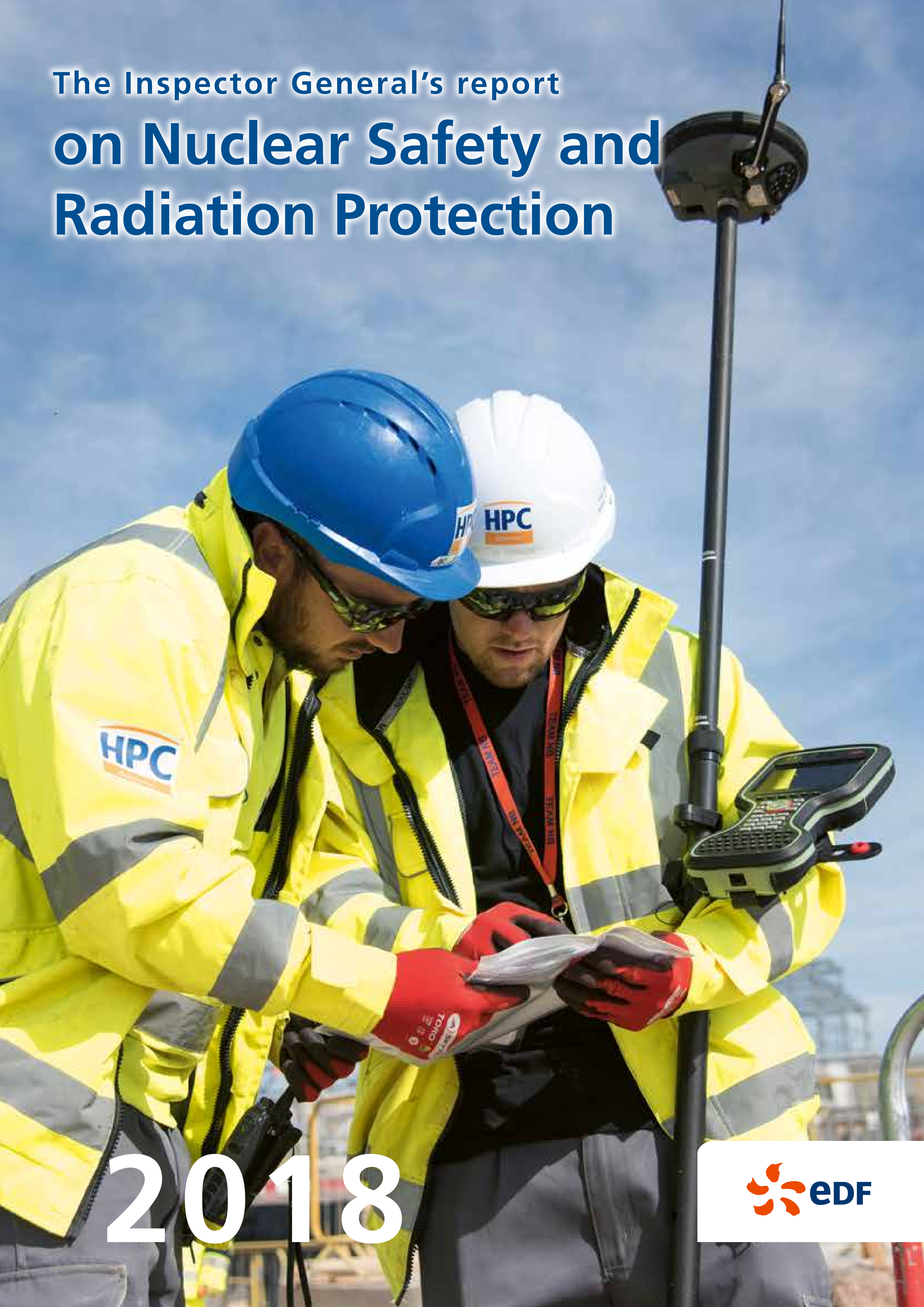
The Inspector General's report

on Nuclear Safety and Radiation Protection



2018

EDF

FOREWORD

This report, written for the Chairman of EDF, gives my assessment of nuclear safety and radiation protection within the EDF Group.

The report is also intended for all those in the company who contribute in any way to nuclear safety and radiation protection through their day-to-day actions and decisions. It will have achieved its purpose if it provides food for thought on their contributions in these areas.

It also aims to identify any early warning signs and recommend areas for improvement. It therefore focuses on difficulties and weaknesses rather than strengths and progress. This may seem unfair to those who spare no effort to ensure that complex, demanding nuclear power facilities are designed, built and operated safely.

Like each year, this report does not set out to cover the subjects in depth. The number and length of the chapters are intentionally kept to a minimum to highlight the most important points.

This report focuses on all matters within the EDF Group that contribute in any way to the safety of its nuclear activities. It is particularly the case for engineering and operations in both France and Great Britain. It is, however, important to avoid making any hasty comparisons between these two fleets as the reactor technologies, the fleet sizes and the regulatory contexts differ.

My assessment is based on information gathered and observations made during the year, whether from workers in the field, or during visits to plants and meetings with the main stakeholders: contractors, staff representatives, members of the medical profession, and chairmen of local information commissions in France and of Site stakeholder groups in the UK. It also makes use of comparisons with other international players on the nuclear scene, and draws on dialogue with WANO[1] and the nuclear safety regulators.

As of 1 January 2018, EDF became the majority shareholder of Framatome which has taken over all nuclear reactor activities formerly belonging to AREVA NP. Relations between IGSNR[2] and Framatome's general inspectorate have been developed: joint visits were organised and a chapter of this report focusing on Framatome was written by its Inspector General, Alain Payement.

I would like to thank all those I met for their unstinting help and candour, not to mention the breadth of our discussions. Their openness, which determines the relevance of this report, is fully in keeping with the spirit of a nuclear safety culture.

I would also like to thank Jean-Michel Fourment, John Morrison, André Palu and Bertrand de L'Epinois who have been relentless in their efforts, particularly in drafting this report. I would like to give a special mention to Jean-Jacques Létalon and Bernard Le Guen, who left the team in 2018.

Finally, although this document has not been written for public relations purposes, it is available to the general public in both French and English, as in previous years, on the EDF website (www.edf.fr).

EDF Group Inspector General
for Nuclear Safety and Radiation Protection

François de Lastic
Paris, 21 January 2019

[1] World Association of Nuclear Operators
[2] General Inspectorate for Nuclear Safety and Radiation Protection

CONTENTS

MY VIEW OF 2018

Torness nuclear power plant

NUCLEAR ENERGY SUPPORTING CLIMATE CHANGE

Leaders and public opinion are increasingly aware that global warming has become a major threat. Nuclear energy, combined with greater use of renewable energies, is one of the main ways of limiting carbon dioxide production. In the summary for policymakers in the IPCC[1] report of October 2018, the scenarios for limiting global warming to 1.5°C all include large increases in global nuclear generation.

The interest in nuclear varies from country to country, in particular due to the economic environment and the differing levels of acceptability of the industry. The IPCC report is however unequivocal "… *the assessment of the risks [due to nuclear power] shows that the health risks are low per unit of electricity production and the land requirement is lower than that of other power sources*".

Russia and China significantly increased their nuclear power capacity in 2018, with the commissioning of two reactors in Russia and four in China, including the first EPR, at Taishan. India is also putting together a very ambitious programme.

In the US, where the nuclear industry is facing strong competition from fossil fuels, operators are working on extending the service life of reactors. In the US, there are around one hundred reactors and over 90% of them have been authorised to operate for up to 60 years. As well as this optimisation of the existing fleet, there are a great many new reactor projects embracing technological changes and new economic models. The nuclear regulator is adapting its certification process to deal with these new entrants.

In the UK, EDF Energy's four EPR projects are continuing (see below). Although Toshiba has abandoned its planned reactors, other projects are under consideration. The UK

[1] *Intergovernmental Panel on Climate Change*

Office for Nuclear Regulation has approved the second phase of the design assessment of the Hualong reactor, designed by CGN[1].

In France, the long-term energy plan announced in November 2018 is scheduling the closure of 14 reactors by 2035 and proposes a programme to build new reactors, which could be decided in 2021. In view of this, the nuclear sector has been restructured: EDF (together with Mitsubishi and Assystem) has taken over AREVA NP, which has been renamed Framatome, AREVA NC has been reorganised to become Orano, and GIFEN[2], a group of nuclear industry companies, has been set up.

CHANGES IN THE EDF GROUP

I have not been made aware of any significant problems with staff despite the reduction in workforce planned across the two fleets.

IN FRANCE, EDF SA IS CONTINUING TO ADAPT

To begin with, I note the consistency of EDF's low-carbon strategy based on two complementary aspects: nuclear and renewables.

In France, the *Parlons énergie* (Let's talk energy) initiative has been positively received, in particular because it brings staff together and shows that the Group is listening to teams in the field. Employees are still generally concerned about the future of the Group and want more robust communication, in particular in support of the nuclear industry.

The changes to the Group have also led to numerous changes in methods, including a digital transformation (see Chapter 5), which should help improve efficiency and provide useful enhancements to nuclear safety. There is, however, some resistance to change in many areas, which must be resolutely overcome (see Chapter 4).

Each plant carries out a nuclear safety review every ten years. For the first time, a public consultation has been launched on the measures proposed by EDF SA to ensure nuclear safety for operation of the 900 MW reactors beyond 40 years. This consultation is based on the organisation of local events and the establishment of a digital platform which provides information and a forum for public comment. This is not a legal requirement but an EDF initiative in conjunction with the HCTISN[3] and the other institutional stakeholders in nuclear safety. The consultation is separate from the French Nuclear Safety Authority (ASN) authorisation process which will include, at the appropriate time, a public inquiry for each reactor.

In 2018, the detailed examination of the 2,000 Le Creusot manufacturing documents affecting EDF (unmarked files, see 2017 report) was completed without uncovering any major new problems. In addition, the tests and demonstrations initiated following the discovery of excessive carbon content (segregation) in some components were continued.

The DIPNN[4] has completed a series of reorganisations (see Chapter 7) which I feel is benefiting the prioritisation of issues and the management of projects.

The decommissioning of recent and future plants is planned right from the design stage, which was not the case with older reactors. The decommissioning of the UNGG[5] reactors requires major, long-term studies. An industrial demonstrator will be used to validate the methods and procedures. I think it is useful to arrange review points so that the solutions can be adapted and schedules optimised in the light of initial results. The Fessenheim dismantling programme, which has the benefit of operating experience (OPEX) from the Chooz A PWR programme, is ambitious but reasonable given that the plan is for it to be completed 20 years after the end of operation. These issues are being responsibly and proactively managed.

Particular attention is being directed towards the staff at Fessenheim, to ensure that they can continue to safely operate the plant through to the end of its reactor operation and withdrawal from service.

EDF R&D is focusing on the expectations of its customers, combining preparation for the future with real-time support for the French and UK nuclear fleets, giving them the benefit of its expertise and experience. The 'Nuclear plant of the future' programme provides a coherent framework for the R&D activities. A three-party research institute brings together EDF, the CEA and Framatome to consider various topics, notably nuclear safety. I am also aware of the important work being carried out on enhancing the synergy between renewable energies and nuclear energy.

Digital transformation

1 *China General Nuclear power corporation*
2 *French Nuclear Energy Industry Group, established in June 2018*
3 *High committee for transparency and information on nuclear matters*
4 *Engineering & new-build projects directorate*
5 *Gas-cooled graphite-moderated reactor*

IN THE UK, THE AGR/EPR TRANSITION HAS STARTED

The UK nuclear fleet will undergo a major change over the coming decade with the shutdown of most AGRs[1] and the commissioning of PWRs requiring new skills. Progress has been made in preparing for this transition, particularly through the identification of key skills.

I appreciate the new organisation of the Hinkley Point C (HPC) project management and how well work is progressing on site. However, coordination with the French engineering team still has room for improvement. I believe the next important challenge will be management, supply and installation of the electro-mechanical equipment.

EDF has started talks with the UK authorities on constructing two EPRs at Sizewell, commencing in 2021. Replication of the HPC reactors will consolidate nuclear safety and reduce construction costs.

RESULTS

IN FRANCE, A POSITIVE TREND

The 2018 results are continuing the positive trend of 2017.

Nuclear safety: the number of automatic reactor trips (18) set a new record (22 in 2017, 28 in 2016 and 38 in 2015). The sharp drops in plant alignment errors and significant fire safety events are also worth pointing out. However, the numbers of breaches of technical specifications have increased. Although the amount of sub-standard maintenance and operations work with a nuclear safety impact has decreased, it is still at a high level. The peer reviews introduced in 2018 on quality management are showing promise. Used together with other measures (see Chapters 2 and 4), they should help to provide a significant, lasting improvement.

The installation of ultimate emergency diesel generators across the fleet has seen more delays, particularly on the 1300 MW reactors. As this is one of the main post-Fukushima measures, the situation is unsatisfactory. Lessons must be learned from this for the future.

2018 was marked by two events.

Firstly, wear on the control rod guide sleeves on some 1300 MW reactors carries a risk of the affected control rods becoming jammed. The monitoring programme introduced on all reactors has shown that several of them have been affected by this type of deterioration. The repair procedures have been defined and the work programme is under way. The handling of this event has been improved over previous, similar events (see Chapter 2), in particular by holding regular dedicated CSNEs[2].

Secondly, at Flamanville 3, the cold functional tests were started in December 2017 and the leaktight testing of the containment was successfully completed, but the discovery of anomalies on the main secondary circuit (see Chapter 8) has led to a revision of the project programme: nuclear fuel loading is now planned for the fourth quarter of 2019. This situation highlights the supply chain management improvements that are still required both in-house and within suppliers.

Industrial safety: the Nuclear generation division (DPN) has stabilised its good results, with an overall accident rate of 2.3 (2.2 in 2017). The number of events associated with critical risks has fallen, but there are still many near-misses.

Radiation protection: the collective dose has increased slightly in relation to 2017, as has the number of people who received a dose of more than 10 mSv (see Chapter 3). However, when the results are examined over a longer period they show an improvement, particularly with a good collective dose level during the latest steam generator replacements.

IN THE UK, A SMALL DOWNTURN

The industrial safety results have deteriorated slightly, but remain satisfactory. In terms of radiation protection, two reactor vessel entry programmes resulted in an increase in the collective dose, which nevertheless remains very low.

However, the nuclear safety results show an increase in the total number of automatic and manual reactor trips and the declaration of one INES[3] Level 2 event. This involved the accumulation of corrosion at an AGR site (see Chapter 1). Major repairs have been started, together with checks on the other systems. Cracks were also found on the main steam lines. I will be monitoring the learning from these events closely, particularly the organisational aspects.

During a routine examination on another AGR, cracking in the graphite bricks was found to be occurring at a higher rate than predicted (see below). Though this phenomenon is expected, EDF Energy kept this reactor shut down for the rest of the year to gain a better understanding of the cracking acceleration.

RELATIONS WITH THE NUCLEAR SAFETY REGULATORS

IN FRANCE, A NOTICEABLE IMPROVEMENT…

Relations with the regional offices of the Nuclear Safety Authority (ASN) are generally constructive. Information flows freely, questions are, on the whole, acknowledged to be relevant and encourage open dialogue.

The nuclear fleet's relations with the ASN at a central level have improved significantly and are based on renewed technical dialogue. The new initiative on sites dealing with anomalies and incidents is contributing to this, as

1 *Advanced Gas-cooled Reactor*
2 *DPN nuclear safety review meeting*
3 *International Nuclear Event Scale*

well as the ASN's intention to implement a more graded approach commensurate to risks as set out in its strategic plan.

Preparation for the meetings of the ASN nuclear safety advisory panels[1] is characterised by an enormous volume of work and often high-quality, technical dialogue. However, the number and variety of questions raised during the process leading up to the meetings could be more streamlined so that focus remains on essential matters.

… YET SIMPLIFICATION OF THE REGULATIONS WOULD BE HELPFUL

The proliferation of regulations and legal changes on nuclear safety issues are making processes more complex and leading to the development of abstract jargon. There is also a tendency for all requirements to be at the same level, increasing the risk of losing the sense of the core issues and the overriding priority of nuclear safety.

The difficulties of implementing the French nuclear pressure equipment regulations had led to the introduction of a three-year action plan, which is now coming to an end. The methods for implementing the regulations have been established and I believe that confidence has been restored among those involved. I am nevertheless troubled by the contrast between the volume of examination work required to apply this legislation and its added value for nuclear safety. What is more, understanding the regulatory aspects of the nuclear pressure equipment regulations has become a matter for specialists: very few people can fully grasp them, and the situation may well worsen as current staff leave. I would like to see the authorities take advantage of the ongoing lull to simplify the regulations or their implementation methods.

Penly nuclear power plant

I believe that there are also some weaknesses in the application of the regulations on licensed nuclear facilities (INB). These regulations not only lead to the use of obscure terminology, resulting in the main message being lost, but also the way they have been applied has led to increased amounts of equipment or activities classified for the 'protection of interests': several tens of thousands in a nuclear power plant, each with a number of 'defined requirements'. This is not necessarily to the benefit of nuclear safety, which requires prioritisation and the need to constantly understand the message behind the words (see below). I believe that at some stage a revision of these regulations could be considered, or at the very least their method of implementation.

IN THE UK, MATURE RELATIONSHIPS

The relationship between EDF Energy and the Office for Nuclear Regulation (ONR) is based on transparent, candid dialogue, with each performing their respective roles. The independent nuclear assessment team has a direct relationship with the nuclear safety regulator at all levels, providing its own views.

The reorganisation of the HPC project management and the creation of a robust independent nuclear safety oversight team within the project have restored trust and quality to the relationship.

