technical dialogue between regulator and operator, without antagonism or complacency.

Pressurised water reactors have demonstrated their robustness and reliability, making it possible to consider operating lives of more than 60 years. Experience, probabilistic studies, lessons from major accidents (e.g. Three Mile Island, Chernobyl, Davis Besse, and Fukushima Daiichi) and R&D have gradually shaped an integrated and evolving nuclear safety philosophy. These lessons learnt have led to improvements in the design of Generation II reactors and the definition of Generation III+ standards, embodied by the EPR and then the EPR2, which must comply with what is just necessary.

The 4th ten-yearly outage programmes for 900 MWe reactors (VD4) mark a major overhaul incorporating the lessons learnt from Fukushima and new safeguards against natural hazards, loss of power sources and severe accidents. These changes, extended to other plant series, will robustly reinforce defence in depth, making major new design changes superfluous unless something new occurs. Future nuclear safety reviews will therefore mainly focus on compliance, ageing and the effects of climate change. Addressing obsolescence and long-term maintenance will both play a key role. Faced with increasingly complex systems, the strategy is now focusing on stabilising facilities, simplifying the Operating Standards (RGE) and improving operating quality. The aim is to shift the balance from 'regulated safety' (prescriptive) to 'managed safety' (empowered).

Building identical EPR2s in series is an essential lever for industrial control and quality, and therefore safety. This means stabilising the reference standards and allowing for design margins. Safety management must remain proportionate to the risks, based on graded approach and on weighing up the stakes in order to optimise resource allocation. Nuclear Safety is priceless but comes at a cost. We must therefore make targeted and proportionate investments in the right proportions, re-learn how to weigh up the gains and assume the inevitable share of risk. What is just necessary may not be enough, but the maximum could add complexity and extra costs without significantly improving safety.

Stopping modifying, continuing to protect the existing assets, maintaining and operating to high standards, do not weaken the ambition for continuous improvement which is central to nuclear safety principles. Although this ambition is beneficial in that it requires us to take account of operating experience, it also generates continuous changes in requirements, sometimes with low associated benefits, which can mean the improvement loses its original purpose.

“Simplicity is the ultimate sophistication” (Leonardo Da Vinci). Nuclear safety requires financial, technical and temporal margins in order to prevent economic, ecological or energy pressures from compromising the rigour of our decisions.

NUCLEAR SAFETY: ETHICS

Nuclear safety relies on the quality of the men and women who act, transmit and monitor. No procedure, no matter how perfect it is, can replace an attentive eye, a listening ear, an expert hand, a sharp mind and above all awareness of individual and collective responsibility.

Ultimately, nuclear safety is not just the art of avoiding incidents. It is like ethics in motion, a fragile balance between ambition and prudence, between momentum and moderation. It ensures that despite the risks, man remains equal to the power he has created.

“Perfection is achieved, not when there is nothing more to add, but when there is nothing left to remove” (Antoine de Saint-Exupéry).



The Admiralty at IGSNR



Golfech power station



MANAGEMENT OF NUCLEAR SAFETY

Nuclear safety is the result of continuous learning built up as experience is acquired.

This legacy, which is taken into account in the technical and engineering development of our facilities, also requires the firm integration of lessons learnt from major nuclear industry events into our organisations, our working practices and the culture of our teams.

Nuclear safety is built every day, through our high standards, our capacity to challenge ourselves and our determination to deal with problems before they become significant. It relies on the positioning of leaders, individual responsibility and collective strength.

It is based on a shared conviction of its overriding priority in the quest for performance.

Overall, 2025 saw a gradual improvement in the main safety indicators, with the exception of automatic reactor trips, which remain a challenge for both fleets. The number of technical specification non-compliances is increasing compared to 2024 while remaining below the set target, the number of reactivity management events has halved and fortunately, fire outbreaks, a major industrial risk, remain rare. These results have been obtained in a context marked by a continuing high industrial workload and, in France, by a numerous modulations imposed on the operator. They should be considered with humility.

In some cases, the operator only realised late that the balance between nuclear safety and performance could be jeopardised. In addition, certain events challenged lines of defence, in particular: total loss of Hartlepool's external power supplies, challenge to heat sink, in particular the massive ingress of algae at Chinon (*see Chapter 5*), and unavailability of backup equipment due to non-compliance with fundamentals.

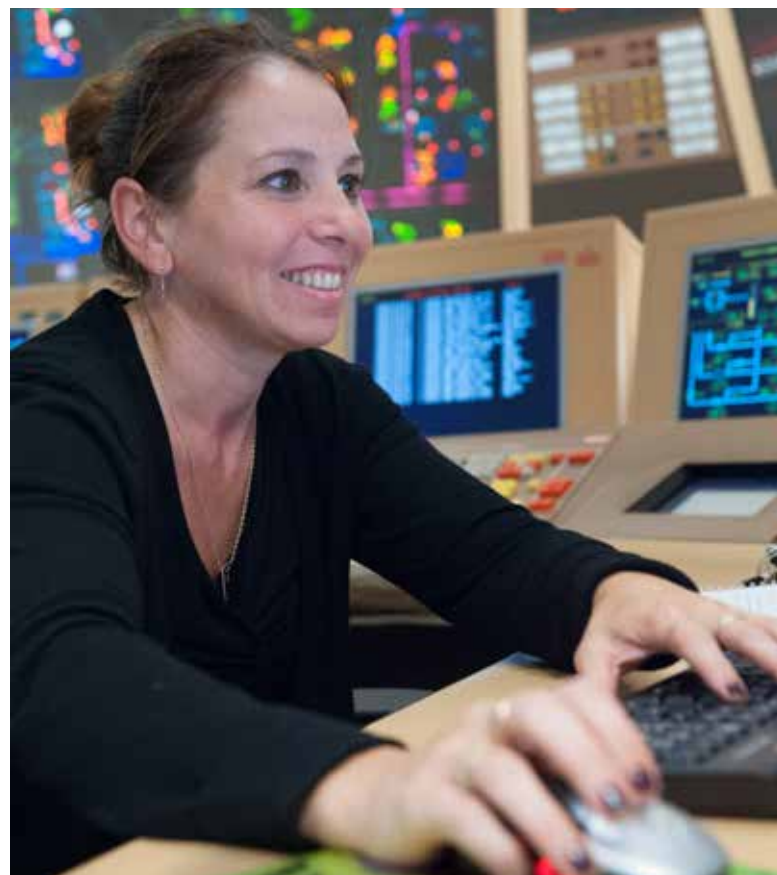
SAFETY EVENTS: WHAT DO THEY TELL ABOUT PRACTICES?

LATE DETECTION: STRENGTHENING ROOT CAUSE ANALYSIS

Late detection of a safety event is of particular importance to me. Ruthless fact, an operator can continue to operate for some time without realising that equipment is unavailable. There may be several reasons for this but I suggest operators should take a closer look at these reasons and tackle them with the necessary focus on detail.

Paying close attention to the quality of troubleshooting in the event of equipment faults. A station measured abnormal temperatures on two emergency diesel generator cylinders for six months and believed that the issue came from instrumentation, whereas in fact the injectors were deficient and therefore the diesel generator unavailable. Although these errors remain rare, I am still dissatisfied with the quality of the lessons learnt and regret that important aspects related to skills and decision-making process were not examined in greater detail.

On a regular basis complete diagnoses are not conducted because it would require to intentionally make the equipment unavailable.



Civaux – Control room operator

According to the technical specifications, if this is done and the equipment failure ultimately not confirmed, a sanction is applied: a significant, and potentially classified, event must be reported. It is probably necessary to review how the general operating rules are drawn up and applied in this area.

Vigilance is required regarding human errors not detected during activities. In the 2024 report I mentioned the mistake made by a field operator, who before carrying out maintenance work, isolated a cooling pump on the reactor at power instead of the reactor in outage. The mistake was only detected a week later, when a test was performed. In 2025, three similar mistakes occurred. In the light of these events, applying human performance tools is not sufficient and cannot replace a questioning attitude. I also suggest considering additional countermeasures (e.g. cordoning and fool-proof safeguards, etc.).

Finally, we must be vigilant about the relevance of post-maintenance testing. This line of defence is occasionally weakened, to the extent that a function is considered available when in reality it is not.

PREVENTING AUTOMATIC REACTOR TRIPS: A CHALLENGE TO ACHIEVE EXCELLENCE

The number of automatic reactor trips is a measure of excellence in nuclear safety. This automatic trip protects the reactor (the control rods fall, immediately stopping the chain reaction), but too often it occurs due to a problem with technical or organisational reliability, and human performance. Automatic reactor trips, beyond their safety function, must be analysed because they are insightful.

As in previous years, the Human and Organisational Factor (HOF) is still the main cause. I reiterate my recommendation to change from seeing human performance as a “tool”, and to instead focus in more detail on work situations. I would also remind you that it is important for managers to demonstrate leadership by getting involved in skills development, more specifically in training (e.g. rehearsing the planned and preparing for the unexpected). Control of automatic reactor trips is an indicator of excellence in nuclear professionalism.

The technical causes are instructive. In France I observe the quality of the analysis and the relevance of the identified technical actions, but also the weaknesses in implementing and perpetuating them in the long-term (*see 2022 report*). We cannot be satisfied if clearly identified causes keep causing the same incidents. Nevertheless, the presence of cables outside their cable route close to hot parts, or the poor quality of connectors, continue to cause automatic reactor trips.

The “SPV” approach for equipment at risk of an automatic RT

Worldwide nuclear operators who obtain satisfactory automatic reactor trip results implement the SPV (Single Point Vulnerability) management method on the whole of the facility. The aim is to eliminate single point vulnerabilities, or at least mitigate their risk. This approach was adopted several years ago in the United Kingdom, and has just been re-introduced by the DPN for the automatic RT risk. This implementation of systematic re-examination will undoubtedly lead to better understanding and mitigation of this risk.

COMMUNICATION IN THE CONTROL ROOM!

Monitoring in the control room is one of the major operations reference standards. Early in 2025 the DPN updated it following discussions about the “ideal control room” as part of the START 2025 programme. The changes included guaranteeing technical condition beyond reasonable doubt and strengthening requirements for control room serenity.

I support this approach but it must be backed up by a more detailed consideration of communication and teamwork in the control room. British operators acknowledge alarms by speaking out loud, and the supervisor collates the information. In France, there is still some reluctance to do this. However more explicit conversations in the control room would have made it possible to avoid events that still occurred in 2025. I encourage everyone to drop the cultural

specificities argument and accelerate implementation of international best practices.

REACTIVITY MANAGEMENT, REMAINING VIGILANT EVEN WHEN THE CORE IS SUB-CRITICAL

Many efforts have been devoted to reactivity management over recent years. They usually focus on optimising reliability of activities when the core is critical. We should remain humble because events are still occurring.

We must not underestimate the risks from activities performed during outages either. What is at stake here is to prevent at any cost the formation of a pocket of clear or cold water (in the reactor coolant system or a connected system) that could cause sudden reactivity surge when pumps restart. Post-Chernobyl studies have shown that a reactivity excursion can occur when putting a previously isolated system into operation, or when re-establishing forced circulation of the reactor coolant system. The DPN has compiled a managerial reference standard which must be strictly followed. Along with the operations department, any discipline, including maintenance, can have a direct impact on reactivity management.



Hartlepool – Round in the turbine hall

REMAINING UNCOMPROMISING ABOUT FUNDAMENTALS

In 2025 several events revealed weaknesses in the implementation of fundamental rules adopted over decades of nuclear fleet operation worldwide: reactor mode changes, prevention of common mode failures, management of temporary design modifications. Although these events did not have any consequence, they are all warning signs. Incidents remembered by nuclear pioneers become part of the past, and fade in people's memories. Risk is caused by an erosion of practices, where new generations have inherited the rules but perhaps not their purpose.

It is vital for everyone to be imbued with the fundamentals with conviction. The booklet of nuclear safety events published early 2024 must be used. Another important text to read, still relevant, is the report by Bernard Noc (19 September 1989) following the incidents that occurred in the summer of 1989 at Gravelines and Dampierre. This landmark report made maintenance staff aware of their responsibility for nuclear safety. It was a key turning point. This

led to the creation of the outage safety committee (COMSAT), led by the station senior management, and was responsible for ensuring compliance with nuclear safety requirements during outage and start-up, preparing reactor changes mode. It also led to the introduction of directive 74, requiring any temporary design modification to be the subject of physical and documentary management.

Forgetting a blind flange on an auxiliary pump during maintenance

During the ten-yearly outage of a reactor, maintenance work was carried out on the auxiliary feedwater pump. During reassembly, a misalignment was observed between the pump suction flange and the manifold flange. This meant the piping had to be realigned by cutting and welding. When the section was reassembled, a blind flange was placed on the suction flange to protect the pump. This action was not indicated in the operating documents. The blind flange was then not removed. This omission was only detected at post-maintenance testing. The pump remained unavailable for more than 18 days.

NUCLEAR SAFETY AND PERFORMANCE, ENSURING THE RIGHT BALANCE

NUCLEAR SAFETY, ARE WE REALLY UNDERSTANDING IT?

Each station makes the effort to draw up an annual nuclear safety diagnoses (DAS), but I often remain doubtful about the completeness of the analyses, and about how it is shared at the plant. When I visit stations, I indeed observe that some important aspects are not included in the summaries.

Too much time is spent analysing the major nuclear safety indicators and associated processes, in other words “the machinery of nuclear safety”. On the other hand, not enough time is devoted to a detailed understanding of the dynamics of the disciplines, in particular maintenance. For example, a team of instrumentation and control experts that sees many experienced lead workers leaving simultaneously may find itself going through a difficult period. This

will have more negative impact on the automatic RT or reactivity management indicator than the positive impact achieved by dedicated action plans. In addition, the DAS documents analyse the past and do not look towards the future.

To move away from this engineering rationale, the “trajectory” tool created by INPO (Institute of Nuclear Power Operations) and widely disseminated by WANO (World Association of Nuclear Operators), would be worth implementing because it leads to examining three factors: organisational effectiveness, succession planning and proficiency, and workload.

In this context, the feedback given by the EDF Nuclear Inspectorate (IN) and WANO at the *Combined Peer Reviews* is very valuable. It is useful to start from the field to assess the performance of disciplines, but I have seen how difficult it is to fully take on board the messages received, in particular in terms of leadership. Yet, without this acceptance phase, it is difficult to implement change.

NUCLEAR LEADERS, A DEMANDING POSITION THAT REQUIRES WORK

During my visits, I have seen some good and less good things in terms of nuclear safety leadership.

I have seen leaders demonstrating leadership by fostering close relations, while remaining demanding. Managers in the field, starting with the station director, is the best way to achieve this. Employees say they appreciate bosses capable of making decisions, demonstrating a pragmatic and effective approach to technical subjects thanks to their understanding of the field and the working conditions for each discipline.

On the other hand, some executives find it hard to “speak the truth” and say what has to be said, especially when it involves a clearly identified person. Is this because they are afraid to challenge an individual’s competence, to be suspected of being unfair, or due to lack of managerial courage? Keeping things vague, when everyone knows the truth, leaves an unpleasant feeling in the team: “*here, when one*

person is ill, everyone gets the same remedy”. In addition, despite some progress, some managers struggle when tackling the problem of skills, and some succession plans are still in difficulty. Finally, listening to the field is laudable, but not using the message is counter-productive.

Faced with the lack of managerial vocation, which I have observed on all plants during my visits, I believe it is vital to restore the desire to take on this demanding but rewarding responsibility. The future of our industry depends on it. Selecting managers based on external assessments will not help to reverse this trend. Our nuclear power plants are marvellous places of learning, where each person, faced with the machine, together with their colleagues, exchanges ideas, learns and grows. There are thousand opportunities to observe, select, test in the field, encourage and guide future leaders.

NUCLEAR SAFETY CULTURE: A NEED FOR CLARITY AND EMBODIMENT

WANO suggests the first attribute of a leader is “to establish a vision of excellence that gives priority to safety”. This may seem obvious, but in a context where there is a legitimate quest for performance, consistency is particularly important between ambition, what is said and the way it is embodied and understood in the field.

There is a need for commitment, but it must remain reasonable; a need for effectiveness, but not to the detriment of a rigorous and cautious approach; a quest for performance, but without trying to break any record. In a system that is complex by nature, nuclear professionals are faced with imperatives that may seem contradictory. It is sometimes tempting to cut corners, to consider that “since it’s not prohibited, it’s allowed” or to adapt the rules without weighing up the risks. Experience shows that a strong nuclear safety culture at every level is the best line of defence.

As human and organisational factor specialists explain, “*what determines a culture is not messages or rules: it is the shared experience of repeated and convergent practices*”.

(F. Daniellou in: “Human and organisational factors in industrial safety, a state of the art”.)

So nuclear safety culture depends above all on its embodiment by senior management and supervisors: exemplary behaviour, consistent messages and actions, priority given to safety when arbitrating, etc.

To disseminate a safety culture requires strong interaction between the central organisations and the stations: the former set the principles, while the latter describe and integrate the reality and paradoxes experienced in the field. The definition given by the DPN director of balanced performance aiming to generate power safely is clear, and everyone must strive to implement it: *“Aiming for sustainable performance is the opposite of trying to break records [...] only replicable performance can be improved step by step.”*

INSO, OPERATIONS AND TRAINING: TOGETHER!

VISIBLE PROGRESS AT POWER STATIONS

Although the realities of Independent Nuclear Safety Oversight (INSO) may vary from one nuclear power plant to another, I can see a positive overall trend. Among the areas of progress, I note a widening of INSO's scope, gradually opening up from systematic pinpoint focus to a wider perspective. Similarly, succession planning is improving, with better staffed and more balanced teams. Lastly, a national expertise group is working closely with individuals providing coaching. There is still work to do: the teams still need support, and INSO still needs feedback. In this area, in addition to the Senior Adviser for Safety and Quality, close interaction with station directors and directors of work management structures is essential. Further, close cooperation between the Shift Manager and Safety Engineer collective bodies must be maintained in



Hinkley Point B – Operations round

order to share what needs to be said outside real time, listen to each other, and clarify.

ENGINEERING INSO - A WORK IN PROGRESS

I have more reservations about the maturity of certain engineering INSOs. Although they are playing their part in disseminating nuclear safety culture, they are still too restricted to checking safety-related activities or the deliverables quality. In certain engineering entities, the very existence of INSO is called into question, even though it is prescribed by requirement 6 of the Group's nuclear safety policy. I deduce from this that their added value is not always recognised. Perhaps their positioning

should be examined? In particular, we need to agree on their scope and their role in drafting technical decisions. This consideration cannot be separated from the one on the technical authority.

OPERATIONS, WORKING AS A TEAM

Operations is a team sport. Reality shows this is not always put into practice. The Shift Manager is very busy, and needs a technical Deputy Shift Manager to protect the plant and a Tagging Supervisor to act as a reference point for field operators. Operators must submit detailed nuclear safety analyses to the Shift Manager. Field operators must not limit themselves to being a mere operative, which is incompatible with



Nogent-sur-Seine – Activity in the turbine hall

genuine accountability based on proficiency and trust; the former has to be worked on, the latter has to be earned. If a team is unable to pull everyone up, then levelling down will take place. So, let's all be demanding at our own level so that we can perform better as a team! That's the role of leaders, it's the strength of the team.

TRAINING: OPERATIONS AND THE LOCAL TRAINING DEPARTMENT (UFPI) JOINING FORCES

I note with satisfaction the efforts made to improve training for field operators. The subject matter experts to coach them in their initial training are becoming more numerous. They provide a link with the reality of the plant, covering non-routine actions and the new equipment deployed in the ten-yearly outages.

The deployment of Saturne simulators (reduced digital simulator) is facilitating just-in-time training. Skills transfers by control room panel experts, former operators or seconded Deputy Shift Managers

are being developed. I heard encouraging signs of the increasing involvement of Shift Managers in training their team members. I appreciate the fact that the heads of the joint training departments are stepping up their collaboration with operation department heads, particularly for assessing behaviours and practices. It seems to me that instructors observing shift teams in the control room should become standard practice. This gives young trainers an insight into the real conditions in which operations teams work, particularly the time factor, and enables the shift team to benefit from an external point of view.

I remain cautious about old demons persistence: issuing exceptions, not always making use of the training progress sheets, delaying the generalisation of “jour J de reprise de quart”. Training is an opportunity the company is investing in. Everyone should be aware of this.

RECOMMENDATIONS

Late detections reveal various weaknesses affecting the lines of defence. In view of the safety issues associated with late detections, and in order to avoid any recurrence, I recommend that the Directors of the Nuclear Operations and the DPN systematically analyse the technical, organisational and human root causes and draw all lessons from them.

Given the varying maturity of the independent nuclear safety oversight function (INSO, INA - *Independent Nuclear Assurance*) in the Group's engineering centres and projects, and sometimes the difficulty they have in building a strong identity, I recommend that the Directors of the DirIN and the DPPI propose a model that takes account of their operating experience and organisational changes.



Dungeness B power station



BUILDING AN INDUSTRIAL SAFETY AND RADIATION PROTECTION CULTURE ON A DAILY BASIS

An industrial safety and radiation protection culture cannot be decreed; it has to be built up and put to the test on a daily basis through words and deeds.

As soon as he arrived, Bernard Fontana asserted that “nuclear safety, industrial safety and the health of our people are our number one priority, our licence to lead”. This commitment forces us to ask ourselves this question, individually and collectively: as nuclear professionals, are we doing everything necessary to strengthen industrial safety and health?

Activities in the nuclear industry are characterised by exposure to ionising radiation and a risk of contamination. Radiation protection measures allow to protect workers.

INDUSTRIAL SAFETY CULTURE: A LONG JOURNEY

Overall, the EDF Group's safety results have stagnated in 2025, with a Lost Time Incident Rate (LTIR) at the target level of 1.6 and I note major disparities between Framatome, EDF Energy (LTIR of 0.5 and 0.4) and the DPN (LTIR of 2.2). I note that the industrial safety culture is not embodied with the same intensity everywhere. Overall, we regret two lost-time incidents per day in the Group. By 2032, the aim is to achieve an LTIR of less than 0.5, putting us on a par with the best companies.

IN FRANCE, EVENTS KEEP OCCURRING...

Despite regular awareness-raising campaigns, including 'la vie d'abord' at our plants, industrial safety events continue to occur: falls from height, near electrification, falling loads, and hand injuries.

Workers know the rules but sometimes choose to disregard them. The presence of managers in the field is essential, but it will not be sufficient to prevent all behavioural shortfalls. Many different causes are mentioned: focusing solely on the task outcome, time pressure, under-estimating or accepting risks. Safety stand-downs are still rarely used, and the "Just culture" is limited to managerial handling of deviations.

Shared vigilance, placing a collective approach at the heart of the system, remains insufficiently embedded. I have observed it myself: a comment, even a kind one, is perceived as a challenge, or even an attack on individual freedom.

Industrial safety compliance remains an area of concern. While the DPN launched initiatives over the last few years concerning lifting accessories and collective protection (e.g. handrails, cordoning, etc.),



Hinkley Point B – Round in the turbine hall

each site must periodically check, secure worksites and address deviations.

The priority set by the station director is the main lever to drive an industrial safety culture.

... YET THERE ARE SOME INSPIRING EXAMPLES

I have observed that through their involvement, certain groups, especially department heads, succeed in promoting industrial safety more effectively. This is the case for the joint teams in charge of plant modifications. Here are some of the success factors: weekly sharing of industrial safety events and near-misses, credible industrial safety

engineers, work supervisors accountable for field monitoring, and integration of industrial partners.

Innovative communication deserves to be encouraged, such as the one I saw at Tours at the national equipment and electricity generation centre (CNEPE).

At some plants, the Industrial Safety Leaders approach aims to reconcile prescribed and effective work. Spread over several years, bringing together EDF employees and partners, it provides a genuine acculturation programme for leaders.

POSITIVE SIGNS IN THE UNITED KINGDOM...

After a difficult year in 2024, performance has returned to its historically high level. The in-depth approach combining management in the field and resumption of industrial safety training is showing its first positive effects. Shared vigilance, historically well established in the British fleet but recently on the wane, is once again visible in the field.

Got Your Back

This initiative, launched in 2022 by Heysham 1 to develop a collective culture of shared vigilance, encourages staff and partners to:

- speak out when they see dangerous behaviours or deviations from procedures;
- look out for each other, whatever the hierarchical level or age;
- promote mutual responsibility for industrial safety.

It uses various communication channels, behavioural reinforcement methods and discussions in the field about industrial safety events.

It has been replicated and customised by several other plants.

The collaboration between workers and industrial safety champions is improving, encouraging safety stand-downs.

The involvement of industrial partners remains strong, in particular thanks to dynamic learning processes and compulsory training in

rules and standards. The integrated industrial safety field teams bring together EDF employees and partners.

The aim of the *Key Risk Tool* approach is to guarantee plants are compliant from an industrial safety standpoint.

... AND CHALLENGES REMAIN

The industrial safety events that occurred in 2025 in the British fleet remind us to remain humble and fully committed to achieving zero accident. Among the main causes, workers do not perceive their activity as showing an industrial safety risk. Normalising and accepting long-standing deviations (e.g. extended unavailability of a goods lift) lead to dodging strategies and risk-taking. Another major factor is the 'rationalisation' of risk in activities considered as low key. In addition, the quality of risk assessments and their implementation can still be improved.

STOP HAND INJURIES!

Since 2024, we have seen an increase in the number of hand accidents. Although they are not vital rules, they should not be trivialised. The physical damage from trapped, crushed, caught, and severed hands (followed or not by amputation of phalanges) is often severe. Both fleets have started to tackle the issue.

TAKING ACTION WITH MAINTENANCE

In France, the head of the DPN decided in early 2025 to bring together maintenance technicians and prevention experts to deal with root causes. Almost half of all accidents occur when using portable machines, the other half is divided between machine tools and rotating machines. Nuclear professionals had to be reminded of the precautionary measures and best practices. It is prohibited to

insert your hand or a tool into a part of a machine or to dismantle the protective covers on a piece of equipment. Attention must be paid to neutralising the residual energy, which is too often underestimated (spring-loaded system, unstable load during dismantling of kinematic components, etc.).

In the United Kingdom, Nuclear Operations has decided to replace certain high-risk tools with safer alternatives and to check compliance of the tools used. Despite these measures, one worker suffered a hand injury during a grinding.

TAGGING, EVERYBODY'S BUSINESS

A TRUE CHAIN OF RESPONSIBILITY

Although tagging is a key process to guarantee the safety of equipment and workers, the job of tagging officer has low visibility. Yet a mistake in the preparation or implementation of an isolation permit can expose workers to major risks. Although there are very few errors given the thousands of activities, the 2025 operating experience strongly indicates that fundamentals in this field are not fully acquired.

The updated staff rule book (RPP) points out the fundamental principles, presented in the form of dos and don'ts. Each participant in the chain must assume their responsibilities: the work planner who links the activity to the right maintenance slot; the discipline's work supervisor who requests the isolation permit and describes the conditions for the activity; the tagging officer who converts the request into a work permit; the operations representative who gives their authorisation after the final check; the operations technician who applies the permit and carries out the tagging; and the lead worker who carries out their preliminary checks.

OPERATIONS: DEVELOPING SKILLS IN THE FIELD

While the tagging officer's theoretical training covers the essential points, coaching with the Senior Authorised Person (SAP) in the United Kingdom (DSE Délégué Sécurité Exploitation in France) and observation of non-routine actions build up proficiency (e.g. 400 kV disconnection, power resupplies, etc.). This development of skills requires genuine anticipation of the career paths to facilitate the acquisition of practical experience in the field. In France, the recent changes in career paths (possibility to become a Deputy Shift Manager, or even a Shift Manager, without previously working as an Operations Tagging Supervisor and SAP) do not facilitate this learning process. I think it is important for certain plant senior management teams and the expertise group to reconsider this issue.

In the United Kingdom, tagging resources are under pressure due to the influx of new recruits and restricting SAPs to executing tasks to the detriment of their supervisory role. The tagging skills in the operations department are also lacking within work management structures (new equipment or modifications).

TRAINING MAINTENANCE STAFF

Maintenance work supervisors and contract partners are not sufficiently trained in tagging, often resulting in incomplete work permit requests, which are compensated by the tagging officers. Working groups bringing together operations and other disciplines share operating experience and develop improvement plans.

IN FRANCE, DIGITISATION AND DEMATERIALISATION TO SUPPORT DISCIPLINES

Thanks to the impetus of the CoLiMo project, the tagging domain has transitioned from the paper age to the digital age, giving all workers in the field an effective information system close to the best standards, and allowing industrialisation of work permit requests. I encourage Nuclear Operations to be inspired by this at Sizewell B.

Despite these remarkable efforts, I observe that even now computer databases are sometimes incomplete and diagrams are not always up to date. Because of these problems, tagging officers have to carry

out additional searches, creating a risk of error. It is essential for each plant to verify its situation in this regard and set up corrective actions.

RADIATION PROTECTION, MEETING INTERNATIONAL STANDARDS

Activation of the reactor vessel internals and of impurities contained in the reactor coolant contributes to the source term of the reactors. The reactor coolant system structures are covered with a protective layer of oxide which releases some of these corrosion products. These products account for over 90% of radiation exposure.

The most penalising isotopes are those of cobalt (58 and 60) and, in a few specific cases, silver 110 and antimony 124.

In the French fleet in operation, collective radiation exposure remains stable, without any notable improvement. Individual radiation exposure is well under control and well below regulatory limits (20 mSv). Only 0.1% of nuclear power plant workers register an individual dose greater than 10 mSv. Access to work areas with high dose rates was controlled more effectively in 2025 than in 2024, and the number of significant events reported is going down. The RCDN nuclear culture refresher training includes a section on radiation protection. Assessments have been reinforced with pre-requisites that must be validated and an individual assessment at the end of the course.

By design, the collective radiation exposure in the United Kingdom's AGR reactors is roughly 20 times lower than in PWRs. Radiation exposure in these AGRs is optimised. Verification and elimination of hot spots must continue.

SENSITIVE PROCESSES ARE UNDER CONTROL BUT COULD BE IMPROVED

For gamma radiography inspections, the number of events in the French fleet is three, the same as in 2024. The training of technicians who handle industrial radiography equipment has been reinforced to raise their awareness about the importance of verifying no personnel



Golftech - Everest station, radiabox at entrance to the reactor building



Cattenom - RCA work in ventilated airtight suit

are present after cordoning has been put in place, about the risks of unplanned entry via temporary means (e.g. scaffolding), and about degraded cordons preventing access to gamma inspection areas.

For red zones, no deviation has been reported for nearly two years. Classification practices are standardised in all facilities. The key to controlling access lies in the preparation of the activity. In addition, the fleet would like to switch from paper-based to digital access form. The level of rigour will have to be maintained, in particular with regard to the following:

- justification for the work;
- quality of pre-job briefing and raising worker awareness about the specific risks of the activity;
- control of employer authorisations.

Weak signals indicating a deterioration in lock-out equipment need to be addressed at certain plants and in certain areas.

Contamination spread during resin transfer

450 litres of active resins from the chemical and volume control system were spilt on the ground when a valve was removed. Several rooms were contaminated, including one classified as a red zone due to a dose rate of 120 mSv/h at 50 cm from the most radioactive point, and several others classified as orange zones. Bringing the facilities fully back into compliance required the use of robotised equipment by a specialised company (GIE INTRA). The station also had to decontaminate a sump with a mobile filtration unit. This event reminds us of the need for rigorous preparation and risk assessment prior to any safety-related activity.

For access to orange zones, we need to improve in standardising practices. The difference in criteria between plants can lead to as many rooms being classified on a single reactor as on four others. Difficulties are sometimes encountered to bring cordoning back into compliance after the work has been completed. Initiatives should be deployed to make them more robust, e.g. three-dimensional signage with floor markings, or even swing doors. I would also recommend reducing the number of orange zones by reducing the number of hot spots.

MANAGING THE SOURCE TERM

I am pleased to report that the fleet has committed to reducing source terms. The opening of a fleet project at the end of 2025 makes it possible to structure our approach and to consider source term optimisation as a long-term investment: it concerns collective and individual radiation exposure over the long-term, and will require

financing. A Source Term community of practice was set up in 2025 as a means of stimulating the disciplines, sharing knowledge and best practices on a subject that requires expertise from both radiation protection specialists and chemists. To manage the source term requires to understand its origin. This knowledge is obtained through spectrometry, gamma cameras and installation of spectrometers in strategic locations.

The impact of the source term for the units is considered over the long term, and has its origins in the history of steam generators (Nickel 58 content). Reactors with the highest source term must undergo a specific clean-up programme.

The fleet has launched a five-year programme of clean-ups and use of CADOR. This code is a decision support tool and proposes scenarios for installing biological protection to optimise radiation exposure during outages. Clean-ups are performed on three reactors each year. In my opinion, this multi-year programming should also address hot spots. The fleet is also analysing the feasibility of FSD (full system decontamination). Specific silver 110 pollution requires appropriate treatment, managed at corporate level.

Cold shutdown of the reactor and purification of the reactor coolant system drive the source term and must be better controlled. Understanding of the phenomena, definition of the strategy and monitoring of purification activities must be more focused on reaching a dose rate target on the sole radiochemical criteria for shutting down the reactor coolant pumps. Outage cold shutdown strategies need to be adapted, as new steam generators benefit from good passivation. Professionalising and maintaining the skills of the radiation protection specialists and chemists in charge of the shutdown strategy are key to success.

In the United Kingdom, the Sizewell B PWR applies the Electric Power Research Institute (EPRI) recommendations. The source term is stable over time. The plant benefits from favourable conditions with good passivation of the reactor coolant system and few stellites (cobalt/chrome alloy) in its equipment.

Zinc injection is expected to produce significant dosimetry benefits. The plant is upgrading its biological protection and uses T-Flex. I would encourage the DPN and Nuclear Operations to share their dosimetry optimisation practices.

EXPECTATIONS AND RIGOUR TO PREVENT INDIVIDUAL CONTAMINATION

Controlling the risk of bodily contamination is a matter of individual behaviour. Never underestimate the potential risk in the controlled area, be careful with every movement you make, strictly observe the required protective measures and the worksite exit checks (5-point checks).

Worksite containment is progressing with new types of tents, and plants need to secure their investment budget for this. More than 2000 logistics services partners (Contracted Services) have been trained in the installation of static and dynamic containment tents.

Skin contamination, level 2 Significant Radiation Protection Event

During radiographic inspections of a reactor coolant pipe in the reactor building, an operator had to lie on the floor to insert the radio film. On leaving the controlled area, a contamination was detected on the nape of his neck. The radioactive particle was immediately removed, assessed by the occupational physician and the skin dose was above the regulatory annual limit. The radiological survey of the room did not indicate any contamination. This level 2 significant radiation protection event reminds us that even if a room is not identified as contaminated, isolated radioactive particles may be present and that it is therefore necessary to protect yourself properly and to regularly do the 5-point check.

TRANSPORT, RADIOLOGICAL ISSUES AND NUCLEAR SAFETY

The number of events involving class 7 external transport (radioactive hazardous materials) decreased in 2025. The deviations mainly concern labelling and documentation.

I note that 3 contamination deviations were reported in 2025 during spent fuel evacuations, showing improvement compared to 2024. The time spent fuel casks in the CP0, P'4 and N4 plant series reactors are held in a vertical position must be limited for nuclear safety reasons. The related sites have been working on improving the reliability of equipment for handling and tipping into the horizontal position.

Fuel is removed using TN12 and 13 casks, the validity of which is limited by transport approvals and authorisations. Following changes to the IAEA's transport regulations in 2018, a new cask has been developed with Orano. The main changes concern a double nuclear safety line of defence on each aperture and consideration of the impact of assemblies on the plug in the event of a shock. Commissioning is scheduled for 2026.

The vast majority of internal transport movements take place using ADR containers. The fleet has worked with the plants to improve the containment and nature of the packaging for oversized packages as well as packages for waste shells. The conditions for internal transport of unfilled waste shells have been clarified with the regulator. For oversized packages, multi-year investments need to be planned.



Nuclear Fuel Division – Work supervisors

RECOMMENDATION

In order to reduce the source term, I recommend to the Director of the DPN that the cold shutdown strategies at the start of the outage be made more stringent and adapted to the specific features of each reactor.



Sizewell B power station

4

CHAP

EQUIPMENT RELIABILITY, A PILLAR OF NUCLEAR SAFETY

The operator's job relies on the reliability of people, organisations and machines.

Nuclear safety requires reliable equipment, i.e. equipment capable of performing the function for which it was designed.

While both fleets benefit from a solid legacy, we still need to better detect the early signs of failure so that we can intervene more effectively and prepare to extend the operating lifetime of the reactors.

The word reliability may seem intuitive, but when it comes to turning it into a concrete reality, questions remain. How can we make sure that each piece of equipment receives the attention it deserves, particularly when it contributes to nuclear safety? To guarantee availability of the function, what type of maintenance is needed, how often, on which components? How can we detect the early signs of failure? These questions have occupied the nuclear industry since it began and remain at the forefront. At this stage, despite several changes to the maintenance policy, results are still below targets.

BUILDING AN INTEGRATED VISION OF EQUIPMENT HEALTH STATUS

A SOLID FOUNDATION

To retrace the history of approaches to reliability in the nuclear industry would require several books! In France, they come from fossil power plants and in the operating and maintenance guides (GEE) supplied by the manufacturers of the first equipment in the fleet. In the United Kingdom, maintenance programmes are derived from safety cases, translated into maintenance schedules and supplemented over time by routine maintenance.

In France, the equipment-based approach dominated from the beginning, summarised in policies, true bibles written by the experts in the Equipment department. Under the influence of American methods, optimisation of maintenance through reliability calculations (known as “OMF”) was launched in two successive phases. It consists of assessing the probability of failure on the one hand, and its effects on the other, and then combining the two assessments to weigh up the benefits of a maintenance operation. Carried out by the plants and supported by the central departments, by the early 2000s the result was a very solid base of preventive maintenance programmes, a veritable set of the best know-how to look after our machines.

A STRUCTURED ORGANISATION

In the past, several approaches were implemented in row without achieving the desired maturity: condition-based maintenance, maintenance using test devices, reduction of maintenance volumes (RVM), etc. Since both fleets were struggling to find a solution to their chronic availability problems, they turned their attention to an American method: AP913. Based on equipment classification, it associates a preventive maintenance schedule with every potential failure.

In the United Kingdom, Nuclear Operations applies the method strictly. The reliability approach is structured around two cycles for monitoring the basic systems (more than 150 at Sizewell B): long-loop comprehensive system health report (frequency of three to six years), and short-loop system monitoring based on the main reliability indicators (frequency of one to six months). Regular discussions between the engineering manager and the systems engineers make it possible to develop a wider vision on technical threats: repeated work requests or work that is put on hold for too long, accumulated unavailability duration revealing a recurrent weakness or a major problem that needs to be included in the next outage programme.



Cattenom – Reliability for a safe fuel handling operation



Framatome Jeumont
Adjustment of reactor coolant pump hydrodynamic seal

In France, the implementation of AP913 in the early 2010s proved more difficult, requiring adaptation of the initial model and strategy in 2016. Among the problems encountered were the misuse of health reports and generation of a multitude of additional activities out of proportion with the consequences of the relevant failures. Based on this long learning process, the approach was simplified by applying it on a larger scale, namely the functions, of which there are fifteen. Today, each plant reliability committee draws up an annual health report for each function, identifying the main problems and their treatment. At fleet level, a corporate reliability directorate (DPT) brings together the technical directors of the plants and carries out similar work. On the recommendation of the domain managers, it decides

on the major strategies for exceptional maintenance, calling on the support of the engineering centres where necessary. Regarding skills development, the important role of communities of practice, which bring together specialists from sites and engineering entities to share their experience, is to be emphasised.

RATIONALISING THE APPROACH AND CLOSING THE LOOP

Although the French and British approaches to reliability have matured, challenges remain.

First of all, they only seem to produce “more and more”. In their natural propensity to deal with what is not going well, engineers add activities or increase their frequency. They should also analyse what is going well in order to reduce frequencies and identify over-requirements. Optimisation is a question of nuclear safety, as over-maintenance can lead to non-quality. Moreover, the IAEA calls for appropriate maintenance: “*Maintenance optimization helps to ensure that the right tasks are being performed on the right equipment at the right time*”. (SSG 74: Maintenance Testing Surveillance and Inspection in Nuclear Plants).

Secondly, there is still insufficient interaction between those involved in reliability, operations and maintenance. I have met reliability engineers who spend more time in the field and listen better to operations, but there is still a risk they remain too far from the machine and from operators, especially when monitoring is carried out from an office. The link with maintenance also needs to be strengthened. Some plants have begun this process, and the disciplines are more closely involved in preparing reliability committees and drawing up equipment health reports. These health reports encourage the work planners to refocus on analysing the equipment and on making suggestions.

In addition, the value chain for the various functional, health and equipment reports, as well as the associated frequencies, should be re-examined. We need to close the loop and finally implement all the actions resulting from the health reports. It is preferable to define fewer actions but complete them all.

IN FRANCE, MAKING AN EFFORT TO INCREASE VISIBILITY AND SUMMARISE

Despite the investment in health reports, I am still surprised that few sites in France have a simple and comprehensive inventory of the equipment health status, except by consulting numerous documents. The same applies to the fleet as a whole, although the monthly health reports from the domain managers are a major step forward. The lack of an overall summary means that risks cannot be

prioritised and dealt with, and does not give the disciplines and work management structures the visibility they need to organise their work collectively.

I call on local technical departments and central services to be inspired by several initiatives and apply them across the board: mapping the state of systems, an integrated vision of technical risks or a technical threats drill, periodic managerial reviews combining indicators and the conviction of specialists.

BEHAVING LIKE AN OWNER

COMING BACK TO THE MACHINE

Going beyond the issues of process and organisation, I am convinced that good reliability requires clear responsibilities and one overall integrator for each system. In France, this responsibility, meticulously described in organisational notes, is split between the maintenance and engineering disciplines, the shift teams and even the housekeeping team (MEEI). The equipment belongs to everyone to some extent, with a risk of diluting the sense of ownership.

I am calling for maintenance technicians to be brought back to the technical field. They are so busy implementing prescriptions, updating the SDIN nuclear information system and making modifications, that despite their technical inclination, they cannot, devote enough time to analysing and deepening their knowledge of their equipment. Engineers must always keep an active watch, encourage in-depth diagnoses where necessary, and follow through with expert assessments to address the root causes.

Moving away from processes would enable a more action-oriented approach. Don't we spend too much time drawing up reports rather

than dealing with problems? We need to make it easier to take action. The history of work request backlogs, even if they have been reduced, still demonstrates the propensity to classify, prioritise and analyse rather than addressing issues. In a power station, there is no such thing as minor equipment or equipment that serves no purpose. I refer the reader to my recommendation of 2024, which called for solutions to be found between the on-line, outage and long term structures to better balance workload.

LET'S NOT UNDERESTIMATE THE NEED TO RENOVATE OUR ASSETS

The ambition of Sizewell's "Long-Term Operation" project and the French fleet upgrade programme and lifetime extension projects is to go beyond the 40-year mark and, more recently, to outline a new operating horizon beyond 60 years. Despite considerable investment, a number of systems and equipment are not covered by renovation or replacement projects. This is the case for specific systems linked to the water intake, tertiary systems, common plant systems (demineralisation

stations, oil separators, large tanks), civil engineering infrastructures (roofs, cladding, piping) and certain tertiary infrastructures.

To deal with this wide range of issues, multi-year asset programmes (PPP) were launched at all the plants. This approach ran out of steam in some plants. Faced with this situation, the management of the French fleet decided in 2024 to make this a key component of operating lifetime extension. This was a very good decision that I was in favour of. However, to be effective, I would encourage you to check the quality of the inventories, to think about the governance arrangements to take account of plant responsibility and coherence between plant series, and to ensure there is funding support from engineering centres and industrial capacity.

THE SPECIFIC CHALLENGES OF AGRS

After prospects of short-term closure due to graphite cracking and boiler ageing phenomena, the AGR reactors have seen their operating lifetime extended in successive stages. This incremental approach is being conducted based on a review of safety cases and a reinforced graphite inspection programme. This alternative approach that sets a dead line for operation makes it possible to build a more robust strategy on the technical and human levels (*see 2019 report*). Now that Nuclear Operations management has set itself a more ambitious operating target, the conditions are right to engage all the stakeholders in a coherent approach and to better inform the investments to be made.