INDEPENDENT NUCLEAR SAFETY OVERSIGHT

IN FRANCE

At the DPN's sites, independent nuclear safety oversight teams are listened to and their positioning within the organisation is satisfactory. The skills and experience of the nuclear safety engineers are improving. They are well-supported by site safety and quality managers who are firmly established within the management teams. It is regrettable that efforts are sometimes too focused on regulatory notification and categorisation rather than on the analysis of behaviours and nuclear safety issues.

Difficulties encountered in recent years, particularly with non-conformances, have led to increased involvement of the nuclear fleet's nuclear safety director in monitoring the treatment of issues which are reported to corporate level. I recommend that this very positive initiative be extended to all decisions with a nuclear safety impact that are taken at corporate level.

The Design Authority[2] for the fleet has been strengthened and is gradually establishing itself. It is already providing a very good service. As it has not yet reached full maturity, I reiterate my appeal for prioritisation in this area of work.

The organisation of the independent internal oversight of engineering should be extended, as described later.

IN THE UK

The internal nuclear safety oversight arrangements for the UK are working well. I am reassured by the positioning and involvement of the Safety, security and assurance director, who has a robust organisation behind him. The independent nuclear assurance (INA) teams are experienced and very well integrated in the plants.

1 *Standing groups of experts known as* Groupes Permanents
2 *The Design Authority ensures that plants comply with their initial design, and assists the DPN with design modifications*

They provide relevant assessments on the nuclear safety situation and culture.

The independent nuclear safety oversight at HPC is progressing well and improving the positioning of the project on nuclear safety issues.

WANO

The World Association of Nuclear Operators (WANO) is a rare organisation in industry as operators pool their resources in order to help one another, check one another and improve performance together (see inset). WANO has put in place its post-Fukushima action plan, which involves:

- Increasing the frequency of peer reviews of nuclear sites
- Ensuring corporate peer reviews are carried out systematically
- Broadening the scope of reviews to include some design features, severe accident management and emergency preparedness
- Increasing the consistency of the association globally
- Developing targeted assistance, for example for new entrants, and providing dedicated advisors to support sites when drawing up their improvement plans.

WANO has recently included simulator-based assessments of shift teams (Crew Performance Observations) in its reviews.

FOUR POINTS WHICH REQUIRE ATTENTION

AGRs NEED INCREASED IN-SERVICE MONITORING AND IMPROVED PREDICTIVE TOOLS

Derived from what is now an isolated technology, the 14 AGRs belonging to EDF Energy are encountering specific problems for which there is no international operating experience like that for PWRs to assist them. The oldest AGRs have been in operation for a little over 40 years. The date for their withdrawal from service, scheduled from the early 2020s, will depend primarily on their ageing.

The condition of the graphite bricks, used as the moderator in AGRs, will most probably determine their service lives. Subjected to neutron bombardment and oxidation, these non-replaceable graphite bricks lose weight and start to crack. At some point, in the event of a major earthquake which could initiate brick failures, possible restrictions to control rod entry could result when a reactor trip is initiated.

Keyway root cracking was detected in a brick in one of the Hunterston B reactors during inspections in 2015. This phenomenon has been monitored regularly; it has remained in line with predictions up to the beginning of 2018. An unexpected acceleration was discovered during a routine inspection in the spring of 2018. Although the existing cracks do not give rise to any risks in their current state, EDF Energy preferred to keep the reactor shut down to give itself time to understand this acceleration and prepare a safety case. Inspections have been carried out in the other reactor on the same site, but no equivalent issues have been discovered. More generally, the graphite in all the AGRs will be subject to increased inspections.

Other AGR plants are also being closely monitored. In 2014, a crack was discovered on one of the boilers in a reactor at the Heysham 1 plant. These boilers are complex metallurgically and operate at high temperatures (around 600°C), leading to creep fatigue. The Heysham 1 boiler was isolated and all the other boilers of the same type inspected.

The long-term operation of these reactors therefore requires particular attention and forward planning within the EDF Group. I would like to underline the efforts that EDF Energy has made to manage the ageing of these plants and to improve and restore margins. EDF SA engineering and EDF R&D are also playing a valuable role in this.

I recommend increasing the in-service monitoring of the AGRs and improving the predictive modelling tools to anticipate any deterioration and to ensure that nuclear safety margins are maintained. At the appropriate time, EDF Energy will thus be able to decide the date on which these reactors will be withdrawn from service.

Refuelling machine at Hartlepool nuclear power plant

INDEPENDENT NUCLEAR SAFETY OVERSIGHT OF ENGINEERING AND PROJECTS: SCOPE TO BE EXTENDED

The principles of nuclear safety management were developed in the context of reactor operations. One of the most important aspects is the implementation of independent internal oversight. This is now universally accepted, and the independent nuclear safety oversight teams in France and the UK are providing an essential service.

Engineering and nuclear projects play a major role in the nuclear safety of the sites they design, build or modify: they therefore have independent oversight bodies. The organisation, methods and involvement of these bodies in the decision-making processes are not, however, as comprehensive and formalised as for operations.

The diversity of the responsibilities of the engineering functions, from the choice of nuclear safety options, right through to monitoring fabrication and construction, means that it is probably not possible to adopt a uniform oversight model.

However, I believe that the management of the Engineering & new-build projects directorate (DIPNN) and each engineering function, project management team and construction site should have an independent oversight body. It should be led or supervised by a manager reporting to the head of the function and would be their 'nuclear safety conscience'.

FRAMATOME JOINS THE GROUP

Framatome became part of the EDF Group in 2018. Its integration must be continued so that synergies can be developed, in particular concerning methods and tools, in order to enhance quality.

Collaboration with the Inspector General of Framatome has begun, and will be expanded. It has already led to joint visits, frequent dialogue, and the inclusion of a chapter devoted to Framatome in this report. This chapter highlights the nuclear safety, radiation protection and industrial safety results for its first year in the EDF Group, which are generally satisfactory.

I emphasise the need to:

- Ensure the long-term effectiveness of Le Creusot's restructured quality assurance system following the marked and unmarked files and the segregation issues
- Make use of all the technical and organisational lessons learned from the anomalies encountered on the main secondary circuit at Flamanville 3
- Deliver the skills renewal process, often for very specific skills, so that Framatome can fully perform its role.

Framatome is structuring its independent nuclear safety oversight team to give it an appropriate remit which extends beyond the nuclear sites to cover all activities that may have an impact on nuclear safety: engineering, construction, fabrication, maintenance, etc. The breadth and diversity of the areas covered mean that this independent oversight team must achieve a balance between targeted compliance checks and general assessment.

While continuing to increase compliance checks within the functions, I believe it is important to:

- Develop a general appreciation of nuclear safety across the whole of Framatome's remit
- Review the adequacy of the resources allocated to the nuclear safety oversight team for the tasks it has to perform.

NUCLEAR SAFETY CULTURE: PREVENTING ORGANISATIONAL INERTIA

During my visits over the past four or more years, I have had the opportunity to meet a great many people involved in nuclear safety. They are all aware that they are carrying out a job that demands special care. There is a strong nuclear safety culture running through and underlying day-to-day activities everywhere. I also commend the strengthening of dialogue between the French, UK and CGN fleets on nuclear safety management.

However, the very nature of nuclear safety culture means that teams do not settle for a situation even when it is satisfactory. In fact this culture, which is so widely shared, may stagnate if we are not careful, and I notice weak signals that must not be ignored.

The main threat to this culture is still to lose meaning because of too much complexity and dilution of responsibilities. I have identified three main causes.

In France, this is partly due to the increasing complexity of regulations, which sometimes encourages the operator to focus on compliance with regulations rather than all the factors that contribute to nuclear safety.

Taking operating experience into account and applying rigorous methods are cardinal virtues for nuclear industry professionals on both sides of the Channel. This is leading to numerous processes being drawn up, applied and checked. Focusing on the form of these processes causes the message to become obscured, and the original intention behind their creation gets forgotten. The process itself becomes the purpose. Beyond the necessary adherence to procedures, it is essential that leaders be committed to reminding staff of the message.

The third cause is more complex. I regularly see how long it takes for information to travel from the bottom to the top and from the periphery to the centre. This organisational inertia often increases with the size of the organisation. It is sometimes seen as a lack of transparency, delaying the recognition of the potentially harmful effects of an event.

Reactor building

Various means must be combined to ensure that important information is identified as such and gets to the appropriate decision-making level quickly enough, without being truncated.

Firstly, the reporting of information must be organised using processes which involve the engineering functions, as recognised by the DPN (see Chapter 2).

However, the nuclear safety culture must also be further developed, in particular having a questioning attitude and everyone being accountable (see Chapter 4). In fact, in the fleets and the engineering divisions, the challenge lies in identifying important information within a huge volume of data and then the capability of individuals to take ownership of the nuclear safety issues.

Finally, the missions of the independent nuclear safety oversight teams in the DPNT and DIPNN must be strengthened. They are observers who are separate from operational activities and aware of the nuclear safety issues, thus offering additional guarantees.

NUCLEAR SAFETY ACROSS THE WORLD IN 2018

View of Jacques RÉGALDO, Chairman of WANO

I was elected Chairman of WANO at the end of 2012, less than two years after the accident at the Fukushima-Daiichi nuclear power plant. Six years on, the global nuclear scene has changed a great deal.

Following a general slowdown in all countries with nuclear power plants, the global fleet has changed, with a reduction in Western Europe and North America, and resumption of the development of the nuclear industry in Eastern Europe, Russia, China and India. New countries in Asia, the Middle East and soon in Africa are starting to, or want to, build nuclear power plants to cover some of their electricity requirements.

At the same time, nuclear safety at the design stage has been re-examined over recent years in all countries that are operating or building reactors.

This has been carried out differently depending on the country, but in-depth nuclear safety reviews have been carried out on all reactors: either under governmental authority (stress tests in the European Union), or at the request of national nuclear regulators, or initiated by the operators themselves.

This has resulted in numerous examples of significant investments to improve plants and, everywhere, to enhance operating practices, emergency preparedness and training, particularly in nuclear safety culture.

The same policy to strengthen methods has also been a priority within WANO: increased frequency of Peer Reviews, generalisation of assessments of new reactors before the first fuel load, Corporate Peer Reviews, and close support for plants requiring particular attention.

In the light of all the work carried out by the nuclear regulators, manufacturers, support organisations (like WANO) and above all the operators themselves, it would be fair to say that the nuclear safety of plants has improved over recent years.

But nothing is definitive in this area and there are risk factors, for example: increasing economic constraints, some plants which could pose risks of obsolescence as they age, or new entrants who need to gain initial experience.

Nuclear safety must remain our main priority everywhere. This is, of course, an absolute precondition for the development of a valuable industry for the decarbonisation of energy production worldwide.

1 OPERATIONAL NUCLEAR SAFETY: SATISFACTORY RESULTS

Golfech nuclear power plant

In France, the main safety indicators continue to improve, with the number of automatic reactor trips falling for the third consecutive year.

In the UK, results remain satisfactory for many indicators, yet highlight the need for greater attention to the level of automatic and manual reactor trips and in the monitoring of some AGR-specific anomalies.

GOOD RESULTS IN FRANCE

In contrast to 2017, no nuclear safety-significant events rated Level 2 on the INES scale occurred in 2018. The number of INES-classified events rose very slightly to 1.3 per reactor, from 1.1 in 2017. The total number of nuclear safety-significant events (11 Level 0 events per reactor) continues to reflect a good level of detection and transparency.

In 2015, I flagged up a decline in automatic reactor trip and fire safety results. I am pleased to report that progress has since been made in both these areas.

Work undertaken to reduce the number of non-conformities and sub-standard work is beginning to bear fruit and should be carried on into 2019 to reach the intended goals.

Fessenheim also achieved good results, in spite of the challenges it faces.

GROUNDS FOR SATISFACTION

Yet again, teams have beaten their previous record in terms of automatic reactor trips (see graph), thanks to the effort driven through from corporate level and fully embraced by all plants.

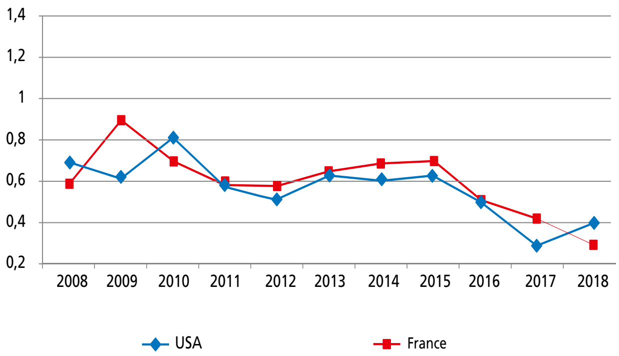
Progress has also been made in fire safety. The number of major or significant events fell markedly from 9 in 2017 to 5 in 2018. This was also true for minor fire events, which fell from 89 in 2017 to 69 in 2018. I have seen positive signs in terms of behaviours and intend to monitor this trend going forward.

The number of plant alignment errors decreased from 1.8 per reactor in 2017 to 1.2 in 2018 as a result of a targeted action plan.

This year again, safety systems have demonstrated excellent unplanned unavailability rates, with the safety injection system, auxiliary feed water system and standby diesel generators recording 0.04%, 0.01% and 0.06% unavailability respectively.

The operator's ability to manage degraded plant situations, like the total loss of external power (see inset), was also evident.

Following on from the progress made in 2017, the resolution of recommendations from the DPN Nuclear Inspectorate (73.9%) continues its upward trend. However, the resolution of WANO Areas for Improvement (AFI) of around 60%, and Significant Operating Experience Reports (SOER) of between 80 and 85%, has faltered.

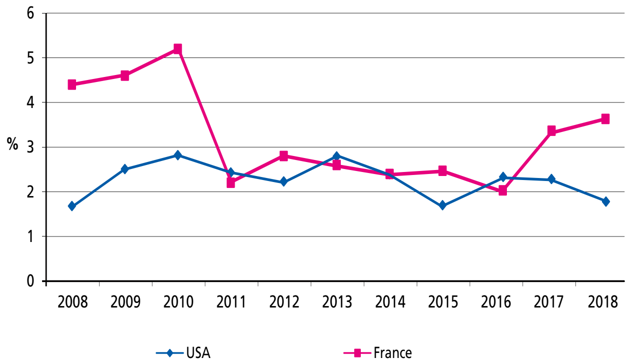


Number of automatic and manual reactor trips per reactor in PWRs in France and the US

AREAS OF CONCERN

In contrast to the improvement I noted in 2017, the number of nuclear safety-significant events attributable to non-compliance with technical specifications rose again, to 1.7 per reactor, compared with 1.4 in 2017. This indicator reflects the quality of operations. Teams are still encountering difficulties in fully implementing certain fundamental operating and maintenance principles. This will need to be a specific focus area for 2019.

The number of events involving maintenance and operations quality remains high at 478, despite an 18% reduction. Many of the actions undertaken thus far have yet to bear fruit. Some indicators have remained at the same level as 2017, whilst others, such as nuclear safety-significant events associated with routine tests, have deteriorated, showing that there is still room for improvement to achieve the desired level of rigour. The main areas of weakness relate to control room monitoring and procedural adherence. I have noticed opportunities being missed to remind staff of the standards required; daily meetings, for instance, offer an extremely effective way for managers to raise team awareness through discussions about safety messages.



Unplanned unavailability rates per reactor for PWRs in France and the US

Unit outage overruns have fallen compared with 2017, but still remain high. I appreciate the fleet decision to retain good outage management as one of its priorities, as this is essential to both quality and a safe working environment.

Turbine hall

UK RESULTS DOWN ON LAST YEAR

There was one significant event graded Level 2 on the INES scale in 2018, the first in nine years, caused by plant corrosion at one of the AGR sites (see inset). The number of Level 1 significant events was stable compared with 2017 (7 events recorded in both years). I should point out, though, that the UK safety authorities apply different declaration requirements to those imposed by the French authorities. The number of Level 0 events remained steady at 6 per reactor. This is a welcome indicator of transparency.

Reactive management of a loss of external power

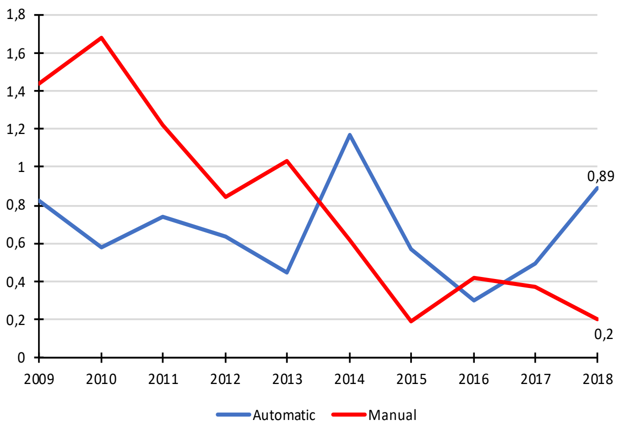
This situation occurred on a reactor that had been taken offline for an outage, with its fuel in the storage pool. Power was supplied via a main grid connection; the backup power line was undergoing maintenance. One of two standby diesel generators was available, whilst work was being carried out on the other one. This situation is normal during maintenance outages and is compliant with regulations.
A fault occurred overnight on the external grid, causing a power cut. The standby diesel generator, which provided half the power needed to cool the spent fuel pool, started up immediately.
The operator responded promptly, following the relevant procedures to reconfigure the pool cooling systems and contain the rise in temperature. The situation was returned to normal within 6 hours (the maximum time defined in the technical specifications is 24 hours), with the grid operator, RTE, having worked in parallel to locate and rectify the fault.
Although there was no significant impact on safety, the simultaneous loss of power to numerous systems resulted in a situation that was particularly complex to manage.
This event illustrates the importance of defence in depth, in this case having redundant equipment and appropriate procedures designed to handle all possible scenarios. It also highlights the vigilance required during maintenance on sections of the grid, as well as the importance of coordination between power plant and grid operators.

After a sustained period of year-on-year improvement, results for the British fleet this year have faded. Whilst some indicators, like the number of non-compliances with technical specifications, remain satisfactory, others have stagnated or worsened despite improvement measures being implemented. Efforts need to be redoubled or new avenues of action explored to give fresh impetus to these initiatives. I note in particular that there has been an increase in the total number of automatic and manual reactor trips.

GROUNDS FOR SATISFACTION

The number of non-compliances with technical specifications has continued its downward trend, falling from 0.6 nuclear safety-significant events per reactor in 2017 to a new record of 0.5 in 2018. This result reflects the hard work and dedication of control room staff.

A single significant fire safety event occurred in 2018. There have been only three such events in the UK fleet in the past four years. There was also a significant decrease in the number of minor fire events in 2018.



EDF Energy Nuclear Generation automatic and manual reactor trip rates

I am pleased to report the high level of reliability of safety systems:

- Sizewell B PWR achieved 100% availability for the eleventh year running.
- There was a small improvement in unavailability of auxiliary power supplies in the AGRs to 0.06%, versus 0.08% in 2017; unavailability of safety injection systems fell to 0.094% compared with 0.124% in 2017; unavailability of standby diesel generators rose, however, to 0.224% (from 0.077% in 2017) due to the extended unavailability of equipment at one particular plant.
- This year again, the uptake of recommendations from WANO peer reviews (85%) and SOERs (90%) is at an excellent level.

A Level 2 event on the INES scale

Areas of corrosion were detected at a plant in 2018, during maintenance outages for two of its AGRs. In response, additional inspections were initiated by the operator which revealed corrosion in several other plant systems.
None of these corrosion issues individually was categorised above Level 0 or 1 on the INES scale. However, given the number of common-cause corrosion findings discovered, it was a concern that availability of certain systems could become an issue if the shortcomings were not addressed in a timely manner. Based on this assertion, it was judged that a Level 2 INES categorisation was appropriate.
An Event Recovery team carried out the additional inspections and initiated a remedial works programme.

AREAS OF CONCERN

The number of automatic and manual reactor trips rose in 2018 to 1.07 per reactor, compared with 0.93 in 2017. Human factors played an important role in this increase.

The number of plant alignment errors (1.6 per reactor) has not built on the significant improvement achieved in 2017 (0.93), although it is still well below the level of previous years (3.1 in 2016).

The same is true of the plant defect backlog. It covers all equipment, including some that contribute to safety. An accumulation of defects can weaken levels of safety. Actions have been taken to address this backlog (see Chapter 2).

As in France, outage overruns are still well above those achieved in better years and result from sub-standard or unscheduled work. These overruns can have an impact on safe and high-quality working practices.

Fire started by a battery charger

A fire broke out during a routine battery charging test on an internal telephone system. The fire was caused by an ageing capacitor which was unable to support the required charge. Emergency response teams had to be mobilised. No-one was injured in the fire, but it caused considerable damage to equipment in the associated electrical cabinet.
The root cause of this incident was a lack of preventive maintenance and monitoring for this type of component, even though relevant operating experience exists.
A lack of rigour was also a contributing factor: inadequate procedures and local plant monitoring by technicians during the test.

SATISFACTORY FUEL PERFORMANCE

Nuclear fuel plays a major role in safety. The fuel cladding, which contains uranium pellets, forms the first barrier between the radioactive material and the environment. It is therefore imperative that its leak-tightness be monitored, for which stringent measures are in place.

In 2018, the fuel assembly failure rate remained at a good level both in France and the UK.

In France, the failure rate was 0.13%, which corresponds to a total of 10 fuel assembly leaks identified in eight reactors. Most cladding failures are caused by foreign matter and debris resulting from stress corrosion of the friction springs on some types of fuel assembly. A new heat treatment for these springs should be available by the end of 2019 and will subsequently be rolled out across the fleet. Four fuel assemblies were not reloaded in 2018 (compared with 10 in 2017 and 8 in 2016) because of damage discovered during fuel handling operations.

There was also an improvement in the UK, with 5 fuel elements found to be leaking out of the 4,000 or so elements unloaded (compared with 8 in 2017 and 20 in 2016). These defects affected three reactors and were caused by carbon deposition found on the fuel cladding. Monitoring of this phenomenon is ongoing, involving endoscopic inspections and metallurgical testing of spent fuel. An oxygen injection system will be commissioned on one of the affected reactors in 2019 to help reduce these carbon deposits. A total of 22 non-conformities were identified on new fuel elements in 2018, 19 of which were related to fuel pins. Credit must go to the plants for their vigilance in this matter and for returning defective fuel elements to the supplier. These were subsequently successfully reloaded following additional inspections and approval of a safety case.

AGR fuel element

No defective fuel assemblies were detected at Sizewell B (the UK's only PWR). A project has been launched into a new type of fuel to mitigate issues associated with obsolescence and to further enhance nuclear safety margins. It should be deployed within the next few years and will use Framatome Q12 guide tubes, which have already delivered good operating results in France.

2 STAYING FOCUSED ON THE FUNDAMENTALS OF NUCLEAR SAFETY

Cattenom nuclear power plant

The attention paid to nuclear safety is evident at all levels of the EDF Group.

The commitment demonstrated by staff, and the skills and resources dedicated to nuclear safety, are considerable.

The system relies on a multitude of complex organisations and processes: more must be done in the field to convey the meaning of requirements and job fundamentals.

CONTINUING TO UPHOLD THE OPERATOR'S RESPONSIBILITY

It is clear to me in 2018, as in previous years, that the operator is fulfilling their primary responsibility for ensuring nuclear safety.

EDF Energy's decision to extend the inspection outage of one of the Hunterston reactors in the UK is testament to this. Faced with a higher rate of cracking than expected (see page 7), the outage was extended to allow time for further inspections on the reactor to investigate the nuclear safety implications and define the criteria for continued operation.

A similar situation occurred in France, when it was discovered that a flange on an emergency feed water system did not provide adequate seismic resistance. The anomaly was detected on one reactor but was soon characterised as a fleet-wide issue. The operator completed the necessary repairs and also made the decision to take one reactor offline as the repair could not be carried out with the reactor in service.

However, I have noticed a tendency in France to overly investigate safety issues with the view to preparing information perceived to be acceptable by the ASN. In many cases, initially at least, the regulatory process takes precedence over the actual safety analysis. I urge all parties, in the first instance, to consider the actual or potential implications on nuclear safety above all else.

A DETERMINED EFFORT TO MANAGE COMPLIANCE

In France, after the Level 2 events declared in 2017, the operator embarked upon an initiative in conjunction with the engineering division, called reactive non-conformance analysis, as a means of guaranteeing: site compliance with its standards, detecting non-conformances, characterising them within acceptable timescales, informing the ASN, and defining and substantiating solutions.

I am pleased to see this clear commitment, which is already delivering a higher level of responsiveness.

The preparation of the safety case for thermal sleeves (see inset) involved a process which drew upon all the Group's technical competencies, led by dedicated DPN Nuclear safety review committees. I appreciated this approach, as well as the involvement of the independent nuclear safety oversight team. The difficulties encountered with this work stress the importance of keeping initial safety margins high when phenomena are not yet fully understood, and of adopting conservative measures from the outset.

Detecting non-conformances is a cross-functional process, involving plants, engineering centres, contract partners, central functions, etc. To avoid the risks associated with organisational inertia, it is essential that staff at every level of the Group, from the top down, detect and characterise non-conformances and communicate them to the appropriate level, in a manner that is responsive and proportionate to the issue.

In my view, maintaining compliance in the UK should look to reducing the existing fleet defect backlogs to enhance plant compliance with their standards, and not settle for such a high level of defects.

On this note, I am aware that a corrosion issue has been identified somewhat belatedly on one plant, in spite of a repair programme that was already under way across the fleet dating back several years (see Chapter 1). Cracks were also discovered late in the day on some secondary circuit main steam lines. I will be paying particular attention to the in-depth analysis of these events and the ensuing learning, especially from an organisational perspective.

Thermal sleeves on control rod groups

These sleeves are mobile guide tubes that pass through penetrations on the reactor vessel head between the control rod drive shafts and the housing for the drive mechanism. The wear on some of these sleeves has caused the upper section to come apart. This in turn presents a risk of a control rod assembly movement restriction.
The issue mainly affects the 1300 MW reactors. Heavy wear impacts one in three control rod clusters in some reactors. Seized rod assemblies have been found during tests in three reactors.
A reactor inspection programme was initiated at each of the subsequent refuelling outages. Once the degree of wear reaches a specific threshold, the sleeves are replaced. Compensatory measures, such as operating at constant power (which exerts less stress on control rod assemblies due to less frequent demands), manoeuvrability tests and monthly rod drop tests, have been applied to reactors which have yet to be inspected. It has been verified that full compliance with the safety criteria is assured for any situation, even if the control rods in question seize in the raised position.

Thermal sleeves

OPERATIONS AND MAINTENANCE QUALITY MANAGEMENT PLAN

Numerous initiatives have been launched in France over the years to improve operations and maintenance quality, yet they have been challenged in achieving their goal. In light of unsatisfactory results, the DPN initiated a clear action plan in 2018. It defined target objectives, focusing on the preparation of maintenance teams to carry out the task and requiring a greater presence of leaders in the field. Quarterly peer reviews for each site have been initiated and is proving to be a promising innovation.

Initial signs of improvement were beginning to appear at the end of 2018. The number of events caused by quality issues fell by almost 20% (see Chapter 1). Automation teams and chemists have made the greatest progress. I would like to see the same effort applied from operations, heavy maintenance and contract partners.

I am pleased to note that the DPN will continue this action plan into 2019. It will bear fruit in the longer term, provided it is deployed consistently at all levels in the field, through individuals taking greater personal responsibility (see Chapter 4).

Both fleets need to place a much greater emphasis on human performance tools. More than a decade after the decision was taken to introduce them, their use is still insufficiently consistent. I notice that there is still variability in their implementation. The expectations are not understood in the same manner by all, including amongst leaders. Standards need further clarification to allow them to be delivered in the field by leaders, adopted by staff and subsequently reinforced.

MORE SIMPLIFICATION NEEDED IN THE DPN

The objective to prioritise key points, clarify their meaning and simplify them is, in my eyes, one of the most important goals for nuclear safety. The DPN has embarked on simplifying its safety standards, with the aim of making requirements clearer and lightening the administrative load. I will be reviewing the results with interest and recommend that plants continue to apply this principle of simplification in the field.

The evidence is clear that processes, documentation and safety case requirements consume an ever-increasing amount of time and effort. Priorities are still not being defined clearly and the tendency to multiply non-essential requirements continues. This can stem from regulations, but also often from internal sources.

Therefore, the fundamentals need to be given top priority, always keeping nuclear safety requirements clear. I stress again the need to increase presence and leadership in the field, with more visible support for leaders from their own supervisors (see Chapter 4).

Likewise, documentation should be drafted with the relevant target audience in mind. According to some document users, its increasing volume often corresponds to a decline in clarity of content. In particular, all operational documentation should focus clearly on the objectives, risks, work location and way of working, in a manner directly relevant to the user.

ROBUST INDEPENDENT NUCLEAR SAFETY OVERSIGHT, WITH FURTHER WORK TO BE COMPLETED IN ENGINEERING IN FRANCE

INDEPENDENT NUCLEAR SAFETY OVERSIGHT IN THE UK

The Safety Director in the UK is very closely linked with fleet operations and with substantial resources at his disposal to monitor nuclear safety at both plant and organisational level.

Central control room operation

The Independent Nuclear Assurance (INA) department is mature and well-structured. It provides a valuable overview of the sites and engineering functions and it has the confidence of the UK regulator, the Office of Nuclear Regulation (ONR). I recognise the added value contributed by team members who hail from companies outside EDF Energy. Advance planning of such resources and skills is a key focus area.

The independent nuclear safety oversight team for Hinkley Point C, reorganised in 2018, is effectively organised and performing well.

FLEET INDEPENDENT NUCLEAR SAFETY OVERSIGHT IN FRANCE

At DPN senior management level, the Director for Nuclear Safety continues to provide support to all sites and to challenge their actions when necessary. In 2018, he placed greater emphasis on monitoring how corporate functions handle non-conformities, anomalies and generic incidents. I recommend that the scope of this aspect of his role be extended, by ensuring that he is systematically provided with the relevant information.

The DPN's Nuclear Inspectorate (IN) continues to conduct its site monitoring duties competently and rigorously. Their overall excellence assessments[1] are always comprehensive and thought-provoking. The IN also conducts reactive inspections, in relation to a specific event, which is a valuable practice.

At plant level, the independent nuclear safety oversight model is clear and firmly established. Nuclear safety engineers are generally well-positioned to raise safety issues through the appropriate channels. They do tend to focus, however, on event declaration to the ASN. Care must be exercised to ensure that this bias toward the reporting aspect - like INES scale classification for example - does not overshadow handling of the event itself, overriding important tasks such as determining the nuclear safety impact, appropriate response, root causes, provisional and final solutions, and learning.

[1] *Comprehensive review of each site conducted every four years by a team of around 25 inspectors over the course of three weeks. A follow-up review, conducted two years later, assesses the progress made.*

INDEPENDENT NUCLEAR SAFETY OVERSIGHT OF ENGINEERING AND PROJECTS IN FRANCE

Some aspects of independent nuclear safety oversight are already established in the engineering functions. I can see that several internal oversight bodies occupy some useful and promising roles, like Edvance's Independent oversight directorate (DACI) for instance. I am also pleased to see that a review of the Nuclear fleet engineering, decommissioning & environment division (DIPDE) was completed by the DPN's Nuclear Inspectorate in 2018. At the Engineering and new-build projects directorate (DIPNN), the DFISQ[1] is tasked with providing higher or second-level independent nuclear safety oversight for some activities (see Chapter 7).

In my view, the role and structure of the independent nuclear safety oversight teams at the DIPDE and DIPNN merit further development. First-level internal oversight should play an inherent role in every worksite, project and engineering function, whilst a second level of oversight should be practised throughout every department or division. Oversight bodies should have complete independence and report at the appropriate level in the hierarchy.

The respective nuclear safety roles of project divisions and technical divisions, design authorities and independent oversight bodies merit further clarification.

A fire safety exercise

OTHER INTERNAL INSPECTION BODIES IN FRANCE

The Site Inspection Department (SIR) whom I meet at the plants, carry out their duties rigorously and professionally.

The Internal inspection organisation (OIU)[2] continues to benefit from a high level of expertise and demonstrates independence. Maintaining the right level of expertise involves forecasting activities into the medium term and ensuring that they have adequate skills in place to meet the anticipated workload.

The Design Authority (DESA) is responsible for ensuring plants conform to the initial design and supports the fleet with plant modifications. It is strengthening and plays an important role in terms of nuclear safety.

INTERNAL OVERSIGHT OF MODIFICATIONS IN FRANCE

The 2015 Energy Transition for Green Growth Act led to a review of internal oversight methods relating to major modifications to licensed nuclear sites, operating procedures and nuclear safety cases. It is expected that more modifications will relate to declaration (for regulator information - Article 27) than to authorisation (for regulatory approval - Article 26), and that full internal oversight will apply to modifications subject to authorisation.

This heightened internal oversight will clearly result in a substantially greater workload, going forward. It will extend the operator's responsibility, increase the internal challenge capability, improve the quality of safety cases, and in turn enhance nuclear safety.

I appreciate the dedication and high standard of work, carried out, notably by UNIE[3] and DESA, in defining the new internal oversight organisation and guidelines: they seem to me to be very well structured, sound and consistent. They are due to come into effect on 1 July 2019. I will be monitoring the roll-out.

FIRE SAFETY: BUILDING ON RECENT PROGRESS

I have met many motivated, proactive fire safety engineers in France and the UK. There is a clearly improving picture in terms of managerial commitment and results in both fleets.

The overall objective remains that fire safety should be everyone's concern, and not just left to the specialists. Although there is some evidence of progress, I believe it is necessary to establish a much deeper, sustainable fire prevention culture in teams.

In France, a 2018 directive led the DPN to call for greater attention to be paid to the most sensitive fire safety areas, like electrical facilities. This positive initiative resulted in some clear actions: reduction in storage areas, alarm sounders on doors which operate if doors are left open too long.

Fire loading remains an area where attention is still required: I ask that all appropriate guidelines are rigorously applied. The same can also be said for fire safety permits. In fact, hot work is one of the main causes of fires.

The DPN tackled the issue of storing explosive and highly flammable products, such as gas cylinders, by introducing a new standard. This positive approach needs to continue and I will look for it happening in the field.

In addition to the fire safety standards, I also want to draw attention to the obligation to understand and apply

1 Independent nuclear safety and quality oversight department
2 Reporting to the DIPNN's Industrial Division (DI), responsible for assessing the conformity of nuclear pressure equipment
3 The DPN's Operations Engineering Unit

regulatory standards, like the French Labour Code, in their entirety.

In the UK, the major efforts and managerial commitment demonstrated over the past few years both strategically and in the field has borne fruit: the number of fire outbreaks has fallen drastically (see Chapter 1). Control of fire loading, oil leaks in particular, still needs to improve though, as does the availability of fire suppression equipment. I am pleased to see that an action plan has been launched addressing both these issues, following recommendations made by WANO.