I am not forgetting the AGRs that have already shut down and are undergoing final fuel unloading. I would like to pay tribute to the performance of the Hunterston and Hinkley Point B sites, which completed this final phase in 2025. During a visit to Dungeness B, I observed the resumption of good unloading dynamics, as the initial conditions in cold pressurised mode had been eased. Although the safety issues at these sites are less severe because of the very low residual power, I stay attentive to how equipment reliability standards will remain high, in terms of machine maintenance and the skills required.

BEING CAPABLE OF CHALLENGING ONESELF

MAINTENANCE STANDARDS, AIMING FOR JUST WHAT IS NEEDED

My reports have already pointed out the difficulty plants have in coping with the workload of maintenance programmes. As a result, preventive activities are postponed every month. A rigorous approach must be used: either the preventive maintenance task is not justified and should be eliminated, or it is necessary and should be carried out within the prescribed deadlines.

On the basis of detailed analyses, a number of plants are intending to propose modifications or reductions to the programmes. Others are finding it difficult to take into account feedback from the field observed during activities, or more generally, operating experience from completed maintenance tasks. To avoid exhausting local initiatives, it is essential to make the standards amending process more effective.

I note that the DPN is relaunching a large-scale initiative to optimise its maintenance programmes with the “Juste Maintenance” project. I think it is essential to adequately coordinate this work with the RGE approach (future operating standards) programme, and to ensure that standards are consistent.

DEVELOPING PREDICTIVE MAINTENANCE

Every day at United Kingdom and French plants, hundreds of sensors send back information about the functioning of the equipment. They are supplemented by parameters recorded during periodic tests or field operator walkdowns. But only a tiny fraction of the thousands of items of data stored in this way is used.



Golfech – Field monitoring of power generation equipment



Cattenom – Work on a steam valve

Trend-following, e-monitoring and transient analysis approaches have been deployed with some success. However, there is still enormous development potential in terms of exploiting and detecting the early signs of failure, and I have found some very promising plants. Some are seeking to install additional sensors (IoT¹) to supplement the original instrumentation, which requires an adapted network (this will have to be taken into account for our future reactors). In 2025, the French corporate engineering support unit (UNIE) carried out a learning expedition with industrial players for an immersion in the state of the art. It returned with the certainty that much remains to be done. While the technologies are known within the EDF Group (R&D and hydraulics), and in most cases are already at the industrial stage, their deployment at the DPN needs to be fast-tracked. The main challenge is to intelligently integrate constraints (cybersecurity, data protection) and unleash local initiatives.

1. IoT: internet of things.

ISSUES NOT TO BE UNDERESTIMATED

DEALING WITH OBSOLESCENCE

In the DPN's global stock of spare parts, around 10,000 types of spares are affected by obsolescence. There are several reasons for this: production has stopped, suppliers withdrawing from nuclear markets, changes in standards combined with low volumes, third party technological change, and even the disappearance of suppliers.

Obsolescence affects all domains, but in particular instrumentation and control, electrical items and valves. Faced with this challenge, UTO, corporate technical support team was expanded in 2025 and is working to strengthen its approach. Budgets for building up end-of-life stocks are rising sharply, offering a long-term or temporary solution to deal with obsolescence. Despite the efforts made, this capacity, although increasing, remains limited. It is necessary to keep accelerating.

CHEMISTRY IS NOT TO BE NEGLECTED

Chemistry is at the crossroads of many subjects. It makes a significant contribution to the reliability and lifespan of equipment. The right parameters protect the primary system, secondary systems, auxiliary systems and support systems. Chemistry is a long-term battle and everyone must play their part. When the operator accepts values in excess of packaging criteria or imperfections in storage during outages, the equipment remembers.

Just before 2010, the clogging of steam generators (SG) raised awareness about the importance of chemistry. Since then, progress has been made. Every plant has a chemical engineer, the domain is

supervised, indicators are monitored, analysed and progress plans are drawn up. Sometimes, performance depends on just a few key players. Over the past few years, an analysis of the Chemical Performance Index (CPI) has shown that there is no more progress. The fact that in 2025 a site could be caught off guard by a faster-than-expected clogging of its SGs raises questions.

Although the initial focus was on priority equipment, large components in the auxiliary systems are ageing (evaporators, heaters), sometimes with a degraded operating mode. I call for vigilance to ensure on each plant that chemical equipment is not disregarded in terms of maintenance, and that chemists are listened to carefully by plant management and in particular by operations ([see 2021 report](#)).

RECOMMENDATIONS

An effective technical reliability strategy is a key prerequisite for nuclear safety. Despite the programmes begun in the French nuclear fleet, a number of equipment still need to be reconditioned or replaced, particularly with a view to operating beyond the lifetime extension of 60 years. I recommend that the Director of the DPNT establish the precise scope, endow all plants with a multi-annual asset programme, and earmark a budget commensurate with the stakes involved.

The lifetime extension of AGR reactors has been modified several times in recent years. To avoid the risks of an incremental approach, I recommend that the Managing Director of Nuclear Operations determine and communicate a maximum deadline for the lifetime extension in order to programme technical and human investments, both centrally and on plants.



Civaux – A specific heat sink



THE HEAT SINK, AN OUTPOST OF THE PLANT

Pumping stations are at the outposts in the environment. Their function is to supply the power plant with water at the right temperature and flow rate, whatever the circumstances, from the sea or rivers.

Essential for generation, the heat sink is also essential for safety: it cools the critical equipment and, when the plant is shut down, removes the residual power (around 1% of the rated power).

The heat sink is a technical facility that interacts with the natural environment on which it depends, requiring engineering and environmental skills. Operating it requires knowledge of the plant's environment and a continuous focus on it.

SEAS, RIVERS, CLIMATE: NUCLEAR POWER AND NATURE

THE YEAR OF JELLYFISH... AND ALGAE

On the evening of 10 August, the condenser cooling pumps (CRF) of reactors 2, 4, 6 and 3 at Gravelines tripped successively for protection due to a high pressure difference (delta P) on the rotating drum screens in the pumping station. This caused the trip of three of these reactors just before midnight, and then the fourth reactor at dawn the following day. The suction of a drifting jellyfish bank clogged the rotating drum screens. Reactors 1 and 5 were already shut down for a refuelling outage. The protections played their role and no equipment was damaged. The clogging was resolved by stopping the very strong suction from the CRF pumps. By design, the essential service water system pumps (SEC) were still able to deliver the low flow rate required. These events did not affect nuclear safety.

The same month, Torness on the east coast of Scotland also experienced a sudden rise in delta P due to jellyfish ingress, without any trip. The same happened at Paluel, which also avoided the trip, but at the cost of a technical specification non-compliance regarding core configuration due to the load dropping too quickly.

On 30 August at Chinon, the SEC pumps tripped due to a high delta P: large amounts of filamentous algae entered the water intakes, partially bypassing the chain filters and affecting RRI/SEC heat exchangers. This was therefore a nuclear safety matter. For several days, teams worked in 3x8 hour shifts to clear the water intake, operate the filters and clean the exchangers. The algae had proliferated in the warm waters of the Loire backwaters, before being washed away by a flood caused by heavy rain at the end of the summer.

At Flamanville 1, for a few days at the end of August, at low tide, a CRF pump tripped due to delta P at the pre-filtration grate: a mass of algae blown off by a gust of wind and sucked up by the pump pressed against the grate, whose “trash rakes” had stopped due to a gutter obstruction. The rotating drum screens remained algae-free and the SEC operational.

Flow-rate orders of magnitude

During generation, the condenser pumps flow rate is between 75,000 and 100,000 m³/h, depending on the reactor series.

The safety-related cooling system must remove the residual power (around 1% of the reactor rated power) and cool the safety-related equipment. Its flow rate is roughly 2 to 4,000 m³/h.

A river like the Rhône has an average flow rate of around 6 million m³/h at its mouth.

CLOGGING AGENT INGRESS: A RECURRING ISSUE, IMPROVEMENTS AND SURPRISES

This type of event is not new: clogging agent ingress regularly affect pumping stations around the world. Global warming changes their nature and probably increases their frequency.

At coastal plants clogging agents can be very diverse: algae, fish larvae, jellyfish (including sea gooseberries, which caused trips at Gravelines in the 1990s), sand, silt, crude oil pollution etc. At low tide it is important to ensure that the flow in the channel does not become torrential² and carry sand or pebbles towards the water intake. The operator therefore carries out bathymetric surveys and, if necessary, dredging operations. The ‘Chenal 3’ calculation code, which incorporates the latest breakthroughs of the EDF R&D, predicts the risk of torrential flow based on the sandbanks’ maps, the tide, the weather and the pumping rate. If necessary, the operator lowers the reactors power and the suction flow rate.

2. If the water level is very low, the pump suction can cause a strong current and turbulent flow similar to a torrent, likely to suddenly erode sand or gravel banks.

Depending on the period, algae ingress has affected Flamanville, Paluel and Penly, which have implemented improvements. Torness, in the path of major storms in the North Sea, had to devote a great deal of work to this issue and made progress in terms of forecasting, observation at sea thanks to agreements with fishermen, and operational response. Other British sites are affected by silt that can clog the filters in the SEC systems. I would recommend that they contact other operators, including the French nuclear operations division (DPN), to consider potential prevention means. Located on the estuary, Blayais experiences episodes of “sare”, vegetal debris swept away by the current.

At the river edge these clogging agents are aquatic plants, branches, foliage, sediment, debris, etc. Floods can carry plants from the river or its banks, mowing residues or sediment. Events occur regularly and have been increasing in frequency over the last ten years. The 2009 incident at Cruas provided significant operational experience. Another example occurred in September 2023, at Civaux, which with the help of the FARN, had to remove tons of plants that had accumulated in the water intake when the river Vienne suddenly flooded. I note from this well-controlled episode that the operator, warned by EDF Hydro's general technical department (DTG), had mobilised staff in advance. The same thing happened in 2023, when a massive influx of filamentous green algae occurred at Dampierre. During the summer of 2023, Chinon also removed 235 m³ of aquatic plants from the heat sink. An annual DTG report lists and analyses all ingress events reported by the sites.

Mussels can develop in structures, filters or heat exchangers, by the sea or rivers, clogging them. EDF keeps a close eye on the development of zebra and quagga river mussels. Cleaning and biocidal treatments may be necessary, depending on the site.

The DTG issues weekly forecasts and warnings to riverside stations, based on aquatic plants growth, hydrology and weather conditions. It carries out seasonal surveys of aquatic plant development. Filamentous algae, pondweed, duckweed, water crowfoot, dense



Flamanville 3 - Cleaning debris accumulated in the channel

egeria, elodea, spiral vallisneria, etc.: EDF is acquiring comprehensive knowledge of aquatic plants.

Significant progress has been made in forecast, vigilance, instrumentation and control (alarm and automatic protection for delta P, switching of rotating drum screens to high speed, etc.), procedures.

However, in August 2025, some sites were taken by surprise by phenomena that they were not used to or that they had not seen coming. I recommend that we learn from this experience with regard to:

- local observation and warning (cameras, sensors, fishermen, forecast updates, etc.);
- prevention upstream of structures (barges, fishermen, nets, etc.);



Penly – Chenal 3 code modelling

- equipment availability at the pumping station and response team backup in the event of an alert to observe, warn, clean the water courses, monitor the trash rakes, change the baskets, etc.

Like farming, our activity is also a combination of nature, mechanics and human intervention. This is something we have to embed in our culture.

FRAZIL: IN FRANCE TOO

During the bitterly cold winter of 1985-1986, the Loire carried ice packs and the Chinon water intake froze over, requiring the army's intervention. A "severe cold" plan was drawn up.

A different phenomenon, frazil, affected the Chooz pumping station in 2009: water that had remained liquid below zero degrees suddenly froze on contact with the pre-filtration grids, reducing SEC's capacity. Sites sensitive to frazil have been identified and modifications made in recent years, by reinjecting hot water from the discharge upstream of the water intake.

I have already mentioned that the frazil modifications at Tricastin affect its ability to prevent driftwood and dredge sediments ([see my 2024 report](#)). The desire not to reduce power when there is

a risk of frazil (which disappears if the CRF pumps and the bottom-surface stirring are stopped), combined with a spiral of constraints and requirements, have led to this solution. I would encourage this system be reviewed to ensure that it contributes to nuclear safety more than undermining it, especially as winter floods have already brought large volumes of sediment to the site.

CLIMATE CHANGE AT WORK

My 2023 report devoted a chapter to this: I will not repeat it here and will only comment on developments.

In France, whether we're dealing with the fleet or new build projects, the Group's commitment is confirmed in terms of science and investment. It applies to all areas: low-water levels, heat management, clogging agents, water use, health, etc. The leadership of the company shows its clear commitment and resources are being allocated.

For a defined timeframe, the aim is to ensure that the figures (temperatures, flows, etc.) are consistent between the fleet's lifetime extension project (DDF) and the new nuclear reactors. The 6th IPCC report is taken into account. An array of methods is needed covering the short term (next ten-yearly outages), the medium term (30 years) and the long term (2100). These methods will evolve from those that already exist to those that will provide greater accuracy, for example, to model the extreme hazards arising from climate change at the end of the century.

As far as hydrology is concerned, I can see that the SHADEX methods, which estimate maximum flood flows, are going to become the standard in the nuclear industry, just as they are at EDF Hydro ([see 2023 report](#)). I encourage the fleet to adopt this approach. DTG is developing an equivalent method for assessing severe low-water levels in a changing climate: MOSAHYCC.

Rising river temperatures will undoubtedly be the main nuclear safety challenge and the Group is paying particular attention to this. The RRI/SEC heat exchangers upgrade is proceeding (increasing the exchange surface area by adding plates), the fleet is studying exchanger replacements and identifying all possible solutions.

It has been confirmed that climate change is causing more violent rainfall in Southern France. Latest modelling is consistent with the recent Mediterranean episodes. R&D is aimed at modelling local heavy rainfall on dry ground, an ambitious scientific challenge.

EXPERTISE AND COMPLEXITY

The Group has solid expertise in the scientific and technical fields of heat sinks and their environment. R&D, DTG and Engineering carry out cutting-edge studies and developments with a view to their operational application.

The French national hydraulics and testing laboratory (LNHE), at the R&D, has precious testing halls where structural models are tested, e.g. dykes and channels, as well as systems. The DTG, a technical gem, confirms the strength of the link between EDF Hydro and nuclear power, which is essential to maintain. From this point of view, the policies on hydroelectric concessions are reassuring, as they are likely to keep hydroelectric plants within the Group.

My visit to the National Equipment and Electricity Production Centre (CNEPE) confirmed my view on the importance of in-house expertise in heat sink design and that dealing with both existing and new nuclear power together is a strength. This could provide a general model. The engineering Technical Department (DT) establishes standards. At the Nuclear Operations Division (DPN), the heat sink topic is managed and this shows; the communities of practice (COP) are valued.

I visited stations in France and the United Kingdom that were more committed than before to maintaining the heat sink and more vigilant about potential hazards. Heat sink engineers are eager to work in the field. The DPN needs to pay greater attention to their training, to the succession planning and to career development. Heat sinks and external power supplies must have the focus of station management: the plant depends on the outside world.

The number of players and the complexity of the organisation, highlighted in my previous reports, remain. The subject of a recommendation in the 2023 report was the overall coordinator, the technical authority and the strategist, and these are still difficult to identify.

The overall organisation, resources and coordination are more limited in the United Kingdom. The topic appears to be largely the sites' responsibility.

INTERNATIONAL: EVERYONE IS AFFECTED

EDF participates in international exchanges with:

- WANO, which considers this topic in its analyses and peer reviews;
- EPRI (American Electric Power Research Institute); one of the topics of its annual seminar in August 2025 was jellyfish;
- Its Japanese equivalent, the CRIEPI, regarding specific technical subjects, e.g. biofouling;
- The Chinese operator CGN, which faces abundant marine life and proactively implements significant in-depth defence measures;
- Canadian and Scandinavian operators regarding frazil, etc.

There is a lot of good information out there and we need to seek implementation from best practices. In the Group, cooperation between EDF SA and EDF Energy, who operate pumping stations on the coasts of the same Channel, should be better structured.



Chinon – Cleaning chain filters

PUMPING STATIONS: A NEVER-ENDING BATTLE

In France, I can see overall progress thanks to the efforts of DPN, which has made this a much-needed priority in recent years. Refurbishment and replacement programmes are under way (neoprene-coated SEC pipes, rotating drum screens, etc.). A “Grand Carénage” project (GK) is dedicated to this issue. Generic problems (trash rakes, chlorination systems, etc.) and spare part difficulties remain to be resolved. Leaks from RRI/SEC exchangers have dragged on for lack of available spare plates and prioritisation.

The condition of the riverside pumping stations visited this year was satisfactory. I noted with satisfaction that the heat sink at Cattenom

has been reclaimed, thanks to the work done in the field by the heat sink engineers, maintenance and operations. By the sea, at Torness, I am pleased with the refurbishment of the pumping station, which was indeed needed.

Alongside maintenance programmes (PBMP) and national projects (GK), which are essential but from which we should not expect everything, the initiative of the sites and their “ownership spirit” will be decisive. I still see too many persistent leaks from glands, poorly managed and collected, which corrode the equipment. Work requests are accumulating and departments are sending each other emails. Sites also need to improve availability of trash rakes, lift pumps, pressure boosters, etc., which are essential in the event of an ingress.

Water corrodes, and salt spray corrodes even more... The fight must be continuous, without waiting for the PBMP deadlines: walk around the plant, scrape, repaint, grease... In other words: protect

and prevent. It is not enough to issue a work request or wait for it to take precedence over other priorities: in the meantime, corrosion will develop. I therefore recommend setting up dedicated teams and training them in the state of the art.

ENGINEERING: UNDERSTANDING RATHER THAN MERELY APPLYING REQUIREMENTS

DESIGN: ADAPTING TO THE SITE

The pumping station must fit with the site's geography. The hydraulic design of structures on riversides is often clever. Some water intakes are naturally protected from clogging agents, although this is not the case everywhere, nor is it foolproof. The nuclear safety of two sites is independent from the river for a significant period of time: Civaux, thanks to a SEC system cooled by cooling towers and tanks, and Cattenom, thanks to the Mirgenbach artificial lake. Depending on the layout, protection against frazil can be either simple or complex. By the sea, protection against sea spray and salt fog has not always been optimally designed.

The EPR2 will have a diverse heat sink, similar in principle to the one at Civaux, which is a real strength. I was pleased that engineers from the CNEPE went to Civaux to get operational experience. The hydraulic models being tested at the LNHE are an asset. The project involves underground SEC piping made of HDPE (high-density polyethylene). Widely used in drinking water supply, HDPE is resistant to corrosion, ground movement and earthquakes. The potential for in-service inspection remain to be defined in order to observe its durability.



Bugey - Pumping station drum filter

I suggest studying the interactions between the new nuclear and existing power plants at a given site, during the construction and operating phases: currents, silting, torrential flows, coastline, etc. ([see Chapter 8](#)).

MODERATING THE MECHANICS OF SAFETY CASE RULES

The heat sink also requires engineering judgement and an ability to understand orders of magnitude, margins and resilience. All the more so since its safety assessment involves natural and evolving sciences: not everything is mathematically demonstrable.

We need to revise certain rules or conservatisms, using common sense and good judgement. For example:

- During a heatwave, the temperature of underground SEC galleries is assumed to be the same as the outside temperature...
- What is the point of safety classifying the grooved concrete blocks of the EPR2 dykes at Penly?

The undersizing of RRI/SEC heat exchangers at FLA3, by a poorly selected and supervised contractor, should be an incentive to always pay attention to our business fundamentals and stay connected with the experience and realities of the industry.

OPERATING FLEET: MODIFYING ADEQUATELY

Necessary and beneficial modifications have been made to the fleet's heat sinks. Others are less successful: adding pipes or wind protection is not always a good idea. The latter are generally the result of a systematic approach based on theoretical requirements, without judgement in the field.

In preparation for the LTO project, it would be a good idea to look for ways of improving robustness and resilience, as well as favourable operating margins and conditions, so as to avoid a situation where, guided solely by the nuclear safety demonstration, we just do "more of the same".

WHAT IF THE PUMPING STATION IS LOST?

In France, in the event of a total loss of heat sink, the H1 procedure is applicable since the 1980s: residual heat removal from the core by the steam generators supplied by Auxiliary Feedwater System; cooling of Component Cooling System and therefore of essential safety-related equipment, thanks to the thermal inertia of the reactor's water reactor tank (PTR). In an unprecedented situation, Cruas had to apply this in 2009.

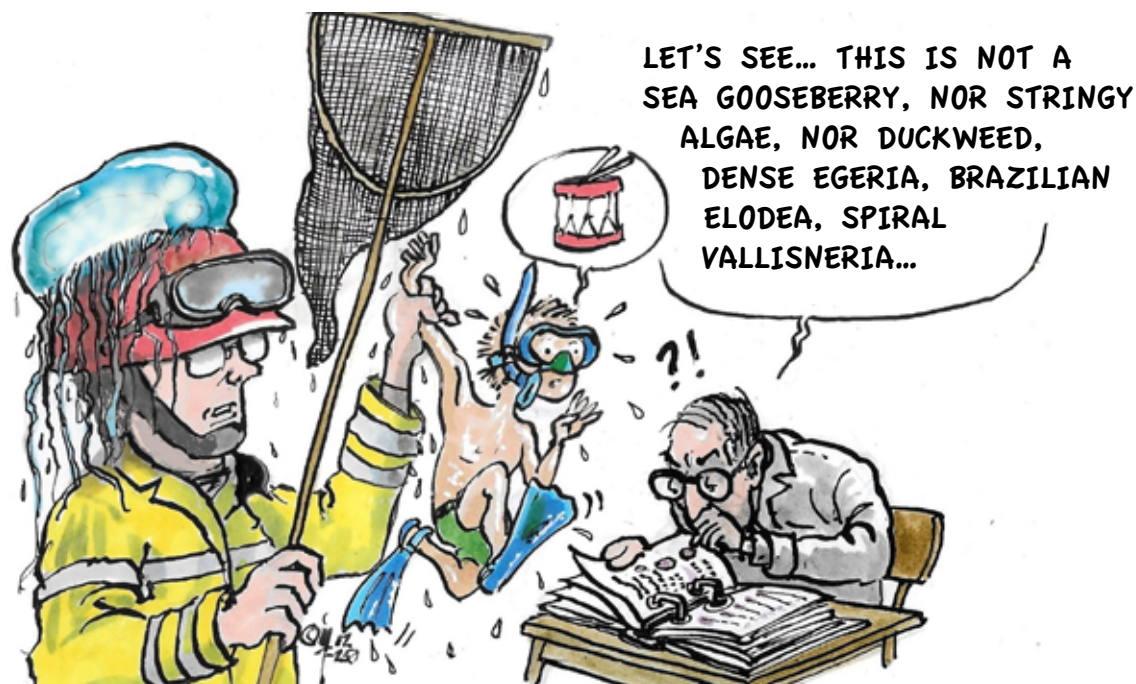
Additional measures have been added since Fukushima:

- In the event of loss of cooling in the fuel pool, maintain its level by water make-up; the FARN could connect a heat exchanger (PTR bis) within 24 hours;
- An ultimate source of water, a well in the water table, basin or reservoir, can supply the ASG tank and the fuel pool; definitive or temporary solutions have been implemented;
- The FARN has pumping facilities in rivers, ponds or the sea;
- In the event of a severe accident, cooling of the reactor building by the EAS-U, thanks to FARN;
- The British BDBUE units (Beyond Design Back-Up Equipment, equivalent to FARN) provide equivalent functionality.