SATISFACTORY HOUSEKEEPING CONDITIONS AND FOCUS AREAS

The housekeeping standards on the sites I visited in 2018 were generally good. The bar needs to be raised, however, to achieve exemplary conditions.

Exchanges, reciprocal visits and participation in peer reviews at the best plants must be sought in order to improve awareness and sharing of best practices.

Amongst the improvement areas there a couple worthy of mention:

- In France, there is a need to refurbish control desks on several of the 1300 MW sites. Some are impressive, proving that excellence is certainly achievable.
- In the UK, corrosion on the conventional island. I note the programmes in place for replacing metal pipework with high density polyethylene (HDPE) pipes.

Good housekeeping

MY RECOMMENDATIONS

Engineering and projects play a crucial role in nuclear safety. I recommend that the director of the DIPNN define and implement a more comprehensive arrangement for independent nuclear safety oversight in these areas.

Across the Group, important nuclear-safety-related information can often take too long to arrive at the right decision-making level and be dealt with appropriately. I recommend that the directors of the DPNT and the DIPNN and the CEO of EDF Energy pursue efforts to overcome such inertia in their organisations.

3 INDUSTRIAL SAFETY AND RADIATION PROTECTION

Civil construction at Hinkley Point C

The industrial safety results have remained at satisfactory levels for both fleets, though the engineering functions are still performing below par on construction sites in France.

The level of radiation protection has remained good but there is room for greater diligence in radiography work.

The EDF Group executive committee has breathed new impetus into the prevention and testing of drug and alcohol abuse at work.

INDUSTRIAL SAFETY: CONTINUE THE EFFORTS ON CRITICAL TASKS

The health and safety policy signed on 23 April 2018 reflects the Group's commitment in this field. The application of this policy specifically includes the life-saving rules and BEST[1] requirements. It identifies five short-term actions, including collective responsibility, drug testing and prevention, and support for managers in industrial safety issues.

IN FRANCE, MIXED RESULTS ...

In the DPN, the overall frequency of industrial accidents[2] was slightly higher at 2.3 per 1 million hours worked in

[1] *Building Excellence in Safety Together*
[2] *Number of industrial accidents per million hours worked by EDF and contractor staff*

2018 compared with 2017 (2.2), though this level remains low compared with past years. There is a large disparity in results between sites. Slips, trips and falls represent the majority of all accidents. The number of accidents occurring away from the work place has increased.

Management of critical risks has improved, with the number of injuries having dropped steadily over the years (10 in 2018, 13 in 2017, 26 in 2016 and 32 in 2015), and hazardous situations are now better identified. Yet, too many weak signals are still observed in this area and I feel it necessary to renew my warning about electrical hazards, even if awareness is more obvious and progress visible. Also, particular attention needs to be given to working at height and lifting operations.

In the engineering functions, the results are still disappointing with an accident frequency of 3.5 in 2018 (3.7 in 2017 and 2.6 in 2016). At the DIPDE, this rate reached 3.1 in 2018 (2.7 in 2017 and 4.5 in 2016).

At Flamanville 3, the accident rate is high, reaching 6.1 in 2018 and 5.1 in 2017. Too many hazardous situations exist, such as with electrical equipment having recently been energised and under the control of operations.

On the decommissioning sites, the accident rate reached 5.2 (2 in 2017 and 5.8 in 2016).

Grinding work

… TO BE IMPROVED BY MANAGERIAL INVOLVEMENT IN THE FIELD…

In the plants, I meet committed and active industrial safety teams, along with a clear management message most of the time. Though the industrial safety culture is developing, it is sometimes left to dedicated groups and there needs to be better integration of the tools into everyone's professional life.

The dissemination of safety messages has become a widespread practice. They must nevertheless be made more systematic during meetings and encourage collective involvement and improvement.

Increasing management time in the field is key. Leaders must be familiar with the risks, standards and good practices in industrial safety. I recommend training for all leaders that is sufficiently comprehensive and operationally focused so they can be effective in the field, with special focus on critical tasks. They should have the means to reinforce requirements, identify gaps, correct hazardous situations, and both train and support their colleagues. As is the case in other areas of work, it is essential that leaders be regularly supported in the field by their supervisor.

Additionally, appointing plant area owners is a good practice that should be incorporated into standards.

For several years now I have been drawing attention to collective responsibility: we must feel responsible for each other by pointing out risks being taken or standards not being observed (e.g. holding the hand rail, wearing a hard hat, safety glasses or a safety harness, etc.). This notion of collective responsibility for safety is still not a natural reflex for everyone: it will only become one through continuing efforts. Contract partners need to be more involved too.

In the DPN, the rules remain disparate between sites, such as those governing personal protective equipment. This can be particularly problematic for contract partners. I'm aware that the DPN has begun drafting joint standards; a good initiative.

…WITH SOME ISSUES REQUIRING ATTENTION

Alongside internal requirements and good practices, it is equally important to continue developing knowledge of and to manage regulatory standards, such as the health and safety at work or regulations governing lifting equipment. It would seem sensible that the DPN reinforce its support to sites in such areas. The engineering division should also make sure these requirements are incorporated into designs.

There are two issues related to asbestos:

- When a coating is likely to contain asbestos, the rules governing any associated work are judged to be cumbersome and often different depending on the site and the contract partner
- Asbestos risk management regulations and radiation protection rules can be contradictory on decommissioning sites.

IN THE UK, PERFORMANCE AT A GOOD LEVEL...

While the overall accident rate for the EDF Energy fleet rose in 2018, it still remains low: 0.5 (0.2 in 2017 and 0.3 in 2016).

I note that three employees were seriously injured and burned following the accidental release of steam from the failure of a valve which they were operating. This accident, which had serious physical consequences on the staff involved, deeply affected personnel at the plant. I will closely follow the analysis and learning from this event.

Working at height remains one of the main areas requiring attention (scaffolding, roofs, temporary platforms, ladders, mobile elevating work platforms, etc.).

The Hinkley Point C site is very well organised. Its industrial safety indicators are good and compare favourably with those of construction sites of a similar scale (overall accident frequency of 1.2). The main issues at present are working at height, movement of vehicles and the potential for dropped loads, which takes top priority. The number of cranes - about fifty expected in 2019 - and the density of work activities in certain areas demands heightened awareness to ensure that no one finds themselves below a suspended load.

... AND STAUNCH MANAGERIAL COMMITMENT

Manager and leader commitment both at corporate level and in the plants is clearly evident. The action plan deployed to reach a performance level identical to that of 2017 has rallied teams in the field and is fostering good dialogue. I commend the video in which several directors and staff share their personal views of a fatal accident that occurred several years ago on an EDF Energy site. Shown to all, it left a lasting impression.

The practice of sharing daily safety messages that are compelling and powerful is exemplary.

Cooperation between the DPN and EDF Energy Nuclear Generation is ongoing, for example on the risks of lifting and dropped loads. I am pleased to see such determination to standardise the indicators between the two fleets as some figures are difficult to compare owing to the different ways of managing time off work.

PREVENTING DRUG ABUSE

Drug use could not be more incompatible with nuclear-related professions which demand constant situational awareness and self-control.

The executive committee has strengthened the Group's commitment through the implementation of a strong drug use prevention and detection policy.

Other than providing staff with medical care, the next phase of this policy will soon be rolled out in France: more widespread communication and random drug testing in all operational sites. The tests results will remain anonymous in the first stage in order to raise awareness, before identifying any staff failing a test that are in roles that can have an impact on nuclear or industrial safety.

Lifting operation

I encourage the rapid deployment of these measures as the safety of the Group's activities and its reputation depend on it. I also note the success of the similar approach taken about fifteen years ago to combat alcohol abuse.

In the UK, the random alcohol and drug testing programme that has been in place for many years now and is considered part and parcel of their culture.

RADIATION PROTECTION: GOOD RESULTS

IN FRANCE, STABLE RESULTS

In 2018, the collective dose results (0.67 man-Sv/unit) met the DPN's objective, i.e. 0.69 man-Sv/unit. The collective dose has risen slightly compared with 2017 (0.61 man-Sv/unit) due to an increased amount of maintenance work.

The average individual dose (EDF + contractors) reached 0.9 mSv while it was 0.83 mSv in 2017. The staff exposed to an annual dose exceeding 10 mSv increased from 89 in 2017 to 160 in 2018 (274 in 2016). One worker received a dose slightly above 14 mSv. The regulatory limit is 20 mSv.

The number of significant events due to non-compliance with the rules governing orange radiation zones has started to rise again (36 in 2018, 29 in 2017, 44 in 2016 and 29 in 2015).

Several hazardous situations were detected during radiography work both in the operational fleet and at the Flamanville 3 construction site. To address this risk, I call for stricter monitoring of the safety rules, in particular when checking that no one has remained inside the barriered exclusion zone.

... AND OBJECTIVES TO BE FIRMLY REITERATED

In France, the teams responsible for radiation protection are skilled and committed.

The primary circuit cleaning programme has proved successful in significantly reducing doses. I encourage continuing the efforts in this area towards the elimination of hot spots.

However, the risk of seeing radiation protection trivialised can occur when good results become stable, and is seen as a matter for specialists alone. Managerial focus on industrial safety can also have the effect of pushing radiation protection into the background. The time has come to redefine the key objectives in this field, particularly for collective doses.

I also urge that the next steps of the EVEREST programme (see inset) be taken, following on from its successful implementation at four sites. It is worth thinking about giving fresh impetus to all or part of this programme which may need small adjustments; radiological cleanliness and the discipline it entails are key sources of progress.

At the Decommissioning & waste projects division (DP2D), I note their determination to better account for the risk of contamination by alpha-emitting particles. This positive drive should be taken even further. Cooperation with the CEA and Orano - both accustomed to working with this risk - would be beneficial.

EVEREST

The EVEREST approach sets out to achieve a level of radiological cleanliness that allows workers to enter controlled areas without having to change into special protective clothing.

When most radiological constraints can be removed, it becomes easier to access controlled areas, to optimise time-consuming operations, and to simplify supervision in the field. One of the key advantages of EVEREST lies in the greater control gained over the radiological conditions. The EVEREST approach does, however, amplify the efforts required in decontamination. Maintaining facilities in 'EVEREST' conditions thereafter demands extremely rigorous behaviour in carrying out routine operations.

The 1300 and 1450 MW reactor series provide the most suitable environment for EVEREST owing to their inherent characteristics and initial radiological conditions. There are currently four plants (10 reactors) applying EVEREST: Golfech, Civaux, Cattenom and Flamanville. Flamanville 3 will soon be joining this list.

Though EVEREST is a French label, its objectives and concept are relatively widespread internationally.

IN THE UK, THE SITUATION REMAINS SATISFACTORY...

Owing to their intrinsic design, AGRs tend to generate very low collective doses during operation. In 2018, the collective dose reached 0.05 man-Sv/reactor (0.02 man-Sv/reactor in 2017). This increase was caused by maintenance work in the reactor pressure vessels of two AGRs. These extensive operations involved tens of workers over several weeks, leading to significantly higher doses than those usually encountered during routine operations. Such reactor pressure vessel entries had not been performed for several years. I observed the seriousness with which these operations were prepared for and executed, which explains why the resulting doses were lower than expected.

The pressurised water reactor at Sizewell B recorded 0.1 man-Sv in 2018 (0.3 man-Sv in 2017), which compares well internationally.

The maximum individual dose, all reactors included, was 7.19 mSv (5.54 mSv in 2017).

Radiological measurements on an AGR charge face

... BUT VIGILANCE MUST BE MAINTAINED ON THE FUEL ROUTE

Maintenance on the fuel handling systems, or fuel route, on the AGR generates the highest dose rates. These systems are also the most complex found in AGRs and their reliability can be a sticking point. Special care needs to be taken in this area, all the more so as spent fuel handling operations will be multiplying with the progressive shutdown of these reactors.

MY RECOMMENDATIONS

This year again, I have seen a number of events and weak signals associated with industrial safety within the Group. I recommend to the directors of the DPNT, the DIPNN and the CEO of EDF Energy that they join forces with their contract partners to consolidate the prevention of critical risks, such as:

- **Electrical hazards and radiography work in France**
- **Working at height across the board in the UK and lifting in particular at Hinkley Point C.**

Leader presence in the field is one of the key factors driving progress in industrial safety and radiation protection. I recommend to the directors of the DPNT, the DIPNN and the CEO of EDF Energy that managers and leaders be trained in a more comprehensive, operationally-focused manner and that they benefit from personal support in the field from their supervisors.

Nuclear professionals require situational awareness and self-control. I recommend the directors of the DPNT and the DIPNN ensure that the Group's policy on drug abuse prevention and testing is rapidly deployed on the ground.

4 MANAGING CHANGE: COLLECTIVE INTELLIGENCE

Training offered by the EDF Group management university

In a world that is constantly evolving, the Group is engaged in delivering some key transformations in a drive to improve performance in safety and quality.

These transformations provide an opportunity to move away from a system characterised by ever-increasing numbers of processes, requirements and reporting, to a more plant-centric approach focusing on operators and maintainers.

Many initiatives have been introduced to boost employee involvement and build collective intelligence through accountability.

MY OBSERVATIONS

SIGNIFICANT RESISTANCE

'Resistance to change' is a common thread in conversations with first-line managers across the fleet, whereas popular terms among leadership teams are 'change management' and 'transformation'. The realities of both these standpoints are poles apart.

When organisational transformations have not been initiated properly, I see managers repeating the same mantras about expected behaviour over and over to their staff, who simply end up feeling misunderstood. The size of an organisation and culture are often cited as the reasons behind such resistance.

I am also aware of the level of dissatisfaction expressed by leadership teams who, in trying to accelerate the pace of change, ramp up their requirements and increase the controls further still.

Changing behaviours to adopt new ways of working is difficult when people remain attached to their own routines, standards and perceptions.

HUMAN PERFORMANCE TOOLS AND DATA QUALITY

Many employees in the French fleet claim that they are not opposed to human performance tools *per se*, but they believe that they should only be implemented in areas where they are most needed, i.e. areas exhibiting the greatest degree of complexity. This demonstrates not necessarily unwillingness, but more a belief that *"you can't go wrong with a simple task"*. Others tell me that these tools should be used, except during busy periods when there is not enough time, which seems to suggest a somewhat optional nature to requirements or the priority of time over quality.

In a move to gain some insight into human behaviours, the fleet invited a group of experts in neuroscience to shed some light on how the human brain works. They deliberately used compelling examples, some of which were representative of everyday life, to raise awareness of the potential mechanisms for making mistakes. According to neuroscientist Dr Isabelle Simonetto, it is not so much a question of knowing if you are going to make a mistake, but more a matter of when and in what conditions. She advocates the need to develop new behaviours to be able to identify potential mistakes before they are made, thus mitigating any negative impact (see inset).

The majority of managers in both fleets are strong supporters of human performance tools, but the lack of any real collective ownership and consistency of approach means they can have difficulties conveying a clear message to their teams. The main problem lies in making sure these tools are used as a matter of course.

Plant monitoring

Staff in engineering departments need easy access to good quality design data. Yet it seems that data is rarely considered a common asset (see Chapter 5). This leads to duplication of data, which in turn causes problems in terms of reliability and in some cases, it can even lead to designs being reworked. Everyone recognises the importance of having reliable data, but few are willing to use a common information system that is considered too cumbersome or less efficient than their own databases.

Learning new behaviours

Neuroscientist Dr Isabelle Simonetto has identified four key stages in the process of workers learning new behaviours, each of which is a prerequisite for the next stage:

- MEANING: Explain why change is needed.
- KNOW-HOW: Teach how to change.
- CONSOLIDATION: Make this new behaviour habitual, so that it becomes the automatic response.
- KEEP ON DOING THE RIGHT THING: Even once a new behaviour has been consolidated, occasional lapses will occur, which usually have some kind of negative impact (like when someone crosses the road without looking and a motorist sounds their horn at them). In everyday life, the odd mistake helps us to keep on doing the right thing. Yet, as Dr Simonetto explains, this is not practical in hazardous environments. We need to find other ways to make sure workers in these environments keep on doing the right thing.

This is where **managerial** support, especially in the form of **debriefs,** comes in, providing a particularly effective means of **reinforcing these 4 steps.** According to Dr Simonetto, without this reinforcement, the virtuous circle is broken and all the effort put into implementing change is wasted. This process delivers the CONSISTENCY required to support any change.

THE IMPORTANCE OF ALIGNING TO THE SAME MESSAGE…

I believe that certain factors can help to embed new behaviours:

- Ownership of goals (see inset)
- Consistency in the way to achieve the transformation
- Employee involvement in developing appropriate tools for their environment
- Training to acquire new skills and behaviours
- Formal commitment from all parties.

I also saw managers:

- Providing support in the field giving positive reinforcement[1]
- Conducting regular checks which, in the case of recurring difficulties or repeated refusal to adopt certain behaviours, can result in someone being removed from doing a task or holding a certain role.

The COLIMO[2] project is a prime example of where this approach has been implemented successfully: the end goals were agreed by staff who were involved from the outset, including optimising the software specifications,

1 *Method used to create, maintain or stimulate appropriate behaviour*
2 *Project to modernise isolation, alignment and mobility practices and methods*

and stakeholders were engaged in the safety-related aspects. The project's success was helped by the training and high level of support provided by a team of experts, known as 'Colimotors'.

Hybrid Management - a concept advocated by Vincent Lenhardt (InterEditions)

According to Vincent Lenhardt, addressing the issue of 'meaning' presents a major challenge: in a world full of uncertainty and complexity, it is up to the individual to make sense of what is being asked of them and to understand what is expected of them in the future. Complexity stems not only from the external environment, but also from within an organisation, where change becomes the only constant. In this context, where "*the best way to predict your future is to create it*", companies need employees capable of building meaning into their work themselves.
Cultivating this meaning is an essential part of leadership in collective intelligence; making sure that the message emerges; i.e. that staff (the **who**) share a common vision of **why** change is needed and **how** it can be implemented so that they can act individually and collectively to fulfil the operational goal (the **what**).

… AND FOLLOWING A CONSISTENT APPROACH

Training is critical as it helps employees learn what the 'right thing' is; it also provides a safe environment in which mistakes can be made. Learning how to correct these mistakes is what helps to establish good practices. This is why I would like see more use made of training mock-ups.

End-of-training assessments should focus on ensuring that requirements are applied rigorously as a matter of course. However, I have seen in France that correct implementation of human performance tools on training simulators or mock-ups is not always necessary to obtain the formal qualification in question. Training is not monitored adequately by managers in this respect. This absence of general alignment goes some way to explaining why transformation can be such a laborious process, despite the efforts made in this field over the past 12 years.

As far as engineering data is concerned, there is often a lack of adherence to common rules, which are defined to guarantee the quality of such data in the first place. It seems to me that the digital transformation can only succeed if respect for these rules is considered as an integral part of the job fundamentals.

Whilst I acknowledge that actions taken so far in human performance tools and data reliability have brought about some improvements, the pace does need to pick up to reduce the number of quality issues.

INTRODUCING NEW MANAGEMENT TECHNIQUES

Committing to a transformation involves accepting to work individually and collectively in moving away from a vision that is no longer appropriate and to change your way of thinking.

First of all, managers should work with their teams to agree on their goals. Everyone should then have an opportunity to share their way of seeing things (their perceptions), focusing on reciprocal key points, analysing the associated impacts and finding solutions to the problems expressed. Once these steps have been taken, transformation can begin. Transformation requires everyone to fully embrace new ways of working. It requires support in the field and reliable mechanisms for measuring results.

IMPROVING PERCEPTIONS - THE BENEFIT OF PEER REVIEWS

Organisational agility means knowing how to stop doing things the same way they have always been done.

To achieve a sustainable change in behaviour, everyone has to change their perceptions and attitudes towards work. Otherwise, only superficial changes will be achieved.

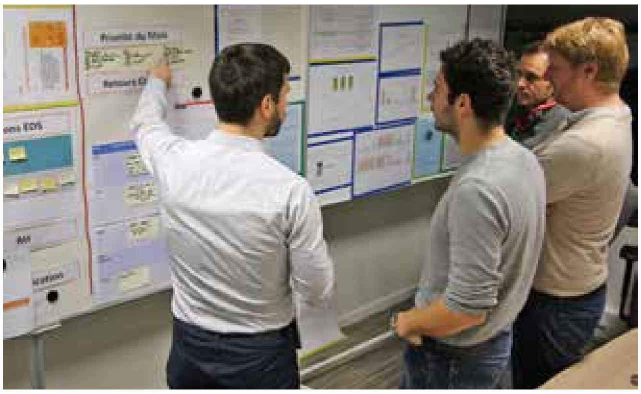
Peer reviews have recently been earmarked by DPN management as a means of reducing the number of maintenance and operations quality issues (see Chapter 2) and are already showing promising signs of helping to break the cycle. They promote a certain degree of awareness and shared experience between staff in the same roles which helps to accelerate the pace of change. I have already seen a positive effect on the openness to accept alternative methods and practices, where it has been acknowledged that a similar requirement may already have been successfully implemented at a neighbouring plant. More work needs to be done in parallel to strengthen adherence to the human performance tools, by re-emphasising the meaning behind the requirements with employees and managers alike. This is an important pre-condition to achieving a sea change in attitudes.

Plant isolation

BUILDING COLLECTIVE INTELLIGENCE

The *Parlons énergie* (Let's talk energy) initiative is a good example of working together in large numbers on the Group's strategic vision by cultivating collective intelligence.

This need for sticking to planned changes could provide the opportunity to develop a new managerial style: one where it is no longer a question of pushing teams to do things but instead collective intelligence is promoted to respond to the complex interactions between all parties. As I see it, there are three conditions here which need to be fulfilled.



Visual management

The first of these conditions is to create a set of common goals that are shared by everyone with a level of confidence that ensures engagement. This gives staff a sense of involvement and responsibility towards their colleagues - the sense that their own individual success is dependent on that of their colleagues and that there is a shared accountability for team performance, because of the shared goals.

I have seen some robust leadership groups, with a shared sense of purpose and ambition. These groups are capable of embodying and sharing with their teams the organisation's common values and job fundamentals. If this behaviour is visible to everyone in the field, including contract partners, then they have the power to deliver the greatest change.

The second condition is to facilitate interaction between parties and develop best practices for cultivating a collective conscience. Numerous initiatives designed to innovate and simplify (e.g. 'Brasserie', 'Marmite', 'Chocolaterie' and 'Phosphore') aim to develop such interactions.

The third condition is to develop personal accountability. The term accountability is used to express something which goes much deeper than simply owning goals and achieving results. It is one of the key attributes of a safety culture advocated by WANO. In the UK, for instance, the safety message is organised every day in the form of a question. This provides daily opportunities for debate, where individual experiences can be discussed, with input from the director as well. The overall aim of this activity is to make people think, participate and engage. This practice reflects a high level of individual engagement. Its regular, repetitive, highly exemplary format helps to encourage much broader participation.

Nuclear leadership academy: 7 steps of accountability

PROVIDING SUPPORT THROUGH TRAINING AND COACHING

Support is needed to help managers and workers become more aware of the limitations of their own ways of thinking and perceptions in a world that is transforming.

The Group's HR director has put forward a support strategy for future managers, which includes dedicated training courses. I have met a large number of managers (e.g. team leaders, group heads) who are experiencing difficulties in leading change. It seems imperative to me that they too are offered individual coaching in a supportive environment. This style of approach already exists at several plants, where regular collective coaching sessions are being run for groups of frontline managers to help them tackle sensitive management issues. These plants are focusing in particular on which behaviours and attitudes to adopt in cases of non-compliance with requirements. I encourage this approach to be generalised.

Accountability: make it happen

I am pleased to see that the UGM (the Group's management university - see inset in Chapter 6) has been providing methodological support for transformations. This includes focusing on the convictions and behaviours of leadership teams and managers, as well as perceptions. The UGM also helps divisions wishing to develop new management methods - firmly rooted in the realities of working in the field - to enhance individual accountability. One of the focus areas of the Edvance transformation programme (see Chapter 7) is to develop managers' leadership skills so that they can build team cohesion, transform behaviours and develop the job fundamentals. I particularly like the fact that this plan establishes the required level of autonomy and accountability, and lays firm foundations to implement the expected transformations.

MY RECOMMENDATION

Managers play an essential role in the success of the Group's transformations through their presence in the field, conveying requirements and their meaning, and reinforcing job fundamentals.
I recommend that the directors of the DPNT, DIPNN and the CEO of EDF Energy, supported by the Group's HR director, provide managers with more training and support to be able to cultivate collective intelligence and prioritise transformations in a way that is relevant to all.

5 DIGITAL TRANSFORMATION: MAKING IT A SUCCESS

An EDF data store

The development of new technologies is accelerating within companies just as it is in everyday life.

Digital transformation is a tremendous opportunity for the nuclear industry to improve its efficiency and the quality of its activities.

The associated changes go well beyond the use of new tools: they involve everyone in changing the way they work, how they interact with one another, and their culture.

HIGH EXPECTATIONS

Digital transformation is part of our daily life. Many new approaches are made possible: mobility (tablets and smartphones), augmented reality, big data, data analytics, artificial intelligence and working as an extended enterprise (see inset).

Companies cannot ignore this change, with its opportunities and pitfalls. Far from being a simple question of tools, it is first and foremost a different way of thinking for those involved (see Chapter 4). It also entails changes in skills and roles, in organisations and in interactions between those involved.

Having up-to-date data that is stored in a single location and can be easily accessed by everyone who needs it improves quality, morale, efficiency and thus the nuclear safety of plants. The same goes for the ability to process huge volumes of data in order to predict phenomena and target, for example, maintenance or operations activities.

Many initiatives have been launched to develop the digital approach, ranging from the CAP 2030 strategy, through to local actions, including large-scale projects within several of the Group's directorates. Staff I speak to, at all levels, have indicated that they have high expectations for greater simplification, improved performance and greater appeal to younger staff. I have also heard numerous requests for greater stability of organisations, work methods and tools.

This illustrates the scale and complexity of the many changes to be carried out.

Some key terminology

Big data: extremely large volumes of data, of various types, including text, photos, videos, etc. produced over decades. Greater storage capacities and increasingly powerful real-time analysis tools offer considerable potential for using this data.
Blockchain: technology for storing and transmitting information. It involves a distributed (decentralised) secure database, the validity of which can be verified by each individual.
Data analytics: used in many industries to improve decision-making, this process consists of bringing together huge amounts of raw data in order to draw conclusions and identify trends which would not have otherwise been identified using conventional analysis techniques.
Data lake: a storage repository holding a vast amount of raw data in its native format, with a view to using it in the future.
Extended enterprise: a form of evolving organisation, which aims at developing strategy, tools/methods and common standards with partner companies. It is facilitated by information technologies.
Artificial intelligence: set of theories and techniques used to create machines that simulate human intelligence.
IoT (Internet of things): set of connected devices and services obtained by linking them together using information and communication technologies.
PLM (Plant Lifecycle Management): process, methods and tools for improved management of a plant's data and associated requirements throughout its life cycle.

DIGITAL TRANSFORMATION IS ALREADY UNDER WAY IN THE GROUP

SDIN AT EDF SA: A COMPLEX TRANSITION FOR EACH SITE

The nuclear technical information system (SDIN) is used to prepare for work in the plants (see Chapter 6) and replaces the Sygma tool. It also includes a document management module.

Launched at the end of 2006, SDIN was gradually rolled out to the sites between 2010 and 2018. The programme included a change management element. However the sites, and not just the first ones, had problems implementing it.

The first sites had to deal with the arrival of the tool, the introduction of AP 913[1], large numbers of new staff and in some cases changes in the organisation of the maintenance teams, all at the same time. This probably intensified the problems of the roll-out, which was also too often seen as being 'simply' a change of tool.

I hear a lot of maintenance teams criticising the quality of the data, and even the user-friendliness of the tool. They have to wait too long for updates to maintenance procedures or software upgrades. Everyone would prefer to work with 'their own' data which they trust and which incorporates experience gained by the site over the past thirty or so years. Many staff are also unhappy that their jobs are losing some of their technical skills and moving towards more IT-based activities.

The aim of improving quality and performance by pooling data and methods is generally shared, but not yet fully achieved.

The SDIN environment is complex, with interactions between many different stakeholders:

- The corporate departments which issue requirements
- The standardised plant series[2] teams responsible for updating shared documents and the associated data
- The sites, which are responsible for the quality of the operating procedures, the staffing of the standardised plant teams and the incorporation of the maintenance programmes
- The site joint project teams attached to engineering divisions which schedule and plan plant modification work.

In October 2018, the directors of the DPN reaffirmed the principles of sharing data and centralising document production. They decided to strengthen the overall management of the standardised plant series by creating a fleet coordination team.

During the changeover to SDIN, sites are experiencing a challenging period optimising processes and updating databases. This often leads to problems during unit outages. I note a positive impact for sites that have completed a two-to-three-year learning period. I will be monitoring the roll-out progress in 2019.

AMS AT EDF ENERGY: AN OPERATIONAL SYSTEM

The UK fleet has been using the asset management system (AMS) since 2003. It is based on the same software package as SDIN, from which it uses more modules, including those for isolations, radiation protection, operating experience and plant spare parts.

The plants in the UK all have significant differences and it is not practical to share data between all sites. Each one

[1] *Strategic initiative for equipment reliability based on operating experience*
[2] *Known as* Structure palier *in France*

is therefore responsible for its own databases and their quality. However, they all use the tool in the same way, with the same data structure.

The importance of managing the data, the application and their upgrades is recognised by all stakeholders.

EDF Energy staff and its contract partners value the system, which they have been using for many years. It is firmly integrated into their day-to-day work.

The way the user group has been involved in the development and implementation of AMS and its deployment over a period of just a few years represents good practice.

SWITCH AND SMART: FOR HIGH-PERFORMANCE ENGINEERING FUNCTIONS

The DIPNN is changing to meet ever-increasing requirements for competitiveness and nuclear safety (see Chapter 7). The SWITCH programme deals with the digital aspects of this change. It involves the implementation of system engineering, which is:

- Designed to manage requirements by organising the data
- Based on a PLM information system (see inset) to manage the data, from design through to dismantling.

A SWITCH team

The programme management includes representatives from the DIPNN, Edvance, the DIPDE, Framatome and HPC project management, emphasising its required cross-functional nature. I am also impressed by the determination to involve the whole industry, in the context of the GIFEN. I recommend that the programme be opened up further to operators, who are the future users of the engineering data.

The tool was chosen in 2018 within the framework of a 20-year partnership with the software supplier. The programme management team is in place.

The main challenge of SWITCH is to ultimately achieve full digitisation (data model, business process, information system architecture) without compromising ongoing projects.

Using a Cradle tablet

The SAFe (Scaled Agile Framework) method used for developing and managing SWITCH, already used by Enedis and EDF's commercial division, is based on added value for the business. It is an Agile method which makes it possible to:

- Adapt the scope of developments to meet quality, cost and timescale requirements
- Deliver work packages at regular intervals, every ten weeks.

This method makes it easier to mobilise the appropriate professional skills and quickly adapt functionality, thus avoiding late detection of problems.

The first modules should be delivered in 2019 as regards the EPR 2, Hinkley Point C, engineering technical standards (RTI) and nuclear pressure equipment (ESPN).

I believe SWITCH shows promise for improving engineering performance. The success of these significant changes involves major changes in team culture (see Chapter 4).

The DIPDE has its own digitalisation programme, SMART. Focusing on engineering in the existing fleet, it also involves those DIPNN divisions that are heavily involved in the existing fleet, in particular CNEPE. This programme is being developed in line with SWITCH. The DIPDE has also launched the development of SYNAPS, a project information system which will be cross-functional across all the DPNT and the DIPNN divisions involved in the Fleet upgrade programme.

MANY OTHER AREAS

The potential of these new tools for sharing and processing data is an opportunity for all businesses to review their methods and improve their performance.

I have been shown many promising initiatives in the Group, including:

- Portable tools, electronic work documents (see inset) at the DPN, or Cradle for managing radioactive waste at EDF Energy-Nuclear Generation (NG)
- Big data and artificial intelligence, for example the Espadon data lake and its hundreds of terabytes of operations and maintenance data, the data analytics factory (see inset), GECKO, which aims to make use

of the numerous nuclear industry OPEX documents via language processing

- The IoT (see inset) with experiments for easy retrieval of data from sensors, or for locating people or equipment
- Working as an extended enterprise, with a number of initiatives including access to electronic work documents for contract partners, or the development of platforms in the context of GIFEN for sharing plans, documents and engineering data
- Standardisation of the use of 2D and 3D data, both on-site and in engineering, for example using digital twins of plants.

For many of these initiatives, EDF R&D is playing a prominent role in investigating new approaches, in collaboration with the rest of the business.

Virtual reality in R&D

CONDITIONS FOR SUCCESS

Digitalisation is one of the enablers for the Group's successful transformation, as identified in CAP 2030 in 2015.

OVERALL GOVERNANCE …

In May 2018, a dedicated executive committee meeting established, for their directorates, a digital roadmap to be monitored and controlled by the Group's information system director. Information system directors play an equivalent role within each business unit.

Data quality and data management are an increasingly important issue as digital technology progresses. The Group's data management policy requires data catalogues to be established. It defines a consistent framework and roles assigned to those required to apply the policy. I highlight the need for a special effort to be made to ensure that data is reliable, consistent between the Group's different directorates and can be used by the various systems (SWITCH, SMART, etc.).

The responsiveness of the support teams is another condition for success. The necessary prioritisation of their work can sometimes result in them abandoning some initiatives or necessitating the development of local applications. Greater coordination between the development teams in the various directorates could improve performance in this area.

Electronic work documents (e-DRT)

The aim of this application is to simplify maintenance activities and improve quality. Users have direct access from a tablet to:

- The sequence of actions to be carried out
- Nuclear and industrial safety information (assistance with pre-job briefing, learning from other users, risk management measures).

This application provides help with readings, e.g. monitoring compliance with thresholds.
Photos can be taken for better traceability of work.
It also makes communication easier between those responsible for procedures, for preparation and for carrying out work.

To develop its information system and its use, the Group needs to employ highly specialised skills that are in great demand, both in-house and externally. It is important that the Group retains the expertise in this vital area.

… AND EMPOWERED TEAMS

I appreciate the freedom given to the nuclear professionals to develop local initiatives in line with the Group's framework. These initiatives are being shared in the DPN, the DIPNN and the DIPDE. Where relevant, I would like to see them shared among all the Group's nuclear divisions, including Framatome, as well as with contract partners.

During my visits I observed similar applications being developed at several sites. While they meet the requirements expressed by a business unit, they also need to be properly controlled, which is key to them being shared, as well as their sustainability, maintainability and quality.

CYBERSECURITY

Technical data that has been accumulated over decades constitutes a unique asset, the management of which must be maintained and its sustainability assured.