In the United Kingdom, the Sizewell B PWR benefits from a back-up heat sink with air-cooled heat exchangers. Because of their low power density and large volume, AGR reactors have a high thermal inertia. Various means can be used to cool the reactor.

Cruas 2009

On the night of 1 December, an exceptional aquatic plants ingress clogged the heat sink. These plants had built up in the bed and banks of the river, and a flood in the Rhône loosened them and swept them away, thus causing the clogging. Loss of the essential service water system was total on Reactor 4, and partial on the other reactors. The operators applied procedure H1, and the inertia of the spent fuel pool was also harnessed. Clearing the pre-filtration grids enabled the heat sink to be restored after 10 hours.



Heat sink

RECOMMENDATIONS

Given that in August 2025 some NPPs were taken by surprise by clogging agent ingress, I recommend that the Director of the DPN draws operational experience from this regarding:

- local observation and alert means;
- prevention and control upstream;
- pumping station equipment availability and on-call staff reinforcements.

I also recommend that the Director of the DirIN integrates this OPEX in the design.

Preventing and fixing corrosion must be a constant battle. In order to prevent equipment from deteriorating, especially on coastal sites, I recommend that the Director of the DPN sets up a robust and lasting organisation at each plant, with specialists where needed who are dedicated to preventing and fixing corrosion throughout the plant, especially the heat sink.



Nogent-sur-Seine power station

CHAP 6

A CHANGING PARTNERSHIP

A high-performance nuclear industry relies on a highly competent and sovereign industrial network. Framatome has acquired a number of companies to ensure their long-term viability and is investing in skills and industrial facilities, particularly in Chalon-sur-Saône and Jeumont.

The supplier platform defines the Group's industrial policy. Through Supplier Development and Recovery, EDF is helping the industry to improve quality and lead times.

The operating organisation must monitor all contracted activities that are critical to safety.

The 2025-2028 strategic contract signed by the French government and the industry's stakeholders aims to strengthen energy sovereignty, competitiveness and the shift to a greener future. The contract covers four areas: improving industrial performance, developing skills and making the industry more attractive, focusing on the future challenges and promoting a responsible and sustainable industry. This excellent news has been a welcome reassurance for the industry.

MANAGING THE WORKLOAD TO RETAIN SKILLS

The permanent partners of the DPN are becoming less mobile, and nearly 95% of them live less than 50 km from the sites. This development is due to family and professional commitments. At the same time, the sites stopped outsourcing some maintenance activities to strengthen internal skills, improve contractors' supervision and increase their autonomy. The seasonal nature of reactor outages leads to significant variations in workload, with periods of underload. Our partners need visibility and effective scheduling to be able to plan ahead.

In New Nuclear Build (NN), engineering partners have to balance their workload following the end of the Flamanville 3 (FLA3) project, the decrease in activity on Hinkley Point C (HPC), the replication on Sizewell C (SZC), the easing of the EPR2 schedule, the loss of the tender in the Czech Republic and the reorientation of the Nuward project. Paradoxically, a strong increase in activity is still expected. Reducing the supplier pool will enable us to redistribute activities and limit the impact of underload and loss of skills.

STRENGTHENING OUR SUPPLY CHAIN

Supply chain maturity remains low. With little automation and a lack of skills, practice and responsiveness, it has a high rate of rework. Methods for dealing with deviations, such as QRQC (Quick Response Quality Control) and FMECA (Failure Mode, Effects and Criticality Analysis), are not used enough. The industry is also hampered by too many specifications, responses to suppliers that are sometimes late or

incomplete and insufficient presence in their factories. The approach, which has become over-regulated, lacks pragmatism and does not focus enough on technical risks.

INDUSTRY EXPECTATIONS

BETTER INTEGRATION IN THE UNITED KINGDOM THAN IN FRANCE

In France, our partners would like to see harmonisation of practices and requirements. They consider our rules to be more cumbersome than those of other manufacturers, whether nuclear operators or not. They perceive an imbalance in requirements between them and EDF, which hampers challenge. In the field, lead workers find it difficult to take on all the responsibilities entrusted to them (in addition to their activities, logistics, radiation protection, etc.). They also highlight the unpredictability of online schedules and the poor quality of documentation. There is a lack of responsiveness when it comes to updating corporate documentation, which has to be compensated for by local documentation. Contracts with a performance obligation are unsuited to the work sites with too little wrench time spent on the plant. They are detrimental to the partnership relationship and, paradoxically, to performance.

In the United Kingdom, partners are integrated into the site organisation. They take part in operational meetings, including leadership coaching reviews and away days. However, the volume and the quality of documentation required remains variable: the risk assessment method statements (RAMS) from contractors may be more comprehensive than the risk assessments required by Nuclear Operations. On the other hand, as they approach the decommissioning phase and the handover of plants to NRS (Nuclear

Restoration Services), the partners lack visibility over the long-term future of their business.

AMTS, TRUSTED PARTNERS

The thermal maintenance agencies (AMTs) work closely with the sites. In addition to the physical work they do, they provide advice and technical expertise. Through their know-how, they contribute to the improvement of site data. Their strengths include the planning of activities through safety reviews, the implementation of worksite safety stand-downs when there is an industrial safety risk and the analysis of OPEX. They carry out supervision, enabling station contractor's supervisors (CSI) to free up time to carry out tasks and maintain their skills.

BEMA: servicing the fleet

The Engineering, Modifications and Projects Department (BEMA) is the brainchild of the Metalworking and Welding Project, which was created as a result of the stress corrosion cracking crisis. It strengthens the Group's industrial autonomy in the fields of metalwork, piping and welding, by giving the Logistics and Maintenance Unit the capacity to carry out complex operations and replace large components. It mobilises internal and external skills and comprises:

- the Engineering Department, responsible for technical analysis and process development;
- the Modifications Department, which guarantees work quality;
- the Projects Department, responsible for workload management.

LOGISTICS AND WRENCH TIME

The restructuring of the Worksite Support Contracts (PGAC) markets by speciality (worksite logistics, scaffolding, radiation protection, etc.) and geographical area aims at pooling resources and balance the workload. The high turnover of site logistics personnel limits the



Cattenom – Automated welding during pre-fabrication work

development of skills. Stabilising teams requires greater visibility, less reactive management and a shift away from a culture that is overly focused on sanctions. Staff retention also depends on permanent contracts.

There are highly effective organisations other than the PGAC that should be used whenever necessary. For example, the “Tapis rouge” (Red Carpet) completely relieves workers of logistical constraints; integrated contracts include logistics. Similarly, dedicated logistics teams or a federation of companies could be considered to manage interfaces.

Requests under the EPSILON logistics information system must be improved. The transition to ELOG will offer a more integrated and adapted system, provided that the complete transfer of data (sizing and positioning of scaffolds, worksite airlocks, etc.), particularly that of our partners, is ensured. CoLiMo terminals facilitate the management of work requests and increase wrench time.

ENGINEERING SERVICES: GEOGRAPHICAL CLOSENESS VERSUS ADAPTABILITY

Current working methods maintain a requirement for geographical closeness between our partners and their clients, reducing their potential for adaptability. Furthermore, regionalisation limits the ability of partners to manage underloads by reallocating national resources.

AN INDUSTRIAL POLICY TO STRENGTHEN THE SUPPLY CHAIN

SOVEREIGNTY ABOVE ALL

The French nuclear industry, which is a matter of national sovereignty, is largely based in France (95%). Framatome has strengthened its vertical integration through several recent acquisitions: Valseive, Vanatome, Segault and Selectarc. Engineering activities that are contracted out remain mainly in France and the United Kingdom. However, Export Control risk management and our technological sovereignty still need to be strengthened in order to secure our international activities and projects in the long term.

SUPPLIER MANAGEMENT ORGANISATION, BALANCE BETWEEN OPERATING FLEET AND NEW NUCLEAR BUILD

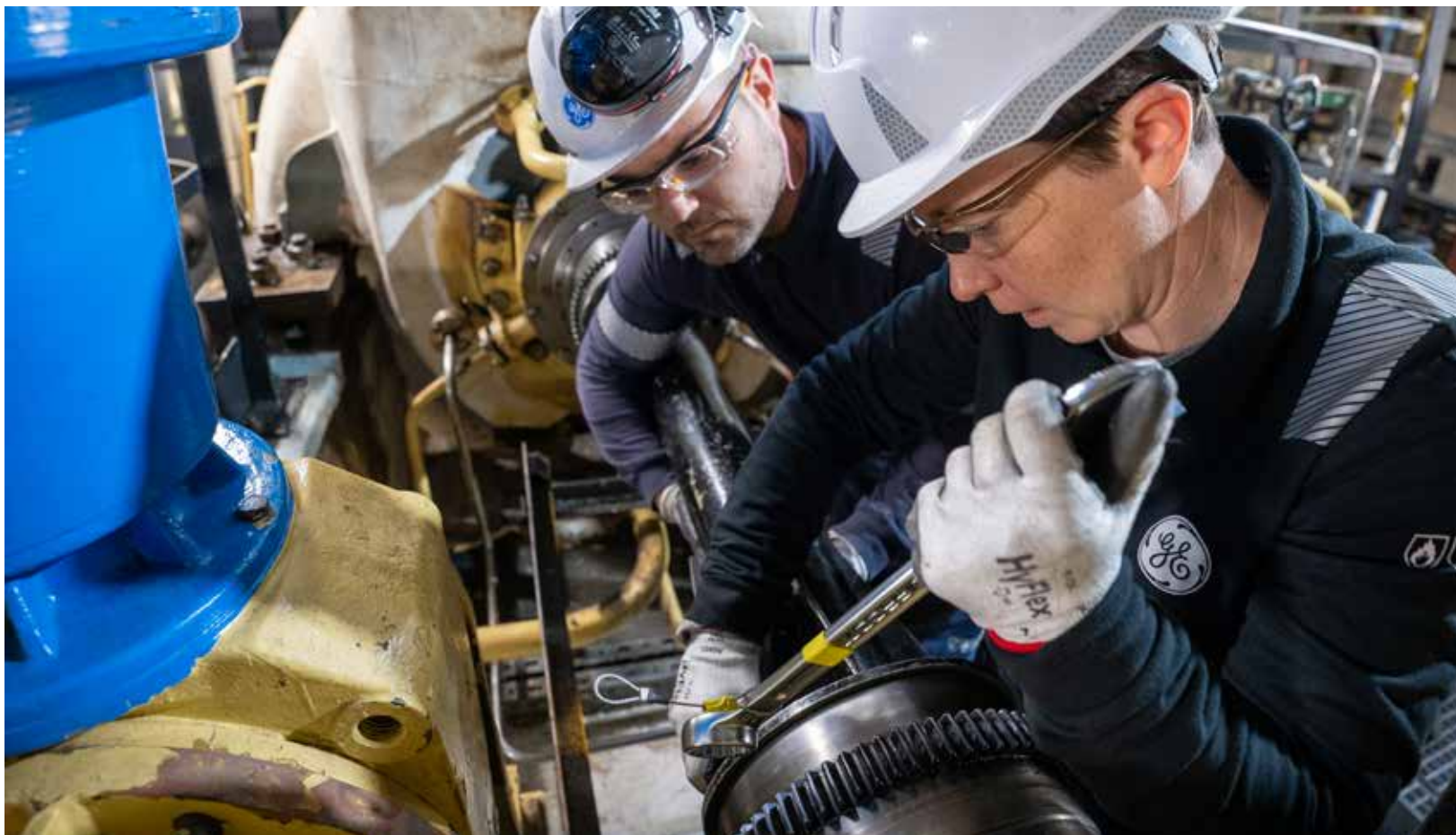
The supplier management organisation defines EDF's industrial policy. It co-builds long-term purchasing policies with the DPN, the GK, EPR2 and United Kingdom New Build projects. It reinforces expectations and fosters pooling. The Group's industrial divisions decide on the supplier pool in line with this strategy. DPN selects the contractors for the work to be carried out and spare parts, while new nuclear build focuses on equipment technology and contractors for worksites. Progress is expected when it comes to protecting our intellectual property.

The supplier management organisation brings together strategic managers, supplier managers, project and contractors managers from new nuclear, as well as representatives of DPNT, including an Industrial Strategy Director and the nine area heads from the operational technical unit (UTO). The recent creation of these positions has strengthened DPN's authority, enabling it to provide valuable operating experience. DPN now has the means to develop a long-term industrial strategy that takes obsolescence into account. Finally, the purchasing division is structured according to a product-based approach, which is a positive development.

ADAPTING OUR INDUSTRIAL POLICY

DPN's industrial policy blends a local embedding approach that fosters skills development with economic performance. It separates the general markets, which bring volume and competitiveness, from the specialist markets, which are reserved for sensitive equipment. National markets encourage standardisation of practices but, paradoxically, cost more because of staff long travels, while local markets offer responsiveness and continuity.

EDF is reducing its pool of tier 1 suppliers, who use subcontracting and local resources. In this context, it is necessary to refocus the missions of the market operating experience and analysis units (CAREMs). More broadly, the governance of local embedding approach, local



Civaux – Work in the turbine hall

markets and regional platforms would benefit from greater clarification for all involved stakeholders.

For reactor shutdowns, the national and yearly allocation may undermine the visibility and stability of partnerships at local level. Sites want more contractor's allocation consistency for identical outages. Partners lack visibility and aren't involved enough in outages

preparation. Competition between NPP and DIPDE for the same resources sometimes creates tension. EDF SA's relations with some of its subsidiaries are tense.

In the United Kingdom, competition between new nuclear build and existing plants remains a challenge, with salaries in new nuclear build being more attractive. Contractors at sites undergoing



Framatome Jeumont
Verification of a reactor coolant pump component

decommissioning no longer benefit from financial incentives specific to outages. Subcontracting contracts are managed in a highly centralised manner, limiting local initiatives and adaptation to the specific needs of sites. Supply chain processes could be improved by adapting tendering deadlines, taking into account suppliers' constraints, and involving them in the drafting of specifications.

FLEXIBILITY IN ENGINEERING: MARKET CONCENTRATION AND INTEGRATION

Every year, engineering organisations update an analysis of the 'added value of nuclear engineering' which guides their subcontracting policy. The competitiveness of partners depends mainly on the degree of market concentration and work package allocation. This is the whole purpose of the new design engineering and technical assistance services contracts (PIAT).

The engineering supply chain continues to be used to provide adaptability in terms of resources. We would benefit from promoting investment in skills, facilitating opportunities to balance the workload between new nuclear build and existing plants, and concentrating contracted activities using a work package approach. This would encourage innovation among our partners. The specific characteristics of Edvance's First Of A Kind (FOAK) tasks require close collaboration with suppliers due to their level of complexity, while replications can make greater use of work packages.

Finally, the approach developed for "intellectual property and right of use (Pidu)" improves the work of Edvance staff with different employment conditions. The renegotiation of Pidu, scheduled for 2027, will need to incorporate lessons learnt.

IMPROVING MANUFACTURING QUALITY

EDF SUPPORTS THE SUPPLY CHAIN

The Supplier Development (SD) approach proposed by EDF aims to improve tier 1 and above suppliers' performance in the long term. After an in-depth diagnosis of the causes of underperformance, a

targeted action plan is drawn up to improve quality (OQD, On Quality Delivery) and delivery times (OTD, On Time Delivery). By encouraging suppliers to quickly address discrepancies and providing them with hands-on support, particularly those who struggle to “get it right the first time”, the sector is making progress. The approach provides an external perspective, boosts customer-supplier relationships, enables the definition of appropriate performance indicators and adjusts the relevance of the monitoring programme. However, the Supplier Development approach has its limitations: it does not impact the lower tiers of the supply chain (suppliers of materials, semi-finished products, components, etc.) and requires detailed knowledge of factory manufacturing processes. It is particularly beneficial for SMEs, which have fewer quality control specialists than larger, better-structured, industries. In addition, the Supplier Recovery approach is used in cases where urgent deliveries need to be secured.

Supplier Development (SD) providing support for the supply chain

Launched in September 2022, SD is an initiative to support suppliers and improve their performance.

It is conducted by a team of twelve industrial experts in lean engineering/manufacturing/intervention.

This partnership-based approach, inspired by the automotive and aerospace sectors, has been adapted to the nuclear industry.

More than 110 SD projects, lasting an average of six months, have been launched at 33 manufacturing sites, producing tangible results with regard to OTD (on-time delivery), lead time, non-compliances, direct orders, capabilities, industrial safety, reduction in the number of hold points, etc.

A SUPPLY CHAIN MORE AWARE OF THE CFSI RISK

Reporting of CFSI (counterfeit, fraudulent, and suspect items) to the French regulator (ASNR) is well coordinated with our partners. The detection capacity is improving and more anomalies are being

detected. Most of these are minor issues resulting from individual behaviour with no malicious intent. The most sensitive cases concern the manufacture of equipment involving numerous tiers of subcontractors. The anti-fraud project is gaining in maturity, but sometimes potential discrepancies are reported too quickly before the facts have even been confirmed. Finally, an e-learning training programme aims at enhancing awareness for all employees and partners by 2026.

SPARE PARTS, A PAINPOINT SOURCE

To meet production needs and maintain close ties with operators, DPN/UTO remains responsible for managing spare parts. Several improvement measures have been launched concerning this sensitive issue: continuing to address frustrations with NPPs, integrating actions into the START project, creating a spare parts barometer in 2025 and deploying a new managerial reference standard. Finally, problem-solving groups are working to quickly address any emerging issues.

SKILLS FOR NUCLEAR SAFETY

Qualification for engineering services requires investment in skills and certified training. Experienced engineers with 3 to 10 years of experience are the most sought after. Before working at NPPs, recent graduates must supplement their knowledge with training courses approved by CEFRI (Certification committee for companies that train and monitor personnel working in ionising radiation environments).

SUPPORTING SMES AND VERY SMALL BUSINESSES

While the staff of large companies have the means to manage nuclear safety issues, SMEs and very small businesses sometimes lack the

resources to obtain ISO 19443 certification or deploy START 2025. While Gifen (French Nuclear Energy Industrialists Group) focuses primarily on the major players in the industry, the regional contractor support agencies provide support to small companies, but their essential role is sometimes not clearly understood.

In addition, lead workers have a very broad responsibility, despite the fact that their training is not as comprehensive as that of EDF staff. Confusion persists between the authorisation levels of partners (HN) and EDF (SN), thus maintaining the illusion that their knowledge is equivalent. HN training would benefit from reintroducing a basic understanding of processes (plant operation).

To facilitate skills acquisition, EDF makes its training facilities and a catalogue of site training mock-ups available to partners. The SIGECO skills mapping tool deployed in 2024-2025 is highly effective. It is shared among partners, and tracks their staff qualifications.

In the United Kingdom, partners participate in Nuclear Operations training. However, as in France, they do not receive process training.

SUPERVISION: BECOMING MORE RELEVANT

A WELL-ESTABLISHED QUALIFICATION

The qualification scope encapsulates all subcontracted safety-related activities (AIP). More than 700 suppliers are qualified, which includes intellectual services, technical assistance, projects, equipment supplies and spare parts. More than 11,000 contractor assessment forms (FEP) are produced each year. Currently, 27 suppliers (36 in 2024) are included in the national action plan (PAN) and eight are suspended. EDF checks and approves the arrangements for

subcontracting on new nuclear build contracts. A special qualification exemption process, approved at management level, offers controlled flexibility for specific services.

The contractors assessment system is satisfactory. However, it would be more relevant if it were based on a more progressive assessment less dependent on threshold effects, which is why the quality indicator is relevant to weigh the services depending on their volumes. At NPPs, dynamic monitoring makes it possible to anticipate deviations and contributes to the partnership relationship. Nevertheless, FEPs issuing remains too concentrated at the end of the year. Finally, the national action plan has its limitations, with some companies appearing on it for several years without any notable improvement.

PROFESSIONALISED SUPERVISION

In France, the supervision of contractor workers has been included in the Operating Standards (RGE) in the form of an addendum. The contractors' supervisors, who are part of a network, base their legitimacy on their technical expertise. Supervision is more challenging when using the supplier documentation, which is less mastered. The supervision information system is popular with users (Argos, eFEP, KALIF). I note that competing partners place greater value on supervision and FEPs than those in a position of monopoly.

IMPROVING CONTRACTUAL OVERSIGHT

Partners have a better understanding of contracts than ordering parties, who are more focused on nuclear safety and industrial facilities. The contract manager role is not sufficiently valued and is often performed on a part-time basis. First-level contract managers are more focused on technical aspects, while second-level managers focus on contractual clauses. The two approaches need to be integrated. Training programmes are robust but too focused on financial aspects and their coordination could be improved in certain technical areas. Career paths in this area still need to be structured.



Cattenom – Introduction of an alternator rotor by the logistics and maintenance team

IN THE UNITED KINGDOM, A STREAMLINED APPROACH

Maintenance, safety and radiation protection requirements are identical at all sites. Monitoring of partner activities is not subject to a supervision plan based on a risk assessment and detailed evaluation criteria as in France, but simply on an annual overall assessment. Deviations are promptly reported and dealt with in a proportionate manner.