There is considerable demand for ease of access to the growing volume of data. It is also necessary to ensure that this data is protected to a level commensurate to the challenges, in particular that of nuclear safety. I note that these two aspects, accessibility and cybersecurity, are being taken into account by the teams I have met, but I urge the utmost vigilance in an environment that is increasingly threatening.

A CULTURE CHANGE

Making directors, managers and their teams responsible for the integrity of the data in their remit underpins the changes to be made (see Chapter 4). Moving from the paper-based approach to work, monitoring and interactions to a data-centric approach requires profound changes to the way work is carried out. It must be recognised that the quality of data depends above all on the rigour with which everyone enters and checks it. This rigour needs to be embedded in how the professionalism of everyone is assessed.

The data analytics factory for operations

This platform, created in 2018, capitalises on data from the Group's power plant operators, using an approach based on data analytics and artificial intelligence. It brings together twenty or so people at the same location with high-level IT, mathematical and technical skills. It is financed by the operators and has powerful storage and computing equipment.
Each project, addressed within approximately 4 months, results in the production of reports and tools (for specialist or industrial use). In 2018, the factory processed the following cases for the nuclear operators:

- Steam generator fouling (anticipating its development by identifying the influencing factors and adapting the operating rules)
- Fuel and manoeuvrability (predicting the axial imbalance of a reactor core by analysing its operating history).

The factory is already working with the DPN and EDF Renewables. It plans to include the DIPNN, EDF Energy and Framatome in its work and to process 20 to 25 cases each year.

It is often difficult to imagine all the possibilities of new technologies. It is no longer simply a case of making small changes to the way we work or learning to use a new tool. It means thinking and acting differently and adapting to a constantly changing environment. This culture change is more difficult in the nuclear industry because of the long timescales necessary and its complex processes. The contribution of EDF R&D, which works on the early stages of innovative topics, e.g. blockchain (see inset), is invaluable for identifying promising solutions and informing the business units about future possibilities.

It is important to ensure that the contribution of digital technology is not compromised by potential negative effects which could result in reducing interpersonal relationships, or reality only being understood 'virtually'.

All the leaders I met are expecting a great deal from digital technology. I recommend developing their 'information system culture' so that they can make an effective contribution to the Group's transformation rather than to just use new tools. To make informed decisions and provide effective support for their teams, they must:

- Be aware of the importance of the quality, management and protection of data
- Ensure that their teams work closely with information technology specialists to build high-performance solutions together
- Be capable of anticipating the future, devising new organisations and ways of working.

MY RECOMMENDATIONS

The success of the Group's digital transformation lies in significant culture changes for all staff. I recommend that the directors of the DPNT, the DIPNN and the CEO of EDF Energy develop the 'information system culture' of their leaders.

Innovative, and sometimes similar, digital transformation processes have been started in several parts of the Group. I recommend that the directors of the DPNT, the DIPNN and the CEO of EDF Energy, together with the director of the Transformation and operational efficiency directorate (DTEO):

- **Reinforce consistency in approach**
- **Develop synergies between business units, including Framatome.**

Like the EDF Group, contract partners are also concerned by digital initiatives. I recommend that the directors of the DPNT and the DIPNN continue the work that has been started in GIFEN to benefit work quality.

6 MANAGEMENT OF WORK ON SITES

On-site maintenance activity

In France, the fleet service life extension programme involves a considerable amount of upgrading work.

In the UK, continued operation of some AGRs and preparations for the shutdown of others is generating a significant amount of work, particularly with regard to making the fuel routes more reliable.

Success for both fleets hinges on internal organisations and processes that are robust and high performing.

INSTILLING A PROJECT CULTURE

An environment that cultivates a project culture is the key to success. Plants in both fleets have developed project structures to manage maintenance and modification activities (see inset). Whilst this approach works well at some sites, others still have some way to go before things can be said to run smoothly. There are two weak points which require particular attention: the quality of preparation for planned work and the lack of performance management based on relevant indicators and high-performing digital tools (see Chapter 5).

FOCUSING ON PREPARATION QUALITY…

Accurate, reliable plans are necessary to minimise the impact of unforeseen work on other planned activities.

In the UK, planning for unit in-service tasks (see inset) begins 30 weeks ahead of the execution week to ensure plans are of a high quality and as stable as possible. This level of discipline is also applied to unit outages, where planning commences 24 months in advance and is reviewed regularly to limit the number of late changes.

In France, scheduling unit in-service and outage activities relies on similar organisations to those in the UK.

Rapid response teams are on hand in both fleets to carry out remedial works for unforeseen events so as to limit the impact on the plans and mitigate any subsequent deterioration in quality and safety. A recent benchmarking exercise comparing the UK fleet with their French counterparts highlighted the need to increase rapid response team numbers in the UK in an effort to address the plant defect backlog.

Long-term, outage and unit in-service projects can also be severely impacted by national modification campaigns, such as the plant changes required for the Fleet upgrade programme in France. I have heard many complaints about the lack of quality of documentation regarding the preparation and completion of modifications. It appears that this work is often completed late and fails to consider the needs of the user, especially in France. The whole process delivers higher quality when plant staff are engaged from the moment where recommendations for modifications are made right through to the reactor return to service.

A robust project culture, underpinned by experienced staff, is necessary to be able to make sound technical decisions and prioritise them better. During the preparation phase, for instance, a plan should be in place and followed to the letter that allows decisions to be made at the right time, without undue time pressures.

Operator rounds

There is too much reliance on reactive 'fire-fighting' as a means of remedying situations. Although there are occasions where such actions are necessary, project managers should concentrate on completing planning preparations as effectively as possible. Whilst this work is often carried out behind the scenes, it contributes significantly to a smooth implementation phase and to overall safety.

… AND ON RESULTS

Considerable progress has been made in project performance over the past 15 years in France and the UK thanks to better organisations, skills and tools. The benefit of using tools such as the asset management system (AMS) and the nuclear technical information system (SDIN) is clear (see Chapter 5): both have helped to standardise working practices and build a results-driven culture. These developments by their nature instil a greater degree of daily rigour.

Managing changes to the plan is key, i.e. when activities are either completed ahead of time or fall behind. I have seen too many instances of imprecision when using performance indicators, especially quality indicators. Sites which use these indicators to support an approach founded on good communication and accountability prove to be the most successful. I would encourage all plants to adopt a more rigorous approach to applying performance management indicators in order to measure progress at each stage of preparation to benefit from a better overall project coordination.

In both fleets, standardised organisations enable easier inter-plant comparisons and sharing of good practices. In France, however, I notice that there is a somewhat variable application of national standards. This slows down the organisational transformation process and reduces the effectiveness of corporate support. A greater level of consistency across organisations in the UK means that the British fleet has achieved more consistent results across the fleet.

Some of the plants in the UK are preparing for end of life and rationalisation of functions and roles on these sites is currently underway. These changes need to be implemented in such a way as to maintain the benefits of standard organisations such as sharing operating experience and enabling the means to collectively improve results.

RESPECTING THE FUNDAMENTALS

I have met with some high performing project teams at sites. These multi-discipline teams bring people together at a single location. Each discipline has very clear roles as well as shared goals. One improvement area is to achieve better integration of contract partners into project teams. This 'one team' spirit needs to become the norm at all sites.

REGULAR DISRUPTIONS TO UNIT IN-SERVICE WORK PLANS IN THE UK

Reliability of the fuel route is a regular source of challenge in the AGR fleet when planning and scheduling work.

Eight of the AGRs were designed to be refuelled on-load. Any slippage in refuelling schedules has a direct impact on planned unit in-service work. Some sites saw more than 3 out of 10 annual refuelling operations being rescheduled less than 10 weeks before the original planned date. This high number of scheduling changes has a knock-on effect on the planning and completion of in-service work-week activities. Better coordination is needed between fuel route engineering and maintenance teams and the other plant departments to improve equipment reliability.

For the other six AGRs which are refuelled during an outage, I can see that these were all completed on schedule this year. This success has been achieved only in recent years and is down to good inter-departmental planning.

When a response to unforeseen events is needed at plant or fleet level, Event recovery teams and Fleet critical programme teams can be deployed. In the UK, as in France, these multidisciplinary teams are extremely effective at providing a rapid response to a plant issue. It is important, however, to restrict this way of working to occasions when it is absolutely necessary, to avoid overburdening resources needed for unit in-service and outage preparation activities.

Making sure that adding more and more tasks to be completed during outages without adversely affecting the overall outage duration remains a challenge. Any delays experienced during an outage have a direct impact on a unit's in-service workload. Reactor outage overruns were still too high in 2018, averaging 25 days.

I would encourage EDF Energy to make full use of the recently deployed critical path monitoring tool so that the lessons learned from any delay of over 2 hours can benefit the whole fleet.

Site project management: long-term/ outage/unit in-service

Long-term: Multi-year projects involve planning for activities that are carried out up to 10 years at plants in both fleets. This schedule is then linked to the in-service and outage project plans one to two years ahead of the planned activity start date.
Outage: In France, outage project teams plan and manage outages for refuelling, plant modifications and equipment maintenance. This work is prepared over a 9-month window up to the outage. The UK preparation is as in France, and is carried out over a period of 24 months prior to the start of the outage.
In-service (or work week in the UK): for each work week, the project teams in France manage a 9-week cycle of preparation for maintenance, project and testing work. The site project team is responsible for coordination of the preparation and delivery of the plan. This again is the same in the UK, but over a 30-week cycle.

IN FRANCE, SIMPLIFY INTERFACES

Teams for the three main types of project – long-term, outage and unit in-service - must work together to coordinate activities to improve their overall performance (see inset).

I note that these projects are not always managed under the same site structure, which hampers opportunities to optimise the whole project process and take full advantage of peer exchanges and corporate support services.

Preparation for plant isolation

In addition, sites often prioritise outage projects when it comes to allocating resources. This places greater emphasis on medium-term actions to the detriment of both short- and long-term preparation, which in turn can have a negative effect on performance, particularly in the area of quality.

Despite an improvement in outage figures in 2018, the average outage duration was still too high (13.4 days overrun on average). I am pleased to see a renewed commitment to peer reviews as a means of making greater progress.

Task forces are set up to handle urgent work. They provide an ideal way of mobilising the necessary expertise quickly with support from engineering. This strategy has been extremely successful for a number of tasks delivering excellent results. Nevertheless, the success comes at the expense of disrupting site projects when staff are called away to work on a task force. It also seems that an increasing number of issues are handled in this way, which overloads the sites and corporate services alike. Once again, I urge restraint when it comes to deciding if a task force is to be deployed; although they are effective when dealing with urgent matters, they are also very resource-intensive and can divert expertise away from site projects when they need it.

Plants are at the interface of a complex environment with corporate support functions (which have high reporting demands) and engineering departments (which are often late to produce the necessary inputs to ensure a smooth outage). Plants also face a variety of logistical problems, such as lack of spares, or preparation support software which fails to meet the needs of the users (see Chapter 5).

From a Fleet upgrade programme perspective (long-term operation, LTO), the interface between plant project teams, engineering divisions and the fleet upgrade project itself works well. The fleet upgrade project team is small, and has clear responsibilities which are shared with all stakeholders. Communication is effective and actions are clear. The coordination, managed by the project, is an important enabler in achieving standardisation across sites.

GUARANTEEING THE AVAILABILITY OF SPARES

I am still seeing the same levels of dissatisfaction in France regarding spares that I referred to in my 2017 report. The spares database still contains inaccuracies and over-ordering remains commonplace through fear of not having the right parts available at the right time.

Cases of unavailability of spares have also been observed increasingly in the UK.

I recommended in 2017 that in France, the plants and corporate services unite around a common vision. There is still a great deal of work to be done in this respect in both fleets, to restore the quality of the databases, to address the issue of spares quality and to ensure the right stock levels.

Valve operation

PROJECT TEAMS

To ensure that safety, quality, planning, costs, interfaces, contractors, and communication are all managed effectively, project teams need to receive appropriate training and guidance, be held accountable and be properly monitored.

ONGOING SUPPORT FOR PROJECT TEAMS

It is important to identify those people who have an aptitude for project management and provide them with the relevant training and support to make sure they possess all the necessary skills. These people must have several key competences to be able to work within matrix structures: the ability to unite teams, managerial rigour, goal clarity, as well as good listening skills to tackle what are often contradictory issues in a way that protects the common interest. These skills do not always come naturally.

I am impressed by the work of the EDF Group's management university (see inset) in building a project culture and supporting project managers.

EDF Group Management University (UGM)

The University's mission is to:

- Support the professional development of leaders and managers within the EDF Group
- Build a common management culture through training in the fundamentals of management
- Cultivate the right conditions to bring about transformation within the Group

Performance management, innovation, and change management are just some of the topics covered in the University's programmes. In addition to defining and developing cross-disciplinary training programmes, the UGM also supports transformation initiatives at certain sites.
Project management is now also included in the scope of the UGM's offering to expand the project culture throughout the Group.

CONSOLIDATING KNOWLEDGE AND KNOW-HOW

In France, I often hear criticism of the staff mobility policy where mobility is felt to be too frequent for certain roles such as schedulers, planners and outage managers. It must be remembered that in these areas it takes time to build up the necessary experience and know-how before it can add value to projects.

Following the retirement of a number of maintenance staff, plant engineering teams were in high demand to assist with plant faults arising. However, now that maintenance team numbers have been bolstered with additional resources and more experience, engineering teams need to be left to refocus on their primary role of ensuring plant reliability.

MY RECOMMENDATIONS

Although task forces have proved particularly effective at resolving urgent unforeseen issues, there is too great a reliance on them, in France in particular. To minimise disruption to other site project activities, I recommend that the directors of the DPNT and the DIPNN seek to further regulate the number of task forces initiated.

In France again, the high turnover of key site project staff is detrimental to the acquisition of know-how in an area where this need is great. I recommend that the director of the DPN strive to strike a balance between job experience and staff mobility.

7 ORGANISATION OF NEW-BUILD ENGINEERING

Technical division of the DIPNN

The engineering divisions have an important responsibility for the nuclear safety of plants, from design, operation and through to dismantling.

Changes in the nuclear industry, project management processes and engineering methods provide opportunities to improve engineering performance and quality.

The success of the changes undertaken by the DIPNN is essential for the future of the nuclear sector.

AN EVOLVING ENGINEERING FUNCTION

In 2015, having learned lessons from the problems encountered with major fleet and new-build projects, the Group decided to significantly strengthen the management of projects. This included the designation of project directors, each reporting to an executive team member, the development of a Group project management policy and improvement of the operational management of activities. The DPN's role as the owner of projects for the French fleet has been strengthened, with the positive effect of it becoming more accountable for modifications on plants.

This initial step saw the creation of the DPNT (Nuclear and conventional fleet directorate) and the DIPNN (Engineering and new-build projects directorate) and the setting up of project divisions: the Fleet upgrade programme and the Decommissioning and waste programme within the DPNT on the one hand, and the Flamanville 3 and EPR 2 programmes (see Chapter 8) within the DIPNN on the other hand. The engineering functions of the former DIN (Nuclear engineering division) have retained their previous areas of expertise but they now report to different directorates. The DIPDE (Nuclear fleet engineering, decommissioning and environment division) was created and is part of the DPNT. Four divisions of the former DIN were moved to the DIPNN, while continuing to carry out a significant portion of their work for the fleet.

As well as strengthening project management, it was clear that there was also an urgent need to improve engineering productivity. In 2017, I pointed out the contribution of the first multidisciplinary integrated teams to quality and effectiveness.

At the same time, the challenge of optimising the performance of the nuclear sector, in particular integrating AREVA NP, renamed Framatome, in the EDF Group, meant further re-organisation, with the creation of Edvance, a joint venture between EDF and Framatome (with an 80% and 20% share respectively), in June 2017.

Since January 2018, the DIPNN has been organised into 3 project divisions, 2 engineering functions, 4 operating divisions and 4 corporate divisions (see inset).

Design oversight at CNEPE

The changes affect all those involved in engineering, significantly altering the way they work and their outlook, introducing greater accountability, the desire for greater efficiency, new tools, new interfaces, etc. The DIPNN transformation plan is based in particular on the SWITCH digital transformation programme (see Chapter 5).

I note that the various stages of the re-organisation have been completed without any significant disruption of ongoing projects. I will be keeping a close eye on how the DIPNN teams adhere to the changes that have been undertaken and their effects on design quality.

EDVANCE: A PROMISING START

This subsidiary of EDF and Framatome was created to provide EPCC[1] services for nuclear islands. It tackles key issues impacting the whole French nuclear sector: ensuring competitiveness, delivering successful projects, sustaining critical skills, supporting international development and renewal of the existing fleet.

It has gradually been establishing itself since mid-2017, as the contracts for the EPR 2, HPC and then Flamanville 3 projects were signed. Edvance also contributes to the preparation of responses to calls for tenders for new projects outside the Group. It is based at several sites in the Paris region, in Flamanville, in the UK and in Germany.

Its teams, comprising more than 2000 engineers and technicians, are composed of staff from the parent companies or from partner engineering companies for each project. Edvance also receives support from the parent companies via service agreements.

Structure of the DIPNN

With more than 4000 staff, the DIPNN is responsible for new-build engineering and assists with engineering for the fleet. It is organised into:

- 3 project divisions: Flamanville 3, Hinkley Point C (HPC) engineering and EPR 2
- 2 engineering functions: Edvance and the CNEPE (Electromechanical and plant engineering support department) providing design services for conventional islands, heat sink and balance-of-plant (BOP) systems, for the fleet and for new-build
- 4 operational divisions:
    - Technical division, responsible for drawing up and maintaining the nuclear safety and design standards across the whole of nuclear engineering
    - Industrial division, responsible for ownership of the nuclear industrial policy, for monitoring suppliers and maintaining expertise in the field of materials
    - Project support and digital transformation division, responsible for the SWITCH programme, managing OPEX from new-build projects and project management methods
    - Development division, responsible for future international projects
- 4 corporate divisions: human resources, coordination and management of transformations, finance and performance, and communication.