ENGINEERING ADAPTS ITS SUPERVISION

Monitoring design studies that require significant resources must be streamlined and commensurate to the risks. It is excessively

standardised and results in too few relevant observations. The oversight of our partners' technical data deliverables must be strengthened and gain in reliability. The new supplier deliverables monitoring tool will automate certain steps and improve data capture. For the operating fleet, the monitoring would be more relevant if risks were assessed better and if it could adapt to difficulties encountered throughout the life of the contract or to any observed weaknesses.

The Industrial Quality Division carries out random monitoring based on a risk assessment and operating experience. It uses the REFLEX tool to target its monitoring and is developing a Praxis interface to adapt the Argos platform to its needs. Statistical sampling methods are also being developed to adapt monitoring to the volume of data generated by automated non-destructive tests.

FRAMATOME INVESTS IN ITS INDUSTRIAL ASSETS

A RELATIONSHIP BASED ON CLOSENESS AND TRUST

Framatome has permanent points of contact at most French NPPs. Interface management is simplified, which is good practice. Its added value lies mainly in its engineering. Its services should focus on activities requiring specialised design offices. The company should also second resources to the DIPDE, in line with the DPN model.

Framatome maintains a permanent presence at the Sizewell B site, which helps coordinate activities related to the LTO (Long Term Operation) programme and reactor outages. The operations entrusted to Framatome, in particular fuel handling and work on steam generators, are carried out by Framatome Inc. in order to comply with Export Control requirements.

INSTALLED BASE FRANCE: CONTINUING AND SUSTAINING PROGRESS

The Chalon-Sur-Saône site brings together facilities dedicated to preparing work, training and developing new processes. It invests in industrial innovation, promoting cooperation between expertise, qualifications and training. Advances include robotisation and TOCE automatic welding, internal weld grinding and innovations in non-destructive testing (laser thermography, ultrasound compliant). EDF does not benefit quickly enough from these up-to-date technologies due to overly long licencing process.

The replacement of the Cruas 3 steam generator (RGV) was a success. These results must be sustained and improved upon. Unplanned events management must be taken into account in the

schedule. This operation should serve as a reference for future RGVs of 1300 MWe reactors in the P'4 plant series. Framatome must also work on the sequence of operations for Paluel 3 and Saint-Alban 2, and anticipate the specific features of the P'4 reactors.

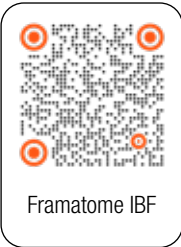
Framatome should become more involved in developing DPN's multi-year maintenance programme in order to anticipate and balance the workload. Steam generator cleaning work will peak between 2028 and 2030, requiring skills to be maintained.

FRAMATOME JEUMONT: SECURING THE RECOVERY

The Jeumont site, which is included in the PAN (national action plan), is under enhanced attention. It benefits from the Supplier Development

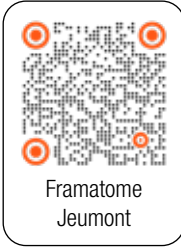
programme and is recovering after a period of insufficient human and industrial investment. Despite improvement on quality and timely delivery, performance remains below expectations.

The site benefits from a strong boost, with 400 new hires over three years, modernisation of its industrial facilities, digitisation of calibration equipment and a major expansion programme at the Maubeuge site. Quality and On Time In Full are improving significantly, rising from 30% to over 70%, with a target of 90%. The action plans aim at improving quality, reduce liabilities and control deviations by monitoring their occurrence rate. The teams are working on standardisation and simplification to improve performance. Finally, Jeumont Électrique, a motor supplier, is also included in the PAN and benefits from Supplier Development support.



RECOMMENDATION

Although the methods for monitoring subcontracted design studies have improved, they still sometimes rely too heavily on document review, not sufficiently correlated to the studies' stakes. Risk identification must dig deeper, and the monitoring must be adapted during contract execution. I recommend that the Directors of the DirlN and the DPPI improve the adequacy of the monitoring methods.





Civaux Nuclear Rapid Response Force (FARN) – Red helmet award ceremony for the IGSNR class

CHAP

CRISIS, FIRE: PREVENT AND RESPOND

Design basis accidents can occur and unforeseen events may also happen. It is necessary to prepare for them through training. Emergency preparedness is an essential component of nuclear safety, one of the operator's core responsibilities and missions; it is not a sideline.

As a major risk on industrial sites, fire requires skills and vigilance from everyone: preventing fire outbreaks (walk rounds, detection, hot spots), limiting its spread (heat loads, zoning) and knowing how to get properly kitted out and fight the fire, without being too bold or faint-hearted.

Leaders must do more to foster a culture of prevention and training, and ensure that these issues are not left solely to emergency preparedness or fire response programme owners.

EMERGENCY PREPAREDNESS: BEING READY

EDF devotes significant resources to emergency preparedness: national emergency response organisation, local crisis centres, on-call teams, local mobile equipment, nuclear rapid response unit (FARN) and its British equivalent BDBUE (beyond design back-up equipment), regular drills, etc.

The Group is particularly strong in ‘firefighting mode’ and never performs better than in times of crisis, as demonstrated by its management of COVID-19 and stress corrosion cracking. And yet, I sometimes feel that something is missing in terms of preparedness on the sites. Emergency preparedness should be seen more as an integral part of the business and as an opportunity to develop skills.

Emergencies are not just a theoretical concept: in 2025, Hartlepool had to rely on its emergency power supplies for five days, the blackout in Spain serves as a reminder that networks are becoming unstable (*see chapters 1 and 2*), and Chinon came close to losing its heat sink (*see chapter 5*).

IT’S A MATTER OF MINDSET, NUCLEAR SAFETY PHILOSOPHY AND HUMAN FACTORS

As the trauma of Fukushima fades, we must remain alert everywhere. During my visits, I have observed that awareness varies greatly. I have also noticed that emergency preparedness is too often left solely to emergency preparedness engineers, some of whom feel isolated and overburdened.

We must all assume that something could happen. We must be prepared, understand the physics, phenomena and equipment, and train. Being able to deal with the unexpected is at the very core of our profession. Senior leaders and managers must be more involved so



Paluel - FARN national exercise

that, despite the constant increase in requirements, processes and reports of all kinds, emergency preparedness does not become just another “sideline” but is fully part of our essential daily tasks.

I welcome pop-up exhibitions in France and the United Kingdom dedicated to historical accidents. They provide an opportunity for focussed attention days led by shift managers. I also noted that the Chinese operator CGN sent its shift managers to visit Chernobyl. Visits to Fukushima bring back to very ground of an accident.

The consideration given to emergency preparedness says a lot about the nuclear safety philosophy. These days, in France, the

scope of the safety demonstration hypertrophies at the expense of crisis management consideration. But there is no point in trying to cover every single eventuality. We must know when to stop trying to demonstrate nuclear safety and accept that, beyond a certain point, nuclear safety becomes a matter of crisis management.

Emergency preparedness itself is becoming increasingly focused on ‘demonstrating everything’.

It concerns me that we are trying to specify everything that is supposed to happen, and that there is a temptation to require a “demonstration” up to a fortnight after the initial event. Sites are overwhelmed with document updates and EP folders contain thousands of pages. We must stop trying to write everything down because we will not be able to read it all. Instead, a capacity based approach should be favoured. This approach must include equipment, organisations and the human factor. Man does not behave like a mere machine, and managing a crisis requires a certain leeway.

As well as being prepared for foreseen scenarios, we must “*be ready for the unexpected, i.e. be unprepared*” (Jean Pariès). Indeed, the price of an extreme optimisation to meet anticipated conditions is poorer ability to adapt to the unexpected. The alternative is to broaden the anticipation scope, the catalogue of planned events or to “prepare to be unprepared”, which implies shifting skills from pre-emptive control to the ability to react in real time. There are therefore two options: to “keep doing more of the same”, by prescribing responses to all scenarios and by tightening discipline and control; or to acknowledge a share of irreducible unpredictability, and to foster our ability to adapt.

In 1981, two years after the Three Mile Island accident, the SCSIN (the former French regulator, which became the ASN) wrote: “*The operator’s ability to think outside of the box in unforeseen scenarios will become their most important quality: this is a new concept of human reliability that must now be nurtured.*”

ROBUST ORGANISATION AND RESOURCES

In France, emergency response management relies on significant resources and a robust organisational structure. EDF significantly strengthened its response capabilities following the Fukushima Daiichi accident.

National crisis centres are well equipped; those at nuclear power plants are being replaced by post-Fukushima local emergency response centres (CCL), designed to operate in extreme situations, adverse radiological conditions and complete autonomy for 72 hours. After delays due to contractual difficulties, all should be operational by 2026.

The on-call rosters are organised and operational. However, the technical expertise of the PCD1s (NPP crisis director, on call) varies, and local crisis team members (ELC) sometimes encounter technical difficulties. I therefore suggest that DPN review these issues thoroughly



Japan's Onagawa power station – Emergency operation centre

and comply with, or even tighten, the training requirements prior to inclusion in the on-call rosters. The national crisis team also lacks a doctor specialised in radiation protection.

Post-Fukushima resources, such as ultimate diesel generators (DUS) and last-resort water supplies (SEU), are in place. These undeniably strengthen defence in depth and nuclear safety.

In addition, there are many diverse mobile emergency equipment (MLC). At the sites I visited, these are well maintained, tested and operational, and their owner is identified. However, inspections by IN and ASNR have revealed delays in implementation by shift or on-call teams.

In the United Kingdom, the crisis organisation also appears to be robust and the response teams are well equipped. The emergency preparedness engineers there also feel under pressure. Recruiting radiation protection specialists remains difficult. The fleet must also ensure that practical problems, such as means of communication, are better resolved and that crisis equipment is properly maintained.

In the new nuclear build, the operational plant crisis organisation and the terms of cooperation between Hinkley Point and Sizewell C, which have the same reactors but different operating companies, need to be defined. In particular, the role of Nuclear Operations and Nuclear Services needs to be clarified in crisis scenarios.

TRAINING TO THE FULLEST

For the most part, in France, EP exercises are conducted as planned and administrative management ensured. But there are signs that the emergency response is taking its toll. In French NPPs, scheduling exercises is a real challenge: avoiding school holidays, outages, Fridays, meal times, etc. In addition, operations staff too often take the position of contractors, considering that simulator refresher training is all that is needed.

The main weakness is the lack of training in local manoeuvres. It is indeed necessary to be thorough and practise the finer details, as these can make all the difference: finding the keys and documentation,

correctly performing line-ups, deploying mobile means without wasting time and establishing the right electrical connections. It is not clear whether all local manoeuvre sheets are available, validated and applied during exercises. I ask DPN to check this.

Added to this is a lack of continuous training and practice for field operators. The DPN is aware of this and I believe it is urgent to develop the system, bearing in mind that the field will be onboarded through technical aspects and practice. I particularly appreciate it when sites deploy mobile means during every exercise, whether or not they feature in the scenario.

After exercises or real crises, OPEX must be enhanced by communicating openly and not leaving the EP engineer alone to deal with the identified actions.

At Sizewell B, I commend the involvement of field operators and the fact that local manoeuvres are systematically carried out. On the other hand, casualty management remains a weakness in the United Kingdom.

My trip to Japan impressed me:

- Humility after Fukushima and TEPCO's confession: 'We had neglected man';
- The importance and quality of the emergency arrangements at the Onagawa site I visited. The equipment there is organised into fixed and mobile equipment (the latter being preferred as it is more resistant to hazards and can be reconfigured);
- Permanent on-site presence of crisis teams, specially adapted to a country with difficult access and different operators.

FARN AND BDBUE, OUTSTANDING TOOLS

Based in Civaux, Dampierre, Bugey and Paluel, the FARN has excellent equipment. The team members at the centre I visited take pride in their work, maintain the equipment and train regularly. The national crisis organisation is beginning to consider gradual equipment replacement in the medium and long term.

I found the FARN to have an excellent spirit and a great deal of motivation and drive. Its members believe in their mission. Training is well-defined, practicing is in their DNA, in a wide range of situations. The teams' resilience is tested under adverse and stressful conditions. Real-life crisis response operations (Roya, Martinique, Mayotte) reinforce its operational capabilities and do credit to EDF's public service mission. The FARN has ensured that these operations do not compromise its ability to respond to a nuclear accident that might occur at the same time.

After a temporary dip, staffing levels are returning to the required level. Career paths between sites and FARN are organised in a meaningful way. Care must still be taken to ensure that employees can return after their secondment and make full use of what they have learnt. Medical examinations and fitness requirements are still not harmonised between centres: this has to be addressed without delay.

The main difficulty lies in the lack of interaction between the sites and the FARN. Apart from the annual national exercise, joint training sessions are rare. Management is not sufficiently involved in the lines of command to be established in the event of a FARN operation (see above). The sites are not fully aware of what the FARN can do for them. Conversely, its existence should in no way disengage the sites from their own preparations: the hours before its arrival will be decisive and entirely their responsibility.

I have already expressed my views on the downsides of adding to the FARN's catalogue of missions and on the mistake of including them in the nuclear safety demonstration. This unnatural formalism burdens its work at the expense of its responsiveness. For example, the pressure sensor on a transport container was safety classified; when it failed, it took months of administrative work to replace it.

In the United Kingdom, I visited the Sizewell B BDBUE centre, a few kilometres from the reactor it is designed to rescue. It is also perfectly fitted out and is largely manned by the site. Field operators drive the trucks, deploy the equipment and train in the line-ups, which is impressive. The means for injecting water into the steam generators are noteworthy.

ENGINEERING: SEEK PRACTICAL SOLUTIONS

It is the responsibility of engineering, the driving force behind nuclear safety reports, to better define the scope of nuclear safety demonstrations and to leave room for crisis management (see above). In the field of emergency response, too, a thorough understanding of the realities on the ground, an appreciation of the human factor in operations and sound engineering judgment are essential to ensure real nuclear safety.

The duration required for the necessary post-Fukushima modifications was certainly dictated by the size of the fleet and the industrial capacity constraints. However, spiralling requirements and conservatism also contributed to this. A review of OPEX would be useful, with comparisons to foreign operators.

FIRE PROTECTION

In France, four emergency situations were triggered in 2025 due to fires outside the controlled area: a fire in a transport shuttle, a commercial building and turbine bearings. Lithium-ion batteries probably caused the first two.

In the United Kingdom, no significant fire was recorded check. The low number of confirmed fires should not lead to complacency.



Sizewell B – Beyond Design Back-Up Equipment (BDBUE)

RELENTLESSLY DEVELOP FIRE PROTECTION CULTURE

There is a lack of collective commitment to fire risk control. In the departments, leaders are not doing enough to enforce basic rules and fire safety culture.

During my visits, I meet fire protection supervisors in France who feel somewhat isolated: fire protection must be a shared responsibility for everyone, everywhere! The fire protection rigour plan launched at one site has, in everyone's opinion, transformed the situation.

In France and United Kingdom, relations are good with the local fire brigades.

PREVENTION AND COMPARTMENTALISATION

In France, in terms of prevention, I note that the management of hot work permits has improved. Maintaining their prerequisites need regular checks in the field.

The closing of fire doors varies over time, depending on the site. They sometimes suffer damage, either because they are not handled with care or because of a lack of replacement hardware (hinges, handles, etc.), whose qualification seems to involve unexpected administrative difficulties.

The maintenance of floor drains remains inadequate, although this is mostly a matter of routine monitoring and filling. Outsourcing their maintenance is perhaps not the best way to ensure ownership. I have noticed that they sometimes provide interesting engineering challenges - for example, because door movements drain them due to dynamic containment depression.

Numerous and diverse hopper malfunctions have led to the creation of a task force. The inventory of deviations has now been completed. A few points have proved to be of concern, without being, by far, the majority, and are being put in order. The next step is to schedule full compliance repairs.

In general, the condition of fire protection equipment has improved where independent nuclear safety organisations (INSO) or WANO had highlighted deficiencies. Although difficulties remain, work requests are being better monitored.

In the United Kingdom, at Sizewell B, the DART fix-it-now team has proved effective repairing faults. Real progress has been made, whereas the site was facing challenges. Other British sites continue to struggle with equipment problems, a recurring issue.

In France and the United Kingdom, insufficient control of fire loading is the main weakness. The issue lies in the definition, communication and systematic application of limits in each room. And I continue to observe a tendency to accept oil leaks, for example at the base of diesel engines or in the turbine hall, under the gratings. In addition to discipline, the culture must be embedded, according to the motto 'Justify, limit, evacuate'. Even if the limit is complied with, equipment with a high heat load, such as cable reels, should not continue to be located in a fire zone when no longer needed.

In both fleets, underground firefighting pipes remain an issue to be addressed.

Lithium-ion batteries regularly cause fires. As their use becomes more widespread, particularly in portable tools and handling equipment, it is becoming urgent to define rules and conditions for charging, storage

and extinguishing. I have noted that this is the case at HPC for the charging and storage of portable tools.

IMPROVEMENTS IN FIREFIGHTING

The first response policy seems to be well established in France: the team on duty tackles the fire according to the situation and their skills, without putting themselves in danger. Drills are carried out and are satisfactory, according to professional fire officer reports. I welcome the fact that they are now carried out much more frequently with pressure hoses. New fire gear are being provided.

On-site firemen teams (GOP) are being deployed where the fire brigade cannot guarantee the required response time. Their organisation varies with stations, and it is important to observe how this system works. My visits confirm the impression expressed in my 2024 report: by no longer responding regularly to real fires, firefighters permanently assigned to a GOP risk losing their skills and motivation. I therefore recommend finding ways everywhere to enable GOP firefighters to respond to external incidents and to include this assignment in their career path. Could an industrial site or nuclear qualification also be awarded to motivate them? In addition, it is essential to take advantage of the GOP and their image to strengthen fire safety culture. Their presence in the field, their expert eye and their respect for uniformed firefighters can change minds.

The IFOPSE (Institute for Prevention and Safety Training) centres remain a force to be reckoned with. I also appreciate the efforts made by certain sites to promote volunteer firefighting; Bugey, for example, has around forty volunteers.

In the United Kingdom, Nuclear Operations asks its first responders to apply the same principle to distinguish between the actions they take right away and those that are the fire brigade responsibility. However, inside buildings, employees can only tackle fires that can be extinguished with a fire extinguisher.



IFOPSE - Operations training

AVOID A NEVER-ENDING REVOLUTION OF STANDARDS

Engineering has changed dramatically, moving from traditional flat-rate methods to increasingly sophisticated and systematic calculations. These are supported by R&D testing facilities, which I visited and whose functionality and instrumentation are state-of-the-art. They feed modelling capabilities that have developed significantly.

This evolution is necessary because it corresponds to advances in knowledge of the physical phenomena associated with fires. But it must be controlled in order to avoid drifting away from a recognised framework and falling into a never-ending state of uncertainty. Sophisticated calculations should therefore, as far as possible, be used to validate flat-rate methods rather than being applied to all

specific cases. These methods could be reviewed regularly, which is preferable to constant revolution.

I reiterate my recommendation to stabilise the EPR2 design standards and to consider which assumptions and combinations are excessive and lead to unnecessary complexity.

As part of the 4th ten-yearly inspections (VD4), studies of the risk of sump filter clogging in the event of reactor cooling water recirculation have shown that this phenomenon could be worsened by the adhesive used in the fire protection cable wrapping. The wrapping was therefore removed from the reactor coolant pumps bunkers in the reactor buildings. Faced with two conflicting goals, recirculation and fire protection, I am not sure that the two risks have been equally weighed and that the conservatism of the recirculation safety demonstration has not been favoured.

I note that at Penly 3-4, mobile and temporary fire detection systems will be installed from the start of construction, which is a positive step.

March 1975 in Browns Ferry, Alabama

In the cable deck beneath the control room, workers were reinforcing the seals on hoppers and checking for leaks with a candle to detect air movements. The candle ignited the polyurethane foam used to reseal the joints.

The fire spread to cables on the other side of the wall, in the reactor building. It caused inconsistent signals and spurious alarms in the control room. This led to losing control of some safeguard systems for both reactors and difficulties in returning them to a safe state.

Reactor 1 was severely damaged and shut down for a year. This incident was a milestone in the history of nuclear safety in the United States. It led to the tightening of fire protection standards.

RECOMMENDATIONS

Preparation for accident response is a cornerstone of nuclear safety and its success depends on actions taken in the field. I recommend that the Director of the DPN develop training for local manoeuvres, integrate them into emergency preparedness exercises, ensure that all local sheets are drawn up and approved, simulate interaction with the FARN more often, and further mobilise operations departments.

With regard to fire prevention, the main risk in industrial facilities, I recommend that the Directors of the DPN, Nuclear Operations and the DPPI define rules and methods for the use of lithium-ion batteries, drawing on standards already established by other industries.



Penly EPR2 – Earthmoving work

CHAP 8

EPR, CAPITALISING ON LESSONS LEARNT

Flamanville 3 (FLA3) reached 100% power on 14 December 2025. It is the fourth EPR in operation after the two in Taishan, China, and the one in Olkiluoto, Finland.

The success of a nuclear power plant project depends on the control and sequencing of numerous phases involving multiple players: feasibility study followed by preliminary and detailed design, contracting and implementation plans, construction with site preparation, civil engineering and electromechanical erection, and finally cold and hot testing, loading and start-up before final commissioning. The successful execution of each of these phases is essential to ensure at least 60 years of operation.

In 2025, EPR projects are continuing to move forward with the Sizewell C final investment decision in July, the continuation of earthworks at Penly, and EDF's decision in May and then September to continue preparations for the construction of two pairs of EPR2 reactors at Gravelines and Bugey respectively, following public debates.

FLA3 REACHES 100% POWER

Flamanville 3 (FLA3) is making progress in terms of operating performance. The number of reported events is decreasing, as well as the number of International Nuclear Event Scale (INES) level 1 incidents. The general condition of the plant is excellent, and the equipment is well maintained.

The priorities are to complete the start-up tests, successfully complete the first production cycle, prepare for the first maintenance outage (VC1), plan long-term structural activities and strengthen operating practices. After a major effort to connect the reactor to the grid, the operator had to resolve various technical problems on the primary and secondary systems.

Still in the testing phase and in commissioning mode, the site is struggling to deal with unplanned events while dedicating resources to preparing for the VC1, which is behind schedule.

The national exercise in October 2025 validated the emergency response organisation.