AN AMBITIOUS TRANSFORMATION PROGRAMME

Edvance, created from various pre-existing engineering functions, has initiated an 18 to 24 month transformation plan, focusing on 5 main areas:

- How projects are carried out with partners
- Engineering transformation and digitalisation
- Knowledge management, including OPEX and constructability
- Cultural transformation
- EPCC skills.

To meet the objectives of the various areas within the plan, Edvance has given leaders, each of whom is sponsored by a member of the management team, the task of defining a clear plan of action. I encourage this participative approach and I commend the support that Edvance has received with these transformations from the EDF management university (see inset Chapter 6).

[1] *Engineering, procurement, construction, commissioning*

SIMPLIFICATION TO IMPROVE QUALITY

In 2017, I mentioned the high expectations for simplification expressed by teams. In 2018, I was shown more flexible interfaces between Edvance and Framatome on the designs of auxiliary systems and consideration of optimised working in an 'extended enterprise'[1] with in-house and external partners.

I will look closely at the contributions of the SWITCH programme (see Chapter 5) to design quality and to the optimisation of engineering processes.

EPR simulator at Edvance

I believe it is important to simplify the decision-making processes and the interfaces between HPC project management and the French engineering teams. It is particularly important to find a balance between the responsibilities of the customer, HPC, and delegating certain decisions to Edvance, for example those concerning technical discussions with suppliers.

The particular positioning of Edvance, which is both a subsidiary of EDF with close ties with the DIPNN and a company with contractual commitments to EDF, obviously offers opportunities for simplification and improving performance. In 2019, I will be interested in the conclusions of the discussions between the DIPNN and Edvance on this.

MANAGING SKILLS AND OPEX

It is essential that the parent companies of Edvance organise the provision of staff who meet the expectations of their subsidiary, in terms of both quality and numbers, with a clear vision of the requirements across its whole remit. I also urge that there be cross-career pathways for staff between Edvance, EDF and Framatome. Edvance must also give partner engineering companies an accurate forecast of the future workload sufficiently far in advance so that they can provide Edvance with the necessary skills.

However, Edvance has not yet taken on some of its EPCC responsibilities, for example monitoring fabrication or tests, in ongoing projects.

Taking technical and organisational OPEX into account and capitalising on it, across Edvance's entire EPCC remit, is also a prerequisite for success. However, the teams, who come from different companies, often mention obstacles to exchanges due to problems in clearing intellectual property clauses and usage rights.

In 2019, I will want to be shown the measures taken by Edvance, EDF and Framatome to ensure that Edvance has all the skills required for ongoing projects and those under preparation.

SYNERGIES TO BE DEVELOPED WITHIN THE GROUP

The creation of Edvance and the integration of Framatome are increasing the engineering strengths of the Group. To improve their performance and adapt to the new structure, the divisions of the DPNT and the DIPNN have initiated transformation programmes aligned to the Group's CAP 2030 project.

REDUCING SILOS

Joint DIPNN and DPNT decision-making bodies, such as the Technical standards committee (CRT) and the Nuclear safety standards committee (DRS), make it possible to take decisions that are harmonised across both directorates.

I also recognise that the DIPNN divisions continue to be committed to working for the fleet, over and above their role in new-build projects. This makes it easier to maintain high-level technical skills for all projects and to share learning, including that from plants. I would like to see this involvement continue, even though the new-build workload is increasing.

However, I still see people functioning in silos all too often: topics, often closely related, are approached differently by the teams concerned. An example of this is the diesel generator buildings being designed by different teams depending on whether the project is for a new-build reactor (Edvance) or an in-service reactor (DIPDE). The organisations, project management practices (indicators, reporting and responsibilities) and choices of technical options, methods and tools could be more consistent. More harmonisation between engineering for the fleet and for new-build would make it easier to share learning, would avoid the same questions being asked more than once and would improve quality.

Tests on electrical cubicles

[1] *Evolving organisation which aims to develop a joint strategy, tools/methods and standards with partner companies*

ENHANCING OPEX

OPEX plays an essential role in nuclear safety, helping to identify best practices and preventing errors being repeated. The more integrated, the more effective it is. Leaders must ensure that their teams are collecting and using OPEX.

The performance and quality of work of the Group's engineering divisions would be improved if technical and organisational OPEX flowed more freely between the fleet and the new projects, and if there was more sharing between Framatome and EDF.

The OPEX process established by the Project support and digital transformation division (DSPTN) for engineering and the various phases of the EPR projects seems relevant and merits a further boost.

SKILLS MANAGEMENT

The management and development of skills are essential for current and future projects. I urge the DIPNN and the DPNT to develop career paths that include Edvance and the divisions of the DPNT, in particular the DIPDE, Ingeum[1] and the DPN sites.

International career paths, in China or the UK, and exchanges with Framatome will also help to sustain and develop the know-how gained for EPR projects.

It is important to check that the key skills development plans cover all the Group's engineering, construction and nuclear project management professions.

Experts in particular, with their knowledge, capacity for innovation and nuclear safety culture, are an essential resource for informing the strategy and the decisions of the Group. I appreciate the work that has been carried out to explain the fundamentals of nuclear engineering expertise (see inset). I suggest that this approach be extended to Framatome, paying particular attention to the areas of expertise which are no longer within its remit but are now within EDF or Edvance.

INTERNAL OVERSIGHT OF ENGINEERING TO BE REINFORCED

The improved productivity must be accompanied by progress in terms of quality and management of EPCC activities. I am therefore particularly interested in the Edvance and DIPNN internal oversight bodies.

EDVANCE INDEPENDENT OVERSIGHT

The Independent oversight department (DACI), which reports to the chairman of Edvance, gives an independent view of risk management and nuclear safety, and provides support and advice to departments and projects on the application of regulations. It carries out reviews, provides internal oversight and manages risks as well as promoting the nuclear safety culture within the subsidiary. I note that it also verifies some designs.

The fundamentals of nuclear engineering expertise

A working group made up of experts, managers and those in charge of HR in the DIPNN, the DPNT and EDF R&D has drawn up a guide listing 7 fundamentals under 3 headings:

- Good technical and industry knowledge:
  - Good knowledge of the individual's own technical field in terms of nuclear safety and industrial performance
  - Connection with industry
- Behaviour:
  - Supporting and defending the interests of EDF, persuading and influencing
  - Networking and mobilising collective intelligence
  - Facilitating decision-making
- Leadership:
  - Developing skills
  - Inspiring innovation.

The guide gives requirements, key points and illustrations for each of the fundamentals. It will be incorporated in the joint DIPNN-DPNT Nuclear engineering skills and expertise policy.

The basic principles of the DACI appear to be appropriate. In 2019, I will want to see the results of its verification and nuclear safety assessment work.

Its links with its equivalent departments in the Group engineering functions should be strengthened.

The organisation of the monitoring and external oversight of Edvance by EDF should be specified, in line with the INB regulations[2] for French projects.

DIPNN INDEPENDENT NUCLEAR SAFETY AND QUALITY OVERSIGHT DEPARTMENT

The DIPNN Independent nuclear safety and quality oversight department (DFISQ) periodically reviews the operational divisions, the CNEPE and the project divisions, as mandated by the DIPNN director. It also reviews the joint site teams[3], whether they report to the CNEPE or the DIPDE. It carries out support and advice on specific topics: six concerning Flamanville 3 since the end of 2017. In 2018, it was involved in the first review of the DIPDE in support of the DPN's Nuclear Inspectorate. This practice should be continued as it provides both teams with a wealth of mutual information, helping to ensure the relevance of their observations.

The internal organisation of the DFISQ has changed and its advance planning of skills is satisfactory in relation to

1 Conventional thermal engineering
2 Ministerial Order of 7 February 2012 establishing the general regulations for licenced nuclear facilities
3 Mixed engineering and operations teams responsible for implementing modifications on plants

its remit. Its rigorous approach to its assigned tasks is valuable.

However, I question its remit, which does not seem to cover the whole of the DIPNN. For example, it does not review the nuclear safety/quality aspect of decisions made. Beyond management of the reviews it has been asked to carry out, it does not have an overall view of the key nuclear safety/quality issues for the whole DIPNN.

The director of the DIPNN chairs the feedback meetings on the reviews he has requested. However, the DFISQ is positioned quite some distance hierarchically from the director: it reports through the performance and risk management unit in the finance and performance division.

More generally, there should be a more comprehensive mechanism for carrying out all the tasks of the independent nuclear safety oversight team at the DIPNN (see recommendation in Chapter 2 and points which require attention on page 7).

MY RECOMMENDATIONS

The success of Edvance will depend on long-term skills management. I recommend that the director of the DIPNN pay close attention to the provision, by EDF and Framatome, of sufficient resources to meet the requirements of their subsidiary, for ongoing projects and those in preparation.

The generalisation and standardisation of best practices, and OPEX sharing within the Group, all contribute to the quality of the work. I recommend that the directors of the DIPNN and the DPNT increase the synergies and the cross-career pathways between their divisions, including Framatome and Edvance in this initiative.

8 EPR: THE FIRST IN OPERATION

Taishan nuclear power plant

The start-up of the first EPR at Taishan in China was a success. The reactor design includes new features that significantly improve nuclear safety.

Five other EPRs under construction will be commissioned in the coming years, and other projects are in preparation.

The sharing of operating experience between EPR operators is key to the development of the nuclear sector.

EPRs IN CHINA AND FINLAND

TAISHAN: A WORLD FIRST

Following the reactor going critical for the first time on 7 June 2018, TNPJVC - subsidiary of CGN[1] (51%), EDF (30%) and Guangdong Yudean Group Company (19%) - continued testing and progressively ramped up the reactor to its nominal electrical power of 1750 MW in late October.

My visit to the site confirmed the following strengths:

- Professional and proactive Chinese operations teams
- Openness to external views
- Smooth transition from construction to operation
- Processing of anomalies inherent to any new reactor
- Plant housekeeping
- Support provided by the seconded EDF teams.

[1] *China General Nuclear power corporation*

The second Taishan EPR is scheduled for commissioning in 2019. It will have the added advantage of teams already trained and being able to exploit the learning from the commissioning of reactor 1. I welcome the operator's efforts to take into account lessons learned from construction and commissioning events, such as fires and automatic reactor trips.

OLKILUOTO 3 EPR IN FINLAND: EXCELLENT PLANT CONDITION

I was invited by TVO[1] to visit Olkiluoto 3 in 2018. I was impressed at the excellent plant condition. After meeting the teams, I feel confident in the start-up of this reactor which will follow the completion of testing and once the operator has taken full ownership.

HINKLEY POINT C: A WELL-MAINTAINED CONSTRUCTION SITE

The reorganisation of the project's management in 2017 has proved to be well conceived. I found a cohesive team comprising professionals from different backgrounds with rich and complementary experience. The project management is clear and assertive, focused on quality and meeting milestones.

Preparation for operations is the responsibility of the Project Director, who is sensitive to the requirements of operations teams. This should promote cooperation between construction teams and the future operator, and make it easier to incorporate their needs.

HPC construction site

Following approval from the ONR, the pouring of the basemat for reactor 1 was started in autumn 2018, along with that of the cooling water pump house. The tunnel-boring machine will be up and ready to excavate the cooling water intake and discharge tunnels in the first quarter of 2019. The levelling work for reactor 2 will be completed, according to programme, in early 2019.

I noted a well-maintained construction site, which encourages good industrial safety results and worker behaviour that is respectful of the rules. I do, however, call for greater care in observing the safety rules applicable when using cranes for lifting loads (see Chapter 3).

The next big milestones for the project include the detailed designs, equipment procurement, fabrication and related supervision, together with electromechanical assembly activities. The organisation between the engineering functions and the HPC project management has improved but remains complex (see Chapter 7). This could slow down the decision-making process for design changes.

FLAMANVILLE 3: PREPARATIONS FOR FUEL LOADING

A VERY TIGHT SCHEDULE

Important milestones were met in 2018, including the end of the cold functional tests and the successful completion of the reactor vessel leak-tight test. The site is getting ready for the hot functional tests, a key step in the commissioning process. The strong commitment of the teams was visible at all levels.

To prepare for fuel delivery in 2019, the operator must make sure its processes meet all operating requirements. At the same time, it is putting in place ways of working with Flamanville 1 and 2.

As not all installation activities have been completed, the project is employing temporary means to carry out the tests. Although these measures are normal on such complex sites, their extent must nevertheless be contained. Failing this, construction site teams find themselves spending a great deal of time designing temporary solutions to meet a test milestone, before having to dismantle them again later to build the permanent facilities. Modifications must also be taken into account when equipment does not conform to design, manufacturing or assembly specifications, e.g. on the main secondary circuit (see below). To this must be added the final installation and clean-up to nuclear standards.

This complex process consumes considerable time and effort, and can even be a source of non-conformities.

In light of the complexity resulting from the scheduling of these phases, I recommend that much greater attention be paid to making the detailed overall schedule more reliable and to sharing it with contract partners whose commitment needs to be maintained.

SENSITIVE TECHNICAL POINTS

Such issues are shared and thoroughly examined by both the project management and the future operator. Some technical points do tend, however, to emerge at the last minute, whether construction non-conformities or design study results. At this stage of the project, it would seem wise to make sure the design study results or the end-of-

[1] *Teollisuuden Voima Oyj, a Finnish electricity utility*

manufacturing files are examined immediately to better anticipate any measures that may need to be taken.

The non-conformity detected in some 'break-preclusion' welds (see inset) is the most significant one at present. Other technical difficulties also call for close supervision. The weld defects were detected by the EDF inspection teams, albeit late in the day. I nonetheless note that new non-conformities were revealed during the ASN examination process. I suggest that as much learning as possible be taken from these non-conformities and past events, e.g. weld non-conformities on the metal brackets of the reactor building crane, particularly for supervision and inspection activities.

Assembly operations on the Flamanville 3 site

AN ORGANISATION THAT CAN ADAPT

To overcome the difficulties encountered, the project management is simplifying its organisation and now basing a large proportion of its teams on the Flamanville 3 site to improve industrial safety, to complete the main secondary system repair programme, to optimise scheduling, and to boost the pace of assembly.

A 'completion work package' team has been set up to provide the operator with equipment and facilities that comply with requirements. I do, however, note the high volume of unresolved non-conformities at a time where the systems are being handed over to the operator. All issues are logged and prioritised according to the different commissioning milestones by agreement with the operator. It seems to me to be important to reinforce the management of this work which is still outstanding.

Very few systems have been handed over to the operator so far, other than the electrical systems. Yet OPEX from construction sites worldwide - particularly Taishan - shows how important it is to stagger these handovers over time. In this way, the operator can progressively take on board their plant responsibilities in a manner of confidence and quality. Strong commitment from the construction teams to meet the handover schedule, shared with the operator, is essential in driving this step by step transfer over of the plant.

ASSESSMENT BY THE DPN NUCLEAR INSPECTORATE (IN)

Flamanville 3 underwent a specific assessment by IN as a result of a joint request issued by the DPN and the project's management. It identified the areas in which improvements can be made leading up to commissioning.

A roadmap or 'nuclear safety leadership plan' has been defined collectively by the operator and the construction team. It is designed to help the operator get ready for their nuclear-related responsibilities by focusing on several key points:

- Definition of the parts of the site for which the operator has full responsibility, including the work methods and relevant DPN standards
- Actions to prevent the risks of foreign material in equipment
- The role of the director for emergency preparedness and the onsite emergency plan.

The operating requirements are essential for reactor commissioning and will be gradually implemented according to a scope and a schedule that has been jointly defined by the project management and the operator. As facilities are successively transitioned into radiation controlled areas, the operator will be responsible for the radiation protection regulations being applied. They will also progressively become responsible for managing fire safety and will re-qualify equipment once the maintenance activities have been performed post testing.

Secondary circuit pipework at Flamanville 3

Two types of non-conformities have been detected on the main secondary circuit of the Flamanville 3 reactor. First of all, it became apparent that the manufacturing requirement to exclude guillotine failure of the pipework had not been implemented. Such a rupture to a pipe is deemed sufficiently improbable that it does not require the examination of all the consequences of such an event in the safety studies. The break preclusion is based on specific manufacturing and quality assurance requirements.
EDF also identified defects in about 30% of the welds, which had not previously been detected either during the manufacturer's inspections or first-level monitoring. The Flamanville 3 project has since developed a weld characterisation and repair programme subject to ASN approval.

A STRONGER VOICE FROM INDEPENDENT NUCLEAR SAFETY OVERSIGHT (FIS) TO BE DEVELOPED

In 2016, I was pleased to see there was much greater cooperation between the construction teams and the operator, including the creation of a joint FIS organisation whose role was yet to be fully defined at the time.

In late 2018, it was decided that safety engineers needed to be more involved in the test results impacting nuclear safety and on-call requirements were defined for this role. The project management and the operator must make sure that these safety engineers are given a strong voice if this measure is to be effective. I was made aware of the example of a piece of plant being started up for testing under less than optimal conditions with respect to fire risks. I therefore recommend that the escalation and consultation process for the FIS be made more robust.

REINFORCING THE OPERATOR'S ROLE

I note a significant improvement in the role and influence of the Operations manager's position between my two visits in 2018. Operations managers are now holding daily meetings with representatives from all the functions and the construction team. The priorities defined are being met. The central control room is under their responsibility even if there is some work to do before it starts to feel like a sanctuary.