ALIGNING WITH THE NUCLEAR FLEET'S OPERATING STANDARDS

The site is struggling to adopt DPN's operating standards (long-term, outage [AT] and online [TEM]). Some digital tools still differ from those used by DPN. The EAM (enterprise asset management) is only partially populated. The heavy operational workload limits the availability of the modifications and maintenance teams to prepare for VC1. They need to be reinforced. Ventilation, cooling units and boilerwork are the areas experiencing the most difficulties, and their preventive maintenance is likely to be postponed until VC1.

Operations runs a plant that is currently being adjusted and conducts a very comprehensive testing programme. The lessons learnt from

Taishan and OL3 are only partially replicable, which cannot be accounted for by design differences alone. Additional requirements apply to FLA3. This means that the tests must be validated again on a simulator. Edvance engineers seconded to the site, in conjunction with their central management, provide the necessary support. The DT and GECC (core-fuel operation team) have been mobilised and will support the site throughout the first cycle. Specific protocols have been established to simplify the process of making changes to the I&C systems. Its mock-up has to be updated and preserved.

FLA3 and the operational technical unit (UTO) have agreed on the national safety stock of spare parts. Some are still being manufactured. The budget for those still to be ordered must be confirmed.

Waste management is based on a radiological protocol approved by Andra.

GENERAL OPERATING RULES : SIMPLIFY AND ALLOW GREATER FLEXIBILITY

Although better controlled, the general operating rules (RGE) remain too complex and time-consuming for the shift teams and safety engineers (IS). The simplification process has been initiated with the ASNR; the first changes are expected in 2026-2027. Like the RASA/RASI/RASR regulatory requirements for the operating fleet, chapters 2, 5 and 11 should be turned into internal requirements. Changes are expected in chapter 3 (general aspects of the technical specifications) and chapter 9 (testing). We must continue to introduce greater flexibility, correct what can be improved (rules for combining group 2 events), and increase maintenance slots from the second production cycle onwards. Certain technical specifications related to highly improbable scenarios that complicate operations (exemptions, leaving defects on the plant, etc.) need to be simplified.



Bernard Fontana's visit to the Penly 3-4 worksite

Chapters 8 (maintenance) and 9 (testing) are too restrictive. I believe it is necessary to allow for some flexibility rather than relying on exemptions. The inconsistencies between commissioning test procedures and periodic test procedures must be addressed. The qualified service life of equipment should be harmonised with that of the existing operating fleet and the testing rules should be simplified. Chapter 8 suffers from an excessive amount of details and an overly cumbersome amendment process. For example, the reference to instruction memos makes updating them too cumbersome.

SUPPORTING CHANGE

Since the fuel was loaded, DIPDE has been performing the duties of Design Authority. The transfer of activities between Edvance and DIPDE will take place in two stages: after VC1 for civil engineering, design support and compliance, then until maintenance outage 4 (VP4) for design studies and projects. The FLA3 fleet upgrade programme will coordinate the technical projects that have not been completed.

These changes require Edvance staff to be trained in the operational engineering guide (GIOP), to align the FLA3 information system with that of the fleet, and to transfer the 3D model data from the plant design management system (PDMS) as well as Edvance's expertise to the DIPDE. Synergies between DIPDE, EPR-E and Nuclear Services should be considered in order to pool technical improvements.

LIMITING THE END OF COMMISSIONING PACKAGE TO WHAT IS STRICTLY NECESSARY

The end of commissioning package (DFD) must reflect the final state of the plant and capture OPEX from testing and the first operating cycle. Its scope has been simplified in order to limit the review to what is strictly necessary. In agreement with the ASN, it will be necessary to ensure that non-urgent equipment and intellectual modifications (studies, data, etc.) resulting from the DFD are included in the ten-yearly outage cycle.

Given the nuclear safety level of the EPR design, it is important to refrain from conducting the periodic review using the EPR2 as a reference, unless the aim is to create a counterproductive level of complexity.

VC1, AN OVERLOADED PROGRAMME AND DELAYED PREPARATION

VC1 of FLA3, scheduled for autumn 2026, is experiencing preparation delays. The extremely dense programme includes numerous major modifications, including replacement of the vessel head and RRI/SEC heat exchangers, upgrading of the I&C systems and the regulatory inspection and preventive maintenance programme. Regulatory deadlines for pressure equipment (ESP) dictate the outage date.

The large number of ESPs and their simultaneous commissioning date result in a considerable volume of hydraulic tests. A multi-year strategy of exemptions for new equipment should be defined to balance the workload. Inconsistencies in equipment classification,

incomplete ESPN regulations at the time of manufacturing and break exclusion requirement (exclusion de rupture) complicate the planning process.

Access to the service area of the reactor building, although provided for in the design, remains limited in time due to a conservative approach; the polar crane can only be maintained at the start of the outage. I reiterate my request to solve this administrative issue.

The EIP classification of a large number of items of equipment increases the administrative workload. In addition, the delay in online preventive activities could add several hundred activities to the programme.

Finally, the lack of experience of the personnel and the low availability of maintenance teams hamper the planning process.

THE EPR FAMILY: TAILOR-MADE SYNERGIES

EPR operators coordinate with each other: EPROOG (EPR Owner Operators Group) handles shared issues and liaison engineers deal with specific technical topics under bilateral agreements. I believe that these exchanges should systematically include significant safety events. FLA3 has good relations with Taishan, and the exchanges are more open with OL3. I deplore the fact that the EPR family did not decide in the long run to retain the option of a common Responsible Designer (RD), at least at EDF between France and the United Kingdom.

OPEN-LOOP OPERATIONAL EXPERIENCE

Operational experience (OPEX) is centralised by the Departments and Project Performance Division (DSPP) and structured into three categories: critical OPEX, short-term OPEX and on-demand OPEX. The main issues are identified and managed by the projects. However, OPEX is still not taken into account consistently enough. An OPEX hub in each project would help to close the loop more effectively.



Flamanville 3 – Onsite electric power source diesel walkdown

The EPR2 project is consulting FLA3, which is a good thing. However, I think it's a shame that the demands of the schedule and the progress of the project don't always allow the recommendations to be taken into account.

In addition to my previous reports, the OPEX on modifications made to plant settings, operation during the construction phase of the section segregation doors and sharing of the local crisis centre in Flamanville should benefit other projects.

HPC, INDUSTRIALISING MEH ERECTION

A PROJECT THAT IS CONTINUING WITH EVIDENT LEVEL OF SAFETY AND QUALITY



HPC primary
circuit welding

The dome of Unit 2 was successfully installed on 17 August 2025, which marked a major milestone. The learning curve for prefabrication has resulted in a 20 to 30% delivery performance gain between Reactors 1 and 2. Framatome's assembly of the primary system on Reactor 1 is proceeding smoothly. Electromechanical installation (MEH) is starting slowly (see below).

The site has become more densely crowded. Traffic management is becoming more complex and storage space is beginning to run out. Reorganisation between the civil engineering and MEH areas on site is improving logistics and the smooth running of operations. The nature of the risks is changing with the MEH: concurrent activities, welding, work in confined spaces and radiographic inspections. The use of multi-element ultrasonic testing (phased array) is reducing the need for radiographic inspection by 40%. This method should be rolled out on the EPR2.

The standards of the Hinkley Health medical department and the HPC Way are significant contributors to the good health, wellbeing

and safety results and should serve as a reference for the EPR2 construction site.

ACTIVITIES TO BE PUT UNDER CONTROL

The design reached an advanced stage of maturity in 2024 and the project is now monitoring its stability. RD engineering resources (Edvance and CNEPE, the French national power generation equipment centre) will need to be maintained, funded and available until final commissioning. The Joint Design Office (JDO), a structure shared by NNB (Nuclear New Build) and EPR-E, inspired by Taishan project, is an effective means of collaboration. However, its staff are still not sufficiently present on site. It will limit their understanding of construction difficulties and the deployment of rapid solutions (standard field solutions). With regard to configuration control, the implementation of modification instructions by equipment manufacturers (contract transfer sheet) should be secured. Equipment qualification is progressing, but the project is proceeding at risk in a number of areas and it is essential that the equipment qualification risks are closed rapidly e.g. for electrical penetrations and diesels. Controlling P355 NH steel welds requires rigorous qualification of materials, processes and personnel, involving experts from the Industrial Quality and Technical Division.



Hinkley Point C power station

MEH, UNDERSTANDING AND IMPROVING

MEH assemblies are falling behind schedule, and the schedule's details level is not appropriate. The project is falling behind schedule for various reasons, including the impact of Brexit on skilled labour (particularly welders), a lack of equipment, local requirements, the complexity of the project, the absence of a central engineering department within the MEH Alliance (similar to Bylor for civil engineering), insufficient

coordination and a contractual framework that could be improved. The delays are disrupting the sequence and increasing the risk of rework or non-compliance with quality standards.

The turbine hall for Unit 1 has been completed. Relations with Arabelle Solutions are tense due to delays, there are challenges in coordinating tier 2 and 3 contractors, and NNB is refining its working methods in line with its CDM (construction, design and management regulation) responsibilities.

The management of open issues is improving thanks to better categorisation and timely processing. However, EPR-E must limit the creation of new issues by applying the ALARP (as low as reasonably practicable) principle. Configuration control, now shared with NNB via common digital tools, is based on three pillars: design freeze, configuration freeze, and strict change management.

Created two years ago, EPR-E has matured. The workforce is stabilising, with less reliance on external contractors. EPR-E's JDO oversees the implementation of field solutions via integrated response teams. Efforts are focused on priority geographical areas and boiler work. The future division of engineering responsibilities between EPR-E, Nuclear Services and CNEPE will need to be clarified.

SCALING MAINTENANCE STAFFING BASED ON FLA3 OPEX

The priority of the project is to ensure that erection ramps up. The organisation will then need to be adapted according to a system-based approach. The commissioning teams are organising themselves with a view to the first start-up tests of the auxiliary transformer in 2026.

The maintenance resource forecast remains unchanged and well below that of FLA3 and Taishan. I encourage HPC to consult with FLA3 to confirm the appropriate staffing level.

SHARING OPEX

Civil engineering activities are under control, with a significantly beneficial learning effect on reactor No. 2 thanks to modular construction, which is expected to reach 60%. Innovations from partners at all levels must be harnessed. HPC is still insufficiently contributing to the OPEX project of the DPC construction project management team. The Bridge project aims at transferring expertise from FLA3 to HPC and then to the EPR2s. To this end, career paths will need to be managed over the long term. Finally, the concurrence of the EPR2 and Sizewell C (SZC) projects must be leveraged to share best practices.

SIZEWELL C, LET'S REPLICATE!

The SZC project partnership was finalised on 22 July 2025, with the final investment decision taken jointly by EDF, the British government, La Caisse, Centrica and Amber Infrastructure. The engineering contract, nuclear service agreement, came into force in early January 2025. The road infrastructure improvements are tailored to the size of the construction site. The Group plays a central role as a supplier of engineering and equipment: nuclear steam supply system, nuclear safety I&C and turbo-generator set.

With the mobilisation of nearly 40 French suppliers, the project strengthens our industry via skills reinforcement, leveraging of OPEX, economies of scale, etc.

REPLICATING AND LEVERAGING OPEX

The design's maturity and the low number of modifications make the project a safe bet. The replication rate is high and developments are under control. This is a good thing. Engineering methods and processes have been adapted and differ from the traditional V-model.

EPR-E teams are structured by specialties. Edvance is transferring its activities to them. The independent safety oversight body (Independent Nuclear Safety Oversight) is fulfilling its role. Equipment manufacturing has begun, avoiding any disruption to the workload, while OPEX from HPC has been fully taken on board. However, environmental and regulatory constraints in the areas of fire protection, civil engineering and supply chain could compromise standardisation. These will need to be rigorously managed by careful application of the ALARP principle. All stakeholders, including Nuclear Services intelligent customer through a delegation, the regulator and shareholders, must ensure that priority is given to this standardisation, which guarantees project control and quality of execution.

The maturity of HPC documentation is essential for replication. Minor adaptations and modifications must be rigorously tracked and communicated. Success will depend on the compatibility of information systems.

STRENGTHENING SYNERGIES

Although progress is being made in managing the interfaces between the Sizewell B (SZB) and SZC sites, greater attention should be paid to certain safety-sensitive interaction issues (potential effects on the SZB heat sink and other examples mentioned in my 2024 report). Potential synergies in the areas of logistics, environment, safety, flood protection and emergency preparedness should be considered. Nuclear Services ensures technical consistency between the plants of Nuclear Operations, HPC and SZC. I believe that the concept of a single operator for a standardised fleet should be endorsed. SZC, a member of WANO and EPROOG, is strengthening its cooperation with HPC and SZB to develop synergies and avoid counterproductive competition.

EPR2, SIMPLIFYING AND STABILISING STANDARDS

SIGNIFICANT PROGRESS



In March 2025, the Nuclear Policy Council established the main principles for financing and regulating the EPR2 programme. In January, the French government published a decree declaring the project to build two EPR2 reactors at Penly to be in the public interest and issued the environmental permits. Earthworks are proceeding



EPR Family

as planned. By 2030, nearly 10,000 people in around 100 different disciplines are expected to be working on the site.

Following public consultations, EDF decided in May 2025 to continue preparations for the construction of a pair of EPR2 reactors in Gravelines and in September in Bugey. In Gravelines, EDF and its partners are considering several types of soil reinforcement depending on the structures: embankments, soil mixing (incorporation in the ground of a cement-type binder), and rigid inserts. EDF has carried out an initial series of geotechnical tests and poured testing rigid inserts. Other types of structural reinforcement are currently being studied. The specific properties of the soil and the proposed reinforcement require a specific assessment of the seismic behaviour.

STABILISING THE STANDARDS

The stability of technical and regulatory standards is crucial to the success of the project. It provides visibility, and the repetition of

activities enables progress to be made. Care must be taken to limit changes to what is strictly necessary, at least during the design and construction period for the first six EPR2 reactors.

To ensure the competitiveness of the programme, a Task Force has been set up to reduce the construction time to 70 months. The project is also working on construction standards simplification. Improving lead times will help to keep costs under control. This will require adapting our processes and manufacturing quality.

Finally, the EPR2 project will move from an engineering project management mode to an execution project mode. This change will need to be supported.

Success will depend even more on the effective management and sharing of data between EDF and its partners than on digital tools. Shared data, shared indicators and integrated scheduling promote



DISC - digital design tools

rapid and consistent decision-making. EDF and the industry are working on extended business operations to enhance their systems' interoperability.

SUCCEEDING TOGETHER

The success of the project depends first and foremost on moving away from a purely prescriptive approach towards a project-based approach with milestones shared by all stakeholders. Our engineering remains too siloed and project management and technical authority need to be reinforced. The increasingly complex regulatory framework ties up skilled resources in administrative tasks, such as opening FACR sheets and NACR memos analysing the regulatory framework during the design phase for any change or deviation, at the expense of higher value-added activities.

To strengthen cooperation, EDF and Gifem (French Nuclear Energy Industrialists Group) signed a performance agreement on Penly in July 2025. Manufacturers are asking for greater visibility on the subcontracting model and access to OPEX. EDF's organisation lacks clarity and relations would benefit from being more partnership-based.

The Engineering and Construction Projects departments (DISC and DPC) are working on career paths: placement at NPPs, mobility from engineering to worksites, the Bridge project, etc. To design effectively, it is necessary to have experience as an operator. Career paths incorporating an operations period to learn about reactors and develop a common culture still need to be organised.

LEVERAGING OPEX

OPEX from the operating fleet should better benefit New Nuclear Build projects. The engineering platforms set up by DISC will facilitate exchanges, provided that collaboration between DIPDE and Edvance is strengthened. The EPR2 programme will need to take into account HPC's OPEX on MEH and harness the benefits of modular

construction. The Constructeur working group, whose mission is to share this information, will need to demonstrate its effectiveness.

DEVELOPING DIGITAL SOLUTIONS FOR CONSTRUCTION

The EPCC transformation programme should lead to new developments, whilst the needs of the Penly construction site are intensifying. Users must specify their requirements to DSIN, which must speed up the delivery of tools. The IS ecosystem will have to guarantee data continuity up to the operating organisation.

The functionalities of 3DX, whose document module has been split off, are stabilising. Modifications management and the transfer of technical specifications to suppliers should be more data-centric to ensure better control.

To operate as an extended business, EDF and its partners are equipping themselves with the Data4NuclearX data exchange hub, which will enable nearly 2,000 companies to securely and independently share design, maintenance and construction information for all projects.

RECOMMENDATIONS

I recommend that the Director of the DPN intensifies support for the FLA3 site to meet operating standards (long-term, Outage, Online) and, if necessary, request exemptions from the ASNR for hydraulic testing of new equipment.

To ensure erection quality required for Hinkley Point C MEH nuclear safety, I recommend that the Director of the DPPI identifies and addresses organisational and contractual hurdles, and uses the OPEX for the Sizewell C project and the EPR2 programme.



Orano spent fuel processing plant, La Hague site - Spent fuel storage pool.

CHAP 9

REASSERT NATIONAL SOVEREIGNTY BY CLOSING THE FUEL CYCLE

Nuclear power is founded on two inseparable pillars: reactors and fuel. It is necessary to have the right fissile materials, know how to use them in a reactor, and then manage spent fuel with future generations in mind.

Established in the 1960s on scientific grounds and backed by solid experience (reprocessing, fast neutron reactor - FNR, MOX), the strategy of closing the fuel cycle with a view to ensuring complete supply continuity has been somewhat neglected, and we can only welcome its revival by the Nuclear Policy Council (CPN).

Developing FNR technology and the associated fuel cycle will require investment in a comprehensive set of R&D resources and test facilities, including reactors.

This chapter is written with a special thought for Joël Guidez, a leading expert and unquestionable champion of FNRs, who passed away on 28 October 2025.

UNAVOIDABLE PLUTONIUM

A CURSE OR A GIFT FROM NATURE?

Uranium-235 (U235) is the only naturally occurring fissile element³ and accounts for only 0.7% of uranium, with the remaining 99.3% consisting of uranium-238 (U238). Although it cannot sustain a chain reaction, U238 can convert into fissile material: by capturing a neutron, it produces plutonium 239 (Pu239), which is fissile⁴.

Thus, in a pressurised water reactor (PWR) loaded with slightly enriched uranium fuel (UNE with 3 to 5% U235), U238 is converted into Pu239, part of which undergoes fission and participates in the chain reaction. This Pu239 provides approximately one third of the energy produced during the operating cycle. Plutonium is therefore inseparable from the use of uranium. In the public mind, Pu's military origins have given it a bad reputation. However, its use in power reactors of the type we use (PWRs) makes it unsuitable for any military use. Overall, non-proliferation issues are treated with the utmost seriousness.

The high radiotoxicity of Pu requires special precautions, which operators are well versed in. If it were to be stored among waste, it would dominate the long-term radioactivity of the waste.

Yet, it is a fissile material with high energy value and provides a means of benefiting from the 99.3% of non-fissile U238 in natural uranium. Transforming France's existing U238 stocks into plutonium would be enough to make us self-sufficient for thousands of years. This requires adapted reactors and nuclear fuel cycle facilities.

³ An isotope that can undergo fission by capturing a slow or fast neutron is called fissile.

⁴ The same is true of thorium, which is not fissile but fertile. When placed in a reactor, it transforms into fissile U233. The thorium cycle has both advantages and disadvantages. In France, switching to thorium would mean building a radically new fuel cycle and losing most of the technical expertise and industrial investment that has already been acquired.

Isotopes and neutrons

Fission emits high-energy neutrons. If they are slowed down by a moderator (water, graphite), this is referred to as a thermal spectrum (PWR, AGR, etc.), and if they are not slowed down, it is referred to as a fast spectrum (FNR). The thermal spectrum enhances the fission of U235 and Pu239, while the fast spectrum enhances neutron multiplication and the fission-to-capture ratio.

In a reactor, Pu239 is transformed into Pu240, then 241, 242, and minor actinides (americium, curium, etc.); Pu238 is also formed. In the thermal spectrum, even-numbered isotopes (Pu238, 240, 242), which are not fissile, are detrimental and their proportion increases with irradiation: the 'isotopic vector' deteriorates. In the fast spectrum, all isotopes can fission and the fission-to-capture ratio is better: the vector stabilises at suitable values, compatible with subsequent use in PWRs.

Examples of isotopic vectors:

- spent PWR UNE fuel (2.8% Pu238, 55.5% Pu239, 25.4% Pu240, 7.7% Pu241, 7.5% Pu242)
- spent MOX fuel in PWRs (4.2% Pu238, 42.6% Pu239, 33.2% Pu240, 6.3% Pu241, 12.7% Pu242)

MOX IN PWRs, THE FIRST STEP TOWARDS CLOSING THE CYCLE

At La Hague plant, spent fuel is separated into uranium (known as reprocessed uranium or URT), plutonium and final waste (fission products and minor actinides which are 4% of the total, and processed into highly stable glass for final storage). Reprocessing at La Hague reduces the number of spent fuel assemblies to be stored by up to three-quarters and optimises the volume of waste.

The Melox plant in Marcoule uses this plutonium to manufacture MOX fuel (mixed uranium and plutonium oxides): mixed with depleted

uranium, the plutonium replaces U235. MOX has been used in France since the 1980s and has a long track record. It saves 10% of natural uranium. MOX consumption determines the volume of reprocessing at La Hague.

As certain Pu isotopes absorb neutrons (Pu240, Pu242), the Pu content of MOX fuel assemblies (8 to 9%) must be higher than that of U235 in conventional fuel assemblies (4%). The use of MOX requires specific nuclear safety measures:

- compliance with a Pu content limit;
- addition of control rods and increased boron content;
- adjustment of protection thresholds and control systems, as Pu239 is more reactive than U235.

MOX and nuclear safety

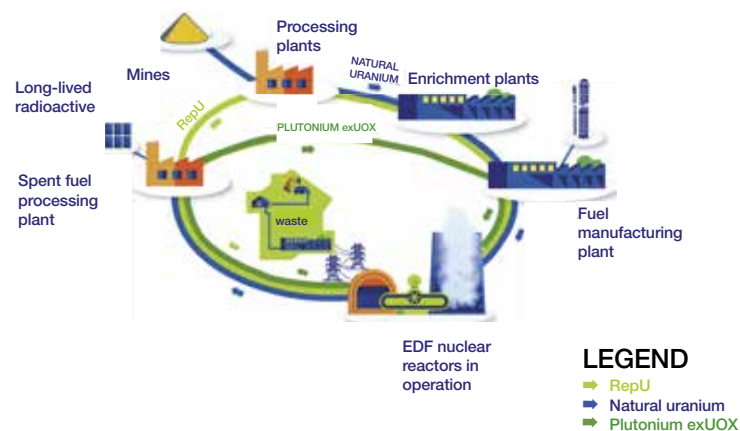
In PWRs, even-numbered isotopes of Pu (240, 242) absorb neutrons. In the event of a loss of water in the reactor coolant system, neutrons are no longer slowed down, even-numbered isotopes no longer absorb them, and they even undergo fission, which increases reactivity. The greater the Pu content, the higher the effect. The Pu content of MOX fuel assemblies must therefore be limited (<12%) in order to ensure core stability in the event of water loss (negative void coefficient).

In addition, the MOX neutron spectrum is slightly more energetic and faster than that of UNE. As control rods and soluble boron less absorb the fast neutrons, their relative efficiency decreases and some rods must be added and the boron content increased (within limits to maintain a negative moderator coefficient).

Since Pu fissions are associated with a lower fraction of delayed neutrons and a shorter neutron multiplication time, the core is more reactive.

In recent years, production issues at the Melox and La Hague plants have limited the supply of MOX to EDF's nuclear power plants. These issues are currently being resolved ([see 2024 report](#)).

Around forty reactors worldwide have used MOX, in the United Kingdom, Belgium, Germany, Switzerland, Japan and France.



Fuel cycle

In France, it is used in 22 of the 900 MWe reactors. Operating cycles last one year and studies are well underway to extend them to 16 months (CAMOX project). Precursor fuel assemblies are being tested in a 1300 MWe reactor to make this option available. No significant difficulties have been reported. The EPR2 generation will be able to use MOX.

URT: A NATIONAL URANIUM MINE

URT, produced from the reprocessing of spent fuel at La Hague, contains approximately 1% U235, which is more than natural uranium. It can be re-enriched to produce fuel. The Cruas reactors operate on URT. Eventually, it is projected to be used in ten of the 1300 MWe reactors.

The presence of other uranium isotopes in URT gives it some specific characteristics. Radioactive U232 imposes radiation protection constraints in fuel cycle facilities. U236 absorbs thermal neutrons, and measures similar to MOX must be taken in reactors.

Because of U232, the conversion of URT, a preliminary step to enrichment, can only be carried out currently in Russia; a European solution is in the pipeline. Enrichment can be carried out in Europe at Urenco or in Russia. The Framatome plant in Romans has been modified to manufacture URT-based fuel assemblies.

MULTI-RECYCLING MOX IN PWRs: AN OPTION FOR TRANSITIONING TO FNRs

In a PWR, multiple recycling of plutonium degrades the Pu isotopic vector. To compensate, either the Pu content must be increased or enriched uranium must be added. The first option has inherent nuclear safety limitations, while the second reduces uranium savings. Furthermore, the quantity of minor actinides derived from Pu increases.

The idea of recycling MOX multiple times in PWRs (MREP), promoted as a solution for closing the cycle after the shutdown of Astrid, a prototype sodium-cooled fast neutron reactor, has matured. However, this could only be a temporary solution and FNRs will ultimately be necessary to close the cycle. The characteristics of multi-recycled MOX-MR have also evolved: similar to current MOX, Pu levels would be of the same order, with moderate isotopic vector degradation offset by a higher proportion of MOX in the core (currently 30%).

INDISPENSABLE FNRs

MAKING THE MOST OF ALL PLUTONIUM AND U238

Using all of the accumulated plutonium, rather than storing it as waste in the long term, requires fast neutron reactors. They are even more essential for recovering all of the U238 and eventually eliminating the need for natural uranium supplies. In the national strategy, combined



Orano La Hague – Remote manipulation

This option does not prevent the subsequent use of this plutonium in FNRs. It allows for some additional uranium savings. On the other hand, as multi-recycled MOX is hotter and more radioactive, its final storage should be avoided, hence the importance of its future use in FNRs.

with the corresponding nuclear fuel cycle facilities, FNRs represent a powerful asset in terms of sovereignty.

They are the only reactors capable of fissioning all plutonium isotopes. They can also improve its isotopic vector, making it suitable for use in PWRs once again. And they are the only reactors that can be iso or

fast breeder reactors (producing as much or more Pu239, via U238, than fissile material is consumed).

This is what led Enrico Fermi to declare, as early as 1945, that *“the country that first develops a fast breeder reactor will have a great competitive advantage in atomic energy”*.

AND YET, WATER REACTORS PREVAILED

Despite Fermi, thermal neutron reactors have dominated the global nuclear industry until now. There are two main reasons for this: the abundance of natural uranium and the technical, industrial and financial success of light water reactors, including PWRs. In a world of abundance and low ore prices, these ‘simple’ and robust machines have won everyone over, even though they utilise less than 1% of natural uranium.

SPECIFIC NUCLEAR SAFETY CONSIDERATIONS

The specific nuclear safety considerations for FNRs relate to their neutron physics and coolant. The cross sections (fission probabilities) are much lower than in thermal spectra, requiring an increase in fissile material density, i.e. plutonium content (around 20%) and core compactness, as well as a higher neutron flux. The latter places greater demands on the materials. The power density requires increased cooling performance. In other words, the core is more ‘boosted’.

From a neutronics point of view, the design must guard against the risk of incidental compaction of the core, which would lead to a reactivity accident. Similarly, it is necessary to prevent the drainage of all or part of the coolant (boiling, passage of a gas bubble) from causing an uncontrolled power excursion. The aim is therefore, on the one hand, to reduce this risk to a highly improbable level and, on the other hand, to design cores with a negative overall drainage coefficient. In addition, FNRs benefit from two favourable neutronics effects:

- fission products absorb very few fast neutrons, unlike thermal neutrons, which simplifies control (no xenon effect, for example, which is a major advantage);
- when power or temperature increases, the core expands and reactivity decreases.

The need for coolants that do not slow down neutrons and cool very efficiently has led to the use of liquid metals, mainly sodium and lead. They offer excellent cooling capacities, high thermal inertia and boiling margins, as well as very good natural convection and passive cooling properties. It is not necessary to pressurise the reactor. The disadvantage of sodium is its violent reaction with water (in the event of a leak in the steam generators, for example), while that of lead is metal corrosion. Due to its mass and its effect in the event of an earthquake, lead can only be used in small reactors. Liquid metals are opaque and require special operating and in-service inspection arrangements.

FNRs, fast breeder reactors and nuclear safety

Only FNRs can be fast breeders because only the fission of Pu239 in a fast spectrum provides a neutron that sustains the chain reaction, another that transforms U238 into Pu239, and a sufficient fraction of neutrons to compensate for leaks and unnecessary absorption.

In terms of nuclear safety, sodium drainage has two opposing effects. On the one hand, as the coolant captures or slows down neutrons very slightly, its disappearance increases the energy of the flux, bringing it into areas of the spectrum where captures decrease and fissions increase. On the other hand, draining increases neutron leakage, slowing down the chain reaction. In the centre of the core, the first effect prevails, while on the periphery, the second effect prevails. The overall effect depends on the size and design of the core. Astrid, for example, aimed for an overall negative coefficient.



Cycle closure

THE RICH HISTORY AND NEW MOMENTUM OF FNRS

Globally, FNRS have a total of 400 years of reactor experience. Sodium reactors are the most common type.

Starting in the 1950s and 1960s, the United States, Great Britain, Germany and Russia, followed by France and Japan, developed FNRS. The first power reactor, in 1951, was an FNR: EBR1, at the Idaho site in the United States.

The United States, whose last FNR shut down in 1994, is now showing clear momentum through confident, well-funded start-ups that can count on the powerful research centres of the Department of Energy. However, reprocessing has been banned in the United States since the Carter administration: this will undoubtedly be a topic for discussion in the coming years.

In Russia, FNRS have long been part of the landscape. In Beloyarsk, the BN 600 has been supplying the grid since 1980 and the BN 800 since 2016. A BN 1200 is in the pipeline, as well as a lead-based

FNR called Brest 300. Japan has reaffirmed its strategy of FNR and spent fuel reprocessing, in an approach very similar to ours; the long-standing cooperation between the two countries is strong. China is showing ambition in this area also, and the CFR 600 has been connected to the grid. India is also interested.

In Europe, Belgium is conducting R&D on lead-cooled FNR. As partners in Superphénix, the Italians have retained a certain level of expertise, which they are applying to Newcleo, a small fourth-generation lead-cooled AMR (Advanced Modular Reactor).

FROM THE VALLÉE DES PILES TO SUPERPHÉNIX AND ASTRID: A FRENCH STRENGTH

Conceived by leading scientists, led by outstanding engineers, initiated and supported by the State, overseen by the General de Gaulle, and backed by Euratom, the French FNR reactor programme was built on a comprehensive testing programme. This programme addressed scientific, technical and industrial issues that had been carefully identified in advance. The result was a remarkable set of testing facilities covering fuel and its cycle, sodium, core physics, thermo-hydraulics, materials and nuclear safety: Atalante, Esmeralda, Masurca, ATPu, TOR, LECA, sodium loops, Cabri, Scarabée, Rapsodie, Phénix and Superphénix reactors, etc. Marcoule and the Cadarache Vallée des Piles were the focal points of this work.

The technical successes were considerable and many problems were solved thanks to this meticulous and progressive approach. In terms of fuel, the entire cycle was demonstrated: semi-industrial manufacture of cores, increased burn-up rates through successive improvements in Phénix, demonstration of fast breeding, reprocessing and production of new cores. The Phénix exchangers had to be replaced and the reactor experienced multiple sodium-water reactions, without consequences: thanks to this operational experience, there were none on Superphénix.

These are just a few examples of a history of valuable achievements, which came to an end in 2019 with the decision to terminate the

Astrid project. Superphénix taught us a great deal, but not enough in terms of fuel and material irradiation due to its premature shutdown in

1997. As for Phénix, which operated for forty years until 2009, it provided a wealth of data.



Sodium school

IMPLEMENTING THE NUCLEAR POLICY COUNCIL'S GUIDELINES

LET'S GIVE OURSELVES THE MEANS TO ACHIEVE SOVEREIGNTY

In a world of increasing geopolitical uncertainty, it is strategically important to be able to ultimately utilise the full potential of our U238 reserves and avoid importing natural uranium. Closing the cycle will enable better use of raw materials and waste reduction.

In March 2025, the CPN confirmed its intention to close the cycle in the second half of the century and relaunched a work programme to this end. Acknowledging the significant technological developments required in the areas of fuel, reprocessing and reactors, the CPN asked stakeholders in the industry to propose a work programme and organisational structure.

Having met with these stakeholders (EDF, Orano, CEA, Framatome) and visited several sites, I welcome the spirit of collaboration that underpins this work. The aim is to build a coherent set of industrial building blocks (reactors, fuel, reprocessing) whose implementation schedule can be adjusted according to the geopolitical context and available uranium resources.

State-driven programme supervision will be essential. It will need to be strong in order to maintain consistency between the cycle and the reactors, to monitor resources and to foster the necessary R&D.



CEA Phénix

FIRMLY ANCHORING REACTORS AND THE CYCLE TOGETHER IN THE LONG RUN

A clear and structured vision of the cycle is shared, projecting it into the long term: this work is to be praised, as are the ongoing investments in the La Hague and Melox plants. The successful replacement of the evaporators at La Hague, a project that came in on budget (€1bn) and on schedule, bodes well.

The durability-resilience programme has been launched. It aims to extend the operating life of La Hague and Melox and make them resilient in the event of unforeseen and prolonged unavailability of a major component. Located in La Hague, the engineering department is close to the equipment and the operator, which is an asset.

Studies and engineering for the Aval du Futur programme are launched. During my visits to Orano and the CEA, I was pleased to see that the technological choices that will need to be made and the associated R&D (for example, for reprocessing MOX) have been clearly identified. The manufacture of FNR fuel and its reprocessing are only options so far, but I believe they are central to completing the cycle, even if the timeframe is a long way off and the financing not yet secured.

The roadmap towards a future industrial FNR seems highly preliminary.

What will be the proportion of FNR and PWR at the end of the 21st century? The aim is to be able to adjust this according to the needs in terms of energy sovereignty, stabilisation of the Pu isotope vector and waste management. The choice may be to have a fleet with a large number of FNRs to do without uranium, with fewer FNRs



CEA Cadarache – Sodium test loop

to recycle Pu between PWRs and FNRs, or with only one or a few FNRs to have the option available.

SKILLS FOLLOWING THE END OF SUPERPHÉNIX AND ASTRID

Launched a dozen years after Superphénix was shut down, the Astrid project remobilised expertise that was still substantial, began training a new generation of engineers, and invested in some testing facilities. Its termination had consequences, even though some R&D work continued. The generation that designed, built and operated fast breeder reactors is fading away; most testing facilities have closed and France has not had a fast breeder reactor since 2009. The amount of data available is considerable and the experience gained from Phénix has been carefully recorded. The IRESNE institute at the CEA has made a significant effort to collect and disseminate this information, including MOOCs featuring interviews with experts. However, in this field too, practical experience remains irreplaceable.

AMRS AS DRIVERS OF IDEAS, SKILLS AND TECHNOLOGIES?

The momentum of start-ups is appealing and brings a breath of fresh air to an industry whose inherently rigorous framework has turned into a real impediment. At last, we can innovate and stop slowing down! Young people are immersing themselves in reactor physics, calculating systems and tackling difficult technical questions. But ultimately, only building systems, test loops, test reactors and prototypes will give substance to this breeding ground for the development of skills and technologies.

Fortunately, fuel, fuel cycle and fissile materials matters have found their way into the landscape. The extent to which AMR FNRs could meet the goals of Pu recycling and sovereignty and scale up to industrial levels remains to be investigated closely.

Start-ups, beneficial as they may be, cannot alone undertake the research necessary to develop FNRs that will enable large-scale closing of the cycle. Nuclear power cannot do without a very solid public R&D infrastructure.

BUILDING A ROBUST SET OF TESTING CAPABILITIES

Even though we have already done so, building FNRs and their fuel cycle will require significant resources. However valuable they may be, not everything can be found in reports and the 'Phoenix treasure'.

FNRs are high-power-density machines with intense neutron flux and demanding core physics. Their materials and fuels must be tested in a test reactor, especially since an industrial reactor must be efficient, optimised and safe. Technical success also dictates nuclear safety and we cannot rely solely on models.

If the core differs from previous designs, a core criticality test facility will probably be required, and if the fuel changes, a Cabri-type reactor for testing reactivity excursions will probably also be needed. In all cases, the fuel will have to be irradiated in a reactor before it can be qualified for industrial use. The type and power of this test reactor will have to be defined. The materials will also have to be tested in fast flux and the large components in sodium loops, on a sufficient scale.

Developing a new fast neutron technology, within a timeframe compatible with our energy sovereignty targets, requires rigorously defining the necessary testing resources, without dead ends or delays. Any solid and sustainable nuclear programme is based on a backbone of R&D, a range of testing facilities and public funding.



Flamanville 3 power station



APPENDICES

RESULTS FOR THE NUCLEAR FLEET

EDF SA
EDF ENERGY

KEY DATES FOR THE NUCLEAR UNITS

EDF SA
EDF ENERGY

THE NUCLEAR SITES

EDF SA
EDF ENERGY
FRAMATOME

TABLE OF ABBREVIATIONS

RESULTS FOR THE EDF SA FLEET

N°	Indicators	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1	Number of significant nuclear safety events graded 1 or greater on INES per reactor ¹	0,98	1,12	1,28	1,45	1,4	1,3	1,4	1,2	0,9	1,2
2	Number of significant nuclear safety events (0 or greater on INES) per reactor ¹	9,78	11,59	12,6	12,7	12,4	12,9	12,2	12,7	12,6	13,3
3	Number of significant events per reactor • Non-compliance with technical specifications • Reactivity	1,48 -	1,41 0,9	1,69 0,7	1,8 0,9	1,5 0,6	1,5 1,0	1,5 0,7	1,1 0,7	1 0,7	1,1 0,36
4	Number of alignment errors ² per reactor	1,64	1,78	1,24	1,4	1,3	1,1	1,3	1,32	0,98	1,03
5	Number of trips per reactor (for 7,000 hours of criticality ³) • Automatic • Manual	0,48 0	0,38 0,04	0,31 0	0,53 0,03	0,29 0,04	0,53 0	0,36 0,02	0,32 0,04	0,54 0	0,42 0,02
6	Average operational collective dose per nuclear unit in service (in man-Sv)	0,76	0,61	0,67	0,74	0,61	0,71	0,67	0,72	0,75	0,68
7	Exposure of individuals: • Number of individuals with doses above 20 mSv • Number of individuals with doses between 16 and 20 mSv • Number of individuals with doses between 14 and 16 mSv	0 0 1	0 0 0	0 0 1	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0
8	Number of significant radiation protection events	117	131	170	171	173	108	140	141	108	118
9	Availability (%)	79,6	77,1	76,5	74	71,9	72,9	58,1	67,3	74,15	77,1
10	Unplanned unavailability (%)	2,02	3,26	3,7	3,95	5	4,55	2,36 ⁵	3,69 ⁵	3,9	2,9
11	Occupational accident rate Tfg (per million hours worked) ⁴	2,8	2,2	2,3	3,3	2,9	3	3,1	3,1	3,6	3,6
12	Occupational accident rate LTIR (per million hours worked) ⁴	-	-	-	2,4	2,2	2,2	2,0	2,0	2,0	2,2

¹ Excluding 'generic' events² Any configuration of a system or its utilities that deviates from the expected situation and is a cause of a significant event (statistical data reviewed in 2018)³ Average value for all reactors, excluding external causes, unlike the WANO parameter which is based on the median value⁴ Accident rate for EDF SA and its contractors⁵ Data doesn't include CSC (8,3% in 2022 and 4,18% in 2023, CSC included)

RESULTS FOR THE EDF ENERGY FLEET

N°	Indicators	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1	Number of significant nuclear safety events graded 1 or greater on INES per reactor ¹	0,27	0,47	0,53	0,27	0,07	0,47	0,13	0,27	0,20	0,13
2	Number of significant nuclear safety events (0 or greater on INES) per reactor ¹	10	6,13	5,93	6,73	5,47	6,2	5,53	5,27	6,27	6,87
3	Number of cases of non-compliance with technical specifications per reactor	0,8	0,6	0,6	0,67	0,87	0,53	0,6	0,47	0,47	0,33
4	Number of alignment errors ² per reactor	3,13	0,93	1,67	1,67	1	1,33	1,2	1,47	1,07	1,07
5	Number of trips per reactor (per 7,000 hours of criticality ³) • Automatic • Manual	0,3 0,42	0,49 0,37	0,89 0,20	0,56 0,32	0,35 0	0,63 0,27	0,49 0	0,23 0,12	0,12 0,24	1,09 0,41
6	Average operational collective dose per nuclear unit in service (in man-Sv) • PWR • AGR	0,544 0,021	0,296 0,02	0,096 0,05	0,255 0,032	0,031 0,013	0,383 0,012	0,028 0,015	0,719 0,014	0,309 0,013	0,054 0,013
7	Exposure of individuals: • Number of individuals with doses above 20 mSv • Number of individuals with doses between 16 and 20 mSv • Number of individuals with doses between 14 and 16 mSv	0 0 1	0 0 0	0 0 1	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0
8	Number of significant radiation protection events	20	10	23	28	26	29	18	19	8	10
9	Availability (%): • EDF Energy fleet • PWR • AGR	83 82 83,1	81,6 83,8 81,2	76,1 89,4 74	65,8 80,6 63,5	61,7 99,4 55,9	60,4 64,2 59,7	77,9 98,7 73,1	73 73,7 72,8	72,7 84,6 69,6	64,2 98,9 55,4
10	Unplanned unavailability (%): • EDF Energy fleet • PWR • AGR	5,1 0,1 5,8	5 0 5,7	3,1 2,2 3,3	4 0,2 4,7	5 0,6 6,2	12,3 0 14,3	4,8 1,3 5,9	4 0,6 4,9	12,1 0 15,3	17,1 1,1 22,8
11	Occupational accident rate LTIR (per million hours worked) ⁴	0,3	0,2	0,5	0,3	0,3	0,3	0,5	0,3	0,8	0,37
12	Occupational accident rate TRIR (per million hours worked) ⁴	0,7	0,4	1,1	1,0	0,7	0,5	0,8	1	0,9	0,74

¹ Excluding 'generic' events (ones due to shortfalls in design)

² Any configuration of a system or its utilities that deviates from the expected situation and is a cause of a significant event

³ Average value for all reactors, unlike the WANO parameter which is based on the median value

⁴ Accident rate for EDF Nuclear Generation and its contractors

KEY DATES FOR THE EDF SA NUCLEAR UNITS

Year in service	Nuclear unit	Power in MWe*	VD1	VD2	VD3	VD4
1977	Fessenheim 1 CP0	880	1989	1999	2009	N/A
1977	Fessenheim 2 CP0	880	1990	2000	2011	N/A
1978	Bugey 2 CP0	910	1989	2000	2010	2020
1978	Bugey 3 CP0	910	1991	2002	2013	2023
1979	Bugey 4 CP0	880	1990	2001	2011	2020
1979	Bugey 5 CP0	880	1991	2001	2011	2021
1980	Dampierre 1 CP1	890	1990	2000	2011	2021
1980	Dampierre 2 CP1	890	1991	2002	2012	2022
1980	Gravelines 1 CP1	910	1990	2001	2011	2021
1980	Gravelines 2 CP1	910	1991	2002	2013	2023
1980	Gravelines 3 CP1	910	1992	2001	2012	2022
1980	Tricastin 1 CP1	915	1990	1998	2009	2019
1980	Tricastin 2 CP1	915	1991	2000	2011	2021
1980	Tricastin 3 CP1	915	1992	2001	2012	2022
1981	Blayais 1 CP1	910	1992	2002	2012	2022
1981	Dampierre 3 CP1	890	1992	2003	2013	2023
1981	Dampierre 4 CP1	890	1993	2004	2014	2024
1981	Gravelines 4 CP1	910	1992	2003	2014	2024
1981	St-Laurent B1 CP2	915	1995	2005	2015	2025
1981	St-Laurent B2 CP2	915	1993	2003	2013	2023
1981	Tricastin 4 CP1	915	1992	2004	2014	2024
1982	Blayais 2 CP1	910	1993	2003	2013	2023
1982	Chinon B1 CP2	905	1994	2003	2013	2023
1983	Blayais 3 CP1	910	1994	2004	2015	2024
1983	Blayais 4 CP1	910	1995	2005	2015	2025
1983	Chinon B2 CP2	905	1996	2006	2016	2026
1983	Cruas 1 CP2	915	1995	2005	2015	2025
1984	Cruas 2 CP2	915	1997	2007	2018	2027
1984	Cruas 3 CP2	915	1994	2004	2014	2024

VD1: First ten-yearly inspection outage
VD2: Second ten-yearly inspection outage
VD3: Third ten-yearly inspection outage
VD4: Fourth ten-yearly inspection outage

Year in service	Nuclear unit	Power in MWe*	VD1	VD2	VD3	VD4
1984	Cruas 4 CP2	915	1996	2006	2016	2026
1984	Gravelines 5 CP1	910	1996	2006	2016	2026
1984	Paluel 1 P4	1330	1996	2006	2016	2026
1984	Paluel 2 P4	1330	1995	2005	2018	2026
1985	Flamanville 1 P4	1330	1997	2008	2018	2028
1985	Gravelines 6 CPY	910	1997	2007	2018	2028
1985	Paluel 3 P4	1330	1997	2007	2017	2027
1985	St-Alban 1 P4	1335	1997	2007	2017	2027
1986	Cattenom 1 P'4	1300	1997	2006	2016	2027
1986	Chinon B3 CP2	905	1999	2009	2019	2029
1986	Flamanville 2 P4	1330	1998	2008	2019	2029
1986	Paluel 4 P4	1330	1998	2008	2019	2029
1986	St-Alban 2 P4	1335	1998	2008	2018	2028
1987	Belleville 1 P'4	1310	1999	2010	2020	2030
1987	Cattenom 2 P'4	1300	1998	2008	2018	2028
1987	Chinon B4 CP2	905	2000	2010	2020	2030
1987	Nogent 1 P'4	1310	1998	2009	2019	2029
1988	Belleville 2 P'4	1310	1999	2009	2019	2029
1988	Nogent 2 P'4	1310	1999	2010	2020	2030
1990	Cattenom 3 P'4	1300	2001	2011	2021	2031
1990	Golfech 1 P'4	1310	2001	2012	2022	2032
1990	Penly 1 P'4	1330	2002	2011	2021	2031
1991	Cattenom 4 P'4	1300	2003	2013	2023	2033
1992	Penly 2 P'4	1330	2004	2014	2024	2034
1993	Golfech 2 P'4	1310	2004	2014	2025	2034
1996	Chooz B1 N4	1500	2010	2020	2030	2040
1997	Chooz B2 N4	1500	2009	2019	2029	2039
1997	Civaux 1 N4	1495	2011	2021	2031	2041
1999	Civaux 2 N4	1495	2012	2022	2032	2042

*Net continuous power

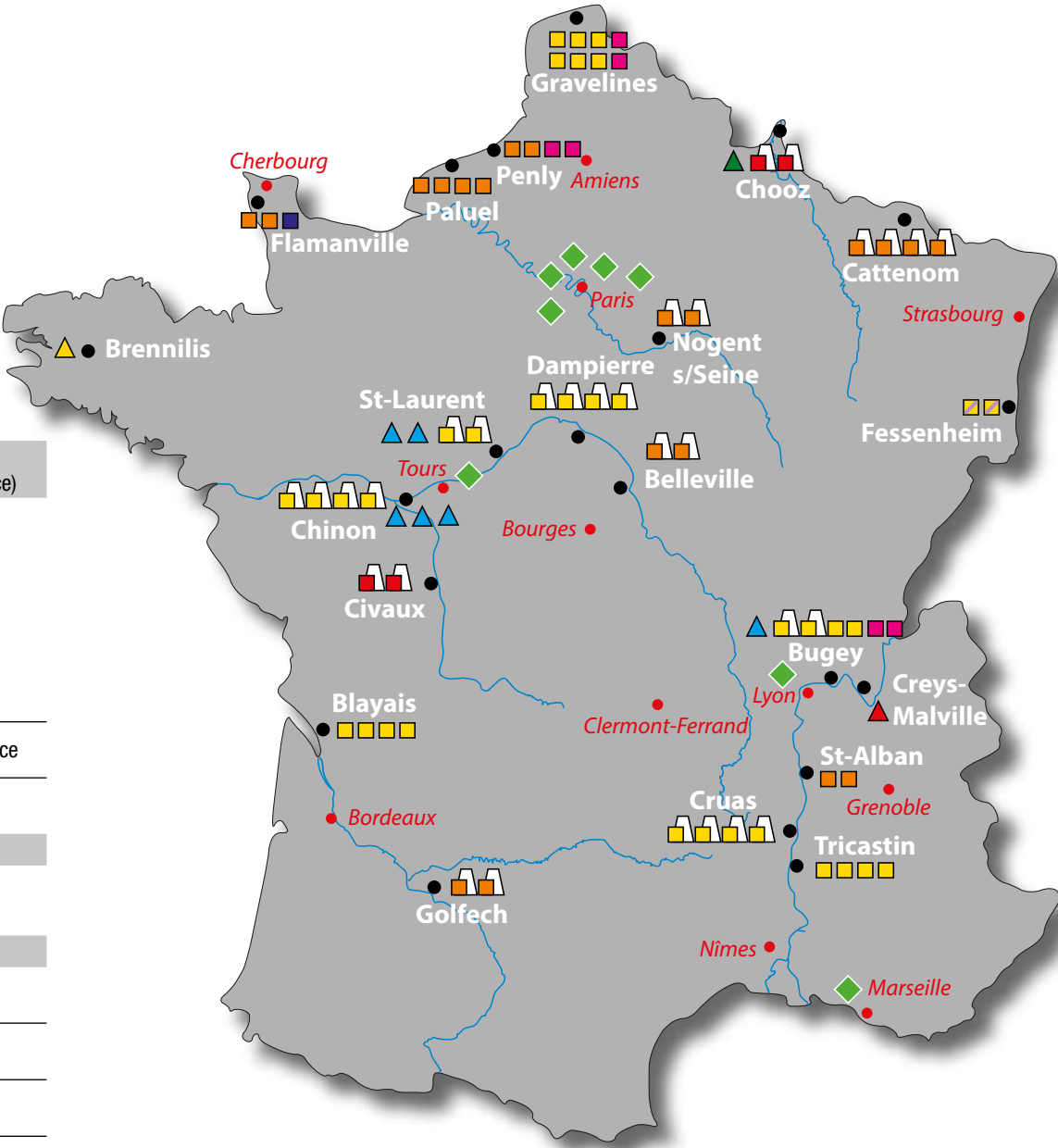
KEY DATES FOR THE EDF ENERGY NUCLEAR UNITS

Year in service	Nuclear unit	Reactor number	Power MWe	Planned date of withdrawal from service
1976	Hinkley Point B	R3	480	Shutdown 2022
1976	Hinkley Point B	R4	475	Shutdown 2022
1976	Hunterston B	R3	480	Shutdown 2021
1976	Hunterston B	R4	485	Shutdown 2022
1983	Dungeness B	R21	525	Shutdown 2021
1983	Dungeness B	R22	525	Shutdown 2021
1983	Heysham 1	R1	580	2028
1983	Heysham 1	R2	575	2028
1983	Hartlepool	R1	595	2028
1983	Hartlepool	R2	585	2028
1988	Heysham 2	R7	615	2030
1988	Heysham 2	R8	615	2030
1988	Torness	R1	590	2030
1988	Torness	R2	595	2030
1995	Sizewell B		1198	2035

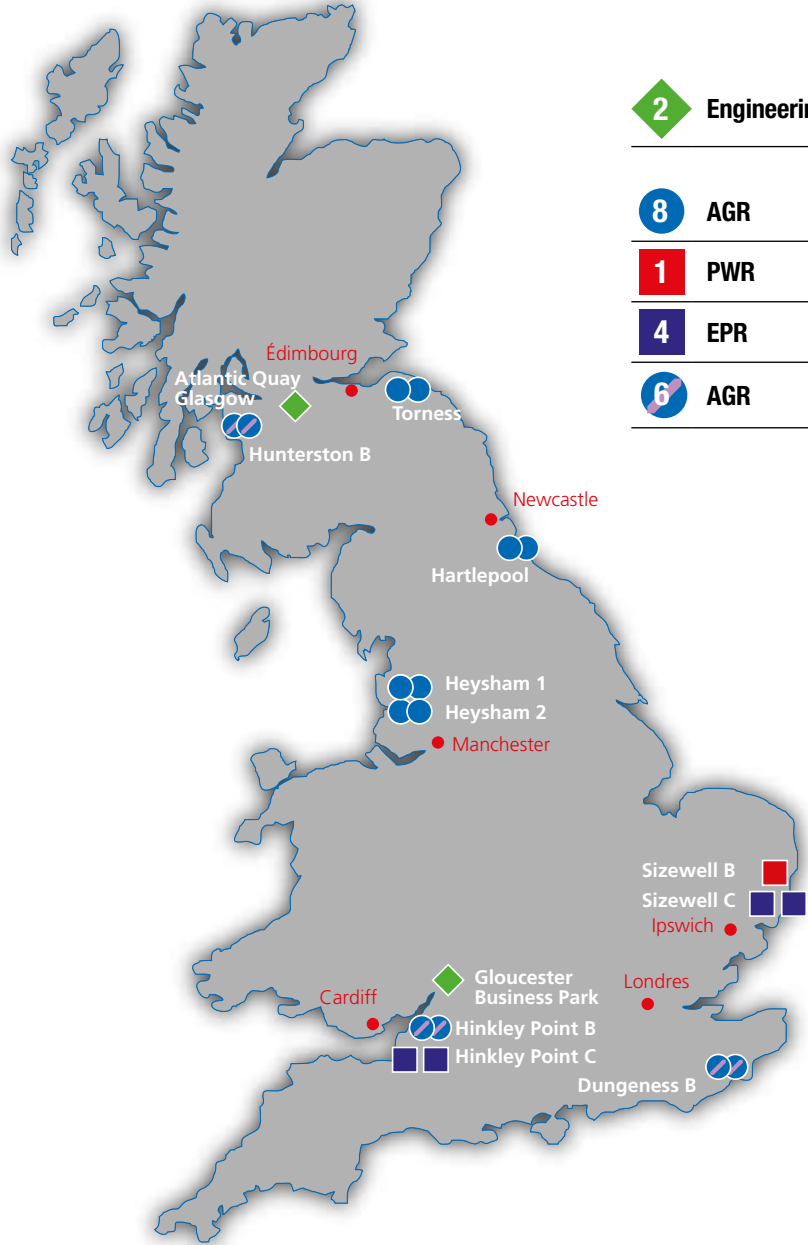
EDF SA NUCLEAR SITES

- Closed loop cooling
- Open loop cooling

Pressurised Water Reactors		
(operation, construction and withdrawn from service)		
32	900 MWe	Operation
20	1 300 MWe	
4	1 450 MWe	
1	1 600 MWe (EPR)	
2	900 MWe	Withdrawn from service
6	1 670 MWe (EPR2)	Construction Project
Engineering		
8	Engineering centre	
Decommissioning		
6	Gas-Cooled Reactor	
1	Heavy Water Reactor	
1	Pressurised Water Reactor (300 MWe)	
1	Fast Breeder Reactor	



EDF ENERGY NUCLEAR SITES



2	Engineering centre
8	AGR
1	PWR
4	EPR
6	AGR

Operation

Construction or Project

Withdrawn from service

FRAMATOME SITES

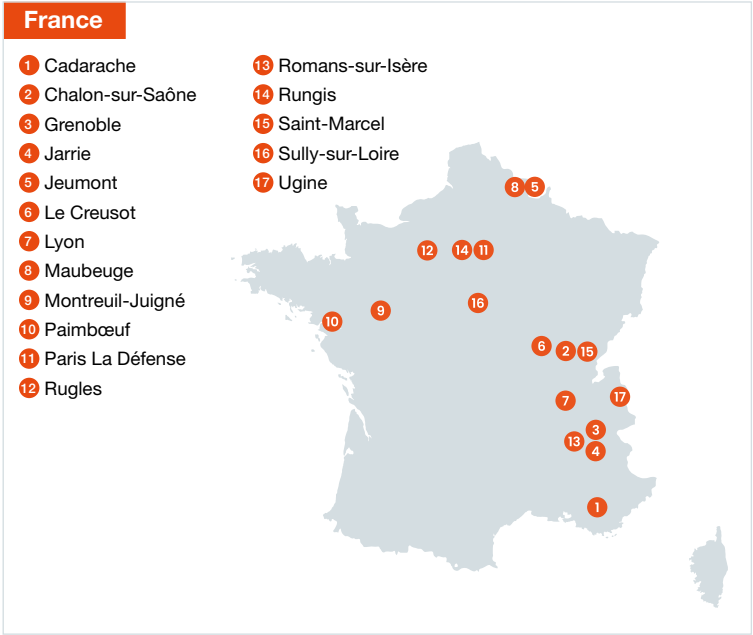


TABLE OF ABBREVIATIONS

A

AAR	Automatic reactor trip
AFI	Area for improvement
AGR	Advanced Gas-cooled Reactor
AIP	Activity important for protection (health, safety and environment)
ALARP	As Low As Reasonably Practicable
AIEA	Voir I = IAEA
ALARA	As Low As Reasonably Achievable
AMR	Manual reactor trip
AMT	EDF fleet maintenance agency
ANDRA	National Radioactive Waste Management Agency (F)
ARENH	Regulated access to incumbent nuclear electricity, established in Fr law 2010
ASN	Nuclear Safety Authority (F)
AT	Outage
ATEX	Explosive atmosphere

B

BDBUE	Beyond Design Back-Up Equipment
BWR	Boiling Water Reactor

C

CCL	Local emergency response centre
CEA	Alternative Energies and Atomic Energy Commission (F)
CEFRI	Committee for the certification of companies in training and monitoring radiation workers (F)
CETIC	PWR Nuclear Steam Supply System Fieldwork Technical Validation Experimental Centre
CGN	China Guangdong Nuclear Power Company (China)
CIPR	International Commission on Radiological Protection (ICRP)
CLI	Local information centre
CIGEO	Project for underground storage of radioactive waste (F)
CNC	Civil Nuclear Constabulary (UK)
CNEPE	Electromechanical & plant engineering support department
CNPE	Nuclear Power Station
CNRS	National centre for scientific research (F)
COLIMO	A DPN campaign to modernise isolation and alignment practices and methods
COMSAD	Start-up nuclear safety committee (F)
COMSAT	Unit outage nuclear safety commission
COPAT	Unit outage operational control committee
CPO	Crew Performance Observation

CRT	Technical standards committee
CRESS	Significant nuclear safety event investigation report (F)
CSFI	Counterfeit Fraudulent and Suspect Items
CSN	Council for Nuclear Safety
CSNE	DPN nuclear safety review meeting
CTO	Central Technical Organisation

D

DACI	Independent oversight directorate for EDVANCE
DART	Diagnostic and Repair Team (UK)
DBUE	Deployable Back-Up Equipment (UK)
DCC	Core-fuel directorate
DCN	Nuclear fuel division
DFISQ	Independent nuclear safety and quality oversight department (DIPNN)
DirIN	Nuclear Engineering Directorate
DQI	Division for Industries Quality
DIPDE	Nuclear fleet engineering, decommissioning & environment division
DIPNN	Engineering & new-build projects directorate
DOE	Department Of Energy (US)
DP2D	Decommissioning & waste directorate
DPN	Nuclear generation division
DPNT	Nuclear & conventional fleet directorate
DPPI	Industrial Partnerships and Projects Directorate
DRS	Nuclear safety standards directorate
DSIN	Digital Standards and Intégration Directorate
DSPTN	Project support and digital transformation division at the DIPNN
DT	Technical division at the DIPNN
DTEAM	Conventional fleet multi-disciplinary expertise & industrial support division
DTEO	Transformation and operational efficiency directorate
DTG	General technical division
DTI	Engineering and technical directorate (Framatome)

E

EATF	Enhanced Accident-Tolerant Fuel
EDT	Dedicated field team
EDVANCE	Joint venture between EDF and Framatome (80% and 20% respectively)
EGE	Overall nuclear safety assessment
EIP	Equipment protected for nuclear reasons
EIPS	Equipment protected for nuclear safety reasons
EMAT	Shared teams providing support during unit outages
EIR	Rapid Maintenance Response Team (F)

EIR	Interesting radiation protection event (F)
EPR	European Pressurised Reactor
EPRI	Electric Power Research Institute (US)
ESPN	Nuclear pressure equipment
ESR	Significant radiation protection event (F)
ESS	Significant nuclear safety event (F)
EVEREST	EDF project to allow workers to enter controlled areas wearing ordinary work clothes

F

FARN	Nuclear rapid reaction force
FIN	Fix it Now Team (UK)
FIS	Independent nuclear safety oversight (F)
FME	Foreign Material Exclusion
FSAT	Fire Safety Action Team (UK)

G

GDA	Generic Design Assessment (UK)
GECC	Core design and engineering group (F)
GIEC	Intergovernmental panel on climate change (IPCC)
GIFEN	Nuclear Energy Industry Group (F)
GK	Fleet upgrade programme (F)
GPEC	Advanced planning of jobs and skills
GPSN	Nuclear safety performance group (UNIE)

H

HCTISN	High committee for transparency and information on nuclear matters
HOF	Human and organisational factors
HPC	Hinkley Point C (UK)
HPT	Human Performance Tools

I

IAEA	International Atomic Energy Agency
ICPE	Environmentally regulated facility
ICRP	International Commission on Radiological Protection
IFOPSE	Fire Safety & Prevention Training Institute (F)
IN	Nuclear inspectorate (DPN)
INA	Independent Nuclear Assurance (EDF Energy)
INB	Licensed nuclear facility (F)
INES	International Nuclear Event Scale
INPO	Institute of Nuclear Power Operators (US)
INSAG	International Safety Advisory Group (IAEA)
IPCC	Intergovernmental panel on climate change (UN)
IRAS	Plant engineer assigned to relations with the ASN (NPPs)
IRSN	Institute for radiation protection and nuclear safety (F)

J

JDO Joint Design Office (UK)

L

LLS Turbo-alternator last-resort power supply
LNHE Hydraulic and Environmental National Laboratory
LOCA Loss-Of-Coolant Accident
LTIR Lost-Time Injury Rate

M

MAAP DPNT performance assessment and support team
MARN Nuclear hazard management support team
MDL Second-line manager
MEEI Campaign for maintaining exemplary housekeeping (DPN initiative)
MEH Mechanical, Electrical and HVAC (UK)
MLC Onsite emergency response means
MME Operations and maintenance methods
MOX Nuclear fuel comprising 8.5% plutonium and 91.5% enriched uranium (F)
MPL First-line manager/front line manager
MQME Campaign to raise the standards in maintenance and operation (DPN)
MVM Maintenance optimisation programme (F)

N

NCC Operations core skills handbook
N3C Tagging and plant configuration errors
NCME In-service maintenance professions common core
NC STE Non-compliance with technical specifications
NDA Nuclear Decommissioning Authority (UK)
NDT Non-destructive testing
NEA Nuclear Energy Agency (OECD)
NEI Nuclear Energy Institute (US)
NN New Nuclear
NNB Nuclear New Build (EDF Energy)
NNSA National Nuclear Safety Administration (China)
NPP Nuclear Power Plant
NQME Non-quality in maintenance and operations
NRC Nuclear Regulatory Commission (US)
NSG Nuclear safety group (UK)

O

OIU Internal inspection organisation
ONC National emergency response organisation (F)
ONR Office for Nuclear Regulation (UK)
OPEX Operating experience

OSART

Operational Safety Review Team (IAEA)

OST

Task observation focused on skills and competences (F)

P

PBMP Basic preventive maintenance programme
PCCF Creusot forge compliance project
PCC-EO DPN skill advisory centre for organisational effectiveness (F)
PCI Pellet-cladding interactions
PDC Nuclear engineering key skills development plan
PFI Human Performance Tools (HPT)
PGAC Worksite general assistance services
PIRP DPN industrial policy and contract partner relations team (F)

PLM

Plant Lifecycle Management

PPAS

Multi-year nuclear safety improvement plan (Framatome)

PPE

Personal Protective Equipment

PPI

Off-site emergency response plan (F)

PSPG

Police site protection unit (F)

PUI

Onsite emergency plan (F)

PWR

Pressurised Water Reactor

R

R&D Research & Development directorate
RASA Rules and Specifications for Hazards
REP Pressurised Water Reactor PWR
REX Operating Experience (OPEX)
RGE General operating rules (F)
RGV Steam generator replacement
RIS Emergency water injection system for reactor cooling
RTE Power grid company (F)

S

SAT Systematic Approach to Training
SDIN Nuclear technical information system
SDIS Local fire and rescue services (F)
SIR Authorised internal inspection department
SMART Digitalisation programme at the DIPDE
SMI Integrated Management System
SMR Small Modular Reactor
SODT Safety Oversight Delivery Team
SOER Significant Operating Experience Report issued by WANO

SOH

Socio-organizational and human approach

SP

Standardised plant teams

SPR

Risk management department

SQEP

Suitably Qualified and Experienced Person

STE

Technical specifications

SWITCH

Digitalisation programme at the DIPNN

SYGMA

Computerised maintenance management system

T

TCO Technical Client Organisation (UK)
TEM Online Work Management
Tfg Occupational accident frequency factor (F)
TNPJVC Joint venture between the Chinese company CGNPC (51%), Guangdong Yuedean Group Co. (19%) and EDF (30%)
TRIR Total Recordable Injury Rate
TSM Technical Support Mission by peers organised by WANO
TSN Nuclear safety & transparency act (F)
TSSM Technical Safety and Support Manager (UK)
TVO Teollisuuden Voima Oyj (Finlande)

U

UFPI Operations & engineering training department (DTEAM)
UGM EDF Group Management University
ULM Maintenance & Logistics Unit (F)
UNGG Gas-cooled graphite-moderated reactor (F)
UNIE Operations engineering unit (DPN)
UTO Central technical support department (DPN)

V

VC Initial inspection outage
VD Ten-yearly inspection outage
VP Partial inspection outage

W

WANO World Association of Nuclear Operators
WENRA Western European Nuclear Regulators Association



The IGSNR team at the Nogent-sur-Seine site:
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Model of the Sizewell B and C sites

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