Central control room on the Flamanville 3 nuclear power plant

I have also seen a considerable improvement in the condition of the fuel storage pool, which is moving closer to the fleet standard. This improvement needs to be maintained and extended to the rest of the plant.

The capacity to provide maintenance with the staff at its current numbers should be verified by both the site and DPN management. I suggest further strengthening the operations teams with staff either with operating experience or having taken part in the Taishan test phase.

EPR 2: THE FIRST KEY MILESTONES

The EPR 2 project sets out to improve the competitiveness of the technology by integrating OPEX from other EPR projects, by simplifying its design to streamline construction (see inset), and by reinforcing the efficiency of engineering through the creation of Edvance (see Chapter 7).

In late 2017, after the ASN had finished its examination of the design changes proposed, the final technical configuration was defined for the partial renewal of the French nuclear fleet. It incorporates OPEX from previous EPRs and meets the needs of manoeuvrability due to the current energy mix having a high proportion of intermittent renewable energy.

Discussions with the ASN and IRSN between 2016 and 2018 endorsed the simplifications provided by the design, thus making it possible to provide a stable safety standard.

A new phase initiated in June 2018 is focused on the benefits of a series of reactors of the same technology (design, procurement, construction), with the aim of launching the construction of the first pair of reactors.

The planning of the different phases takes into account regulatory requirements (public consultation, licensing, preliminary nuclear safety report, etc.) which condition the pace of the detailed design milestones and site works.

The momentum propelling this project forward is clear. I will be paying close attention to:

- Interfaces between the project team and engineering, ensuring that nuclear safety remains top priority
- Operator's role during each phase of the project, including the definition of engineering data for operations and the output of the SWITCH programme (see Chapter 5).

EPR 2

This optimised version follows in the footsteps of the EPRs, having taken on board the same nuclear safety requirements and main equipment.
The key objective is to simplify design and reinforce the competitiveness of the technology by improving its constructability, equipment standardisation, etc. This determination and learning has led to certain options foreseen in the EPR, e.g.:

- The 'two rooms' concept has not been retained, which allowed for maintenance in the reactor building while in service
- A single reactor containment with a liner has been designed to resist external hazards
- The number of systems has been reduced
- The civil structures have been redesigned
- Defence in depth has been optimised and further enhanced for the case of extreme conditions (post-Fukushima).

The reactor performance, particularly its manoeuvrability, has been adapted to work better with a low carbon energy mix with a high proportion of renewable energy.

OPTIMISING OPEX BETWEEN EPRS

Operating experience from Taishan will simplify the commissioning process for other EPRs. The data collected during the core physics tests in this new reactor will be analysed in-depth by TNPJVC in collaboration with the French engineering teams to capture lessons learned and improve computer codes. The operator had to deal with a number of automatic reactor trips for which the feedback process is underway and being shared with the Flamanville 3 operations teams. I commend this open, responsible attitude that needs to be perpetuated throughout the course of the production phase.

At Olkiluoto 3, I also observed the collaboration between AREVA and EDF SA which has brought some specific operations skills to the project. I encourage TVO and other operators to strengthen their ties so that their operating experience is shared openly at an international level.

Thanks to the support of earlier projects, HPC will have the advantage of benefiting from a wealth of operating experience. I suggest the HPC project be prepared to accurately identify the problems faced at Flamanville 3 and Taishan, including the early transfer of engineers with experience into the main test phases. The project also needs to be organised so that OPEX can be capitalised quickly and easily to enable future EPR and EPR 2 projects to benefit from lessons learned.

MY RECOMMENDATIONS

The success of new-build projects requires robust operating experience that encompasses design, construction and operation, as well as methods and organisational aspects. It is also important to take account of the diversity of clients and contractual arrangements that exist. I recommend that the directors of the DPNT, the DIPNN and the CEO of EDF Energy work together to better exploit project OPEX gathered by all players.

At Flamanville 3, conditions required for safe start-up include a plant condition that conforms to operating standards and a successful implementation of the nuclear safety leadership plan. I recommend that the directors of the DPN and the DIPNN assure themselves that the improvement actions underway are being rolled out at a good pace, and that they measure the progressive handover of responsibilities to the operator.

9 REPORT BY THE GENERAL INSPECTORATE OF FRAMATOME

Inspection during the manufacturing of a fuel assembly at Romans-sur-Isère

The reactor and fuel business of AREVA NP - since renamed Framatome - joined the EDF Group in January 2018.

The scope of Framatome's activities includes nuclear fuel, engineering, projects, component manufacturing, supply of nuclear safety control systems, and reactor services, both in France and abroad.

Most of these activities have a significant influence on nuclear safety.

This chapter has been written by Alain Payement, the Framatome Inspector General. He shares his views based on his inspections. Owing to the specific role of the General Inspectorate (see inset), the structure and level of detail provided in this chapter differ from the others.

NUCLEAR SAFETY MANAGEMENT

NUCLEAR SAFETY CULTURE: PRIORITY REAFFIRMED

Maintaining the highest level of nuclear and industrial safety is achieved through developing a common culture that covers the risks and wide variety of Framatome's activities.

Within this context, several actions were initiated in 2018 and have been carried through to 2019.

A seminar was organised for senior management and was attended by the CEO of WANO. It was also decided that any Framatome new starts would go through training in nuclear safety culture.

In the second half of 2018, the General inspectorate (IG) completed an assessment of the nuclear safety culture at the Framatome Le Creusot site, involving experienced operations managers from other business units.

A STRONGER INDEPENDENT NUCLEAR SAFETY OVERSIGHT ORGANISATION

The nuclear safety policy at Framatome clearly states the responsibility of the management in the production units. It also defines the responsibilities of the independent nuclear safety oversight organisation (FIS), i.e. to ensure that the policy is implemented and that the measures in place are appropriate.

The FIS comprises two levels: the first is based at each site, business unit, division and corporate function, while the second is carried out by the IG (see inset).

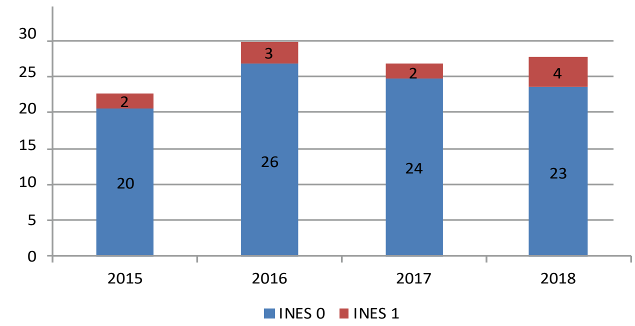
In 2018, the first level of oversight was strengthened, including the appointment of staff to the FIS teams. Assessment criteria for the function were defined. A first assessment report will be published in early 2019.

STABLE NUCLEAR SAFETY RESULTS AND AREAS OF CONCERN

No Level 2 event or higher on the INES scale was declared in 2018. A total of 27 events were declared, 4 of which were Level 1 and 23 were Level 0.

At the site in Romans-sur-Isère, there were 3 INES Level 1 events and 5 INES Level 0 events pertaining to criticality risk management (mass of fissile material) either in the facilities or during operations. These events highlight the importance of adhering more rigorously to the procedures and human performance tools.

In 2019, the IG chose criticality management as a general theme for the nuclear sites of Lingen and Romans-sur-Isère.



INES events

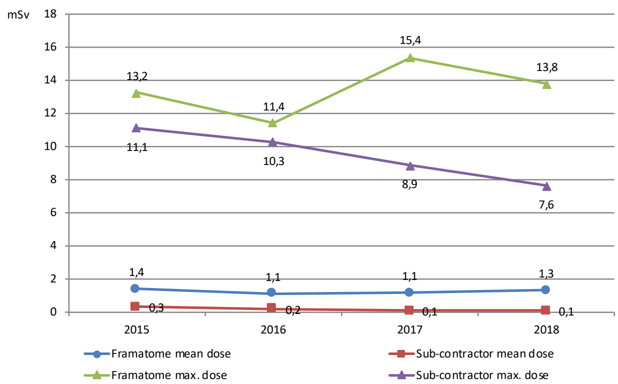
SATISFACTORY RADIATION PROTECTION RESULTS

Six radiation protection events occurred in 2018, with 5 concerning maintenance activities in nuclear power plants. Three involved internal or external contamination, while the other three were human-factor-related, e.g. dosimeters forgotten, or unintentional entry into a controlled area. Three of the six events involved Framatome sub-contractors.

[1] *The management of industrial risks, notably chemical hazards*

General Inspectorate of Framatome

The role of the General Inspectorate (IG) is to provide the CEO of Framatome with an assessment of the robustness of nuclear safety in the operational units, both in France and abroad.
The IG also performs a second-level oversight of the organisation in the areas of nuclear safety, radiation protection, industrial safety[1], occupational safety, and the environment.
The IG is headed by an Inspector General who is assisted by three inspectors.
Its activities are defined in a yearly programme which is presented to the Framatome executive committee.
During its inspections, the General Inspectorate issues recommendations for the relevant business unit to address in the form of action plans. Action progress is regularly checked by follow-up inspections.



Variation in mean and maximum doses for Framatome and its sub-contractors

In 2018, the mean occupational dose for Framatome staff was 1.31 mSv, which is slightly higher than the 2017 level of 1.15 mSv. It was 0.09 mSv for contract partner staff, a level that has been dropping since 2014.

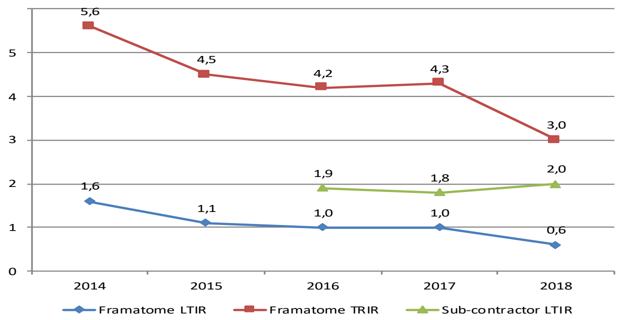
All in all, 30% of the Framatome staff and 16% of contract partner staff received a dose below the minimum recordable level (zero dose). Most doses received were below 2 mSv, which was true in the case of 73% of the Framatome staff and 98% of contract partner staff.

The number of annual doses exceeding 10 mSv dropped sharply, i.e. 37 in 2018 compared with 88 in 2017. The majority of the staff concerned - distributed equally between the US and France - were providing reactor-related services. The highest doses were also received by staff working in the field of reactor services (13.8 mSv in 2018 and 15.4 mSv in 2017). The variations observed from one year to the next are partially due to the nature of the work involved, thus highlighting the importance of having an effective feedback system to manage operational dosimetry data.

INDUSTRIAL SAFETY: STRONG MANAGERIAL COMMITMENT IS ESSENTIAL

Industrial safety continues to improve across the board for all categories of staff at Framatome. The 2018 objectives were thus achieved, with a lost-time injury rate (LTIR)[1] of 0.6 and a total recordable incident rate (TRIR)[2] of 3. These encouraging results reflect the strong commitment from all managerial levels. Special attention must be paid to sub-contractors for whom the LTIR (2) remains high and actually increased in 2018.

In 2019, the IG will review a team trained in workplace risk management that has been deployed on a nuclear power plant.



Trend in accident frequency

Other than reducing the accident rate, eliminating fatal risks takes first priority. This issue is the focus of a specific programme called 'Top 5 killers' (see inset) which has been deployed in all business units.

LESSONS LEARNED FROM INSPECTIONS

In 2018, the IG carried out 13 inspections and 8 follow-up inspections on its recommendations. A reactive inspection was also conducted following an incident that occurred in late 2017.

REACTIVE INSPECTIONS

This type of inspection both supplements and further delves into the root cause analysis carried out by the site teams, as well as assessing how well the event has been dealt with.

The reactive inspection in 2018 concerned an INES Level 1 event dealing with a criticality management issue declared by the site in Romans-sur-Isère. The inspection team checked the quality of the root cause analysis completed by the site. It revealed the need to better prevent foreign material risks during maintenance operations and to incorporate authorised routine practices into the procedures.

INSPECTIONS REQUESTED BY NUCLEAR SAFETY REGULATORS

In the US, the IG carries out two inspections every year at the Richland fuel fabrication facility, as requested by the US Nuclear Regulatory Commission (NRC). They alternately focus on emergency preparedness, radiation protection and the environment, fire safety, criticality management, chemical hazards, and staff education and training.

In 2018, the two inspections covered criticality along with radiation protection and the environment; it was concluded that the facility demonstrated good operational supervision in these fields. However, I underline the need to improve prevention of internal radiological contamination risks. I also recommend strengthening dialogue with similar Framatome sites (e.g. Lingen in Germany and Romans-sur-Isère in France) in the areas of operating experience and expertise.

For this reason, I was pleased to see that the 'Human Perf Lab' had been launched in Romans-sur-Isère, which has been in place for several years in Richland; this initiative aims at improving human performance by putting small groups of Framatome staff and sub-contractors into role-play scenarios.

The Romans-sur-Isère site in France was the subject of reinforced oversight by the ASN from 2014 to May 2018. During this period, the IG checked the progress of the site's multi-year nuclear safety improvement plan (PPAS), every two months. Though its reinforced oversight has ended, the IG continues to check the achievement of project and action plan milestones.

Top 5 killers programme

This initiative is based on the self-assessments conducted by business units to compare themselves against the best practices in the industry over five types of activity with critical risks: working at height, lifting operations, controlling energy sources, using mobile equipment, and confined spaces.
Initiated in 2017, this programme sets out to bring the business units in line with best practices by mid-2020.

OTHER NUCLEAR SAFETY AND RADIATION PROTECTION INSPECTIONS IN NUCLEAR FACILITIES

Every year, the IG visits Romans-sur-Isère in France, Richland in the US and Lingen in Germany to inspect the processes and practices used in areas with significant safety implications, e.g. criticality, containment, fire safety and radiation protection. The SOMANU facility was also subject to these inspections until its classification downgrade from licensed nuclear facility (INB) to environmentally regulated facility (ICPE) in 2018.

The IG's most recent visit to the SOMANU site in 2018 focused on radiation protection. The site complies with French regulatory requirements and is developing its radiation protection culture. Nonetheless, better analysis of the occupational doses received would improve the feedback system to comply with the ALARA approach.

[1] *Lost-Time Injury Rate*
[2] *Total Recordable Injury Rate*

MANAGING NUCLEAR SAFETY PROCESSES

The IG visited the Romans-sur-Isère site where it checked progress against the commitments made during the periodic safety review of INB 98. The proposed organisation seems capable of handling the issues. Given the deadlines for meeting the commitments (late 2019), the relevant plans must be strictly followed and monitored closely. Lessons learned from this organisation should also be put to good use.

An inspection of the Engineering and technical directorate (DTI) focused on the management of abnormal situations and operating experience. Despite fundamental changes made to this directorate's scope of responsibility, the inspection showed that the organisation was still capable of detecting and treating quality non-conformities and their precursor events. The root causes of each event were analysed. The crafts and professions in the different divisions are incorporating operating experience in a structured manner. Verification that root causes are not recurring should be reinforced and weak signals need to be addressed.

OPERATIONAL RIGOUR

The capacity of the business units to comply with the operating standards is determined by analysing the relevance of behaviours and decisions in both routine and abnormal situations, as well as by assessing the quality of records. In 2018, the inspections conducted at the Jarrie and Saint Marcel sites were centred on this theme.

The IG paid particular attention to the manufacturing of zirconium sponge at the Jarrie plant. The outcome of this inspection was satisfactory: quality of records, non-conformities are processed quickly, and key competencies are managed efficiently. Inspection of the plant's production by a dedicated laboratory, with a structured quality organisation and event management process, all contribute to the overall management of quality.

The Saint-Marcel facility initiated a programme to consolidate its industrial safety culture in 2018. The preliminary results are promising as the operating practices and accident rate have significantly improved.

Regulatory compliance is monitored on all Framatome sites in France with the same software tool as that used by EDF. Its deployment requires heavy investment from the sites and it must be done without delay given the gains in efficiency and traceability of non-conformances.

ASSESSING ORGANISATIONS IN NUCLEAR SAFETY AND INDUSTRIAL SAFETY

At Le Creusot (see insets), the IG assessed the nuclear safety culture of this site taking inspiration from WANO methodology. Other than the inspectorate's members, the team also comprised experts from 3SEP[1] and two managers from other business units.

Analysis of the observations made during site visits and the thirty or so interviews with staff from all levels, shows that substantial progress has been made in nuclear safety awareness, thanks to:

- Training coupled with visits to nuclear facilities
- Shared vision of the features of the nuclear industry
- Visual management methods
- Greater manager presence the field
- Continuous learning by sharing and incorporating operating experience.

More than 40 improvement recommendations were made mainly in the areas of:

- Use of human performance tools
- Updating of document standards
- Identification of recurring events
- Application of industrial safety principles in the workplace
- Sharing of information.

Annual report for the Framatome site in Le Creusot

In 2018, the improvement plan initiated in late 2016 for the site in Le Creusot continued, which included the fabrication of test components. Many actions have been completed and incorporated into the quality management system to ensure sustainability.
In late January 2018, the site was given ASN approval to resume manufacturing of steam generator shells for the French fleet.
The site continues to strengthen its nuclear safety culture on all levels through multiple initiatives, such as the day every year dedicated to nuclear safety and visits to nuclear power plants. Set up in early 2018, the independent nuclear safety oversight team (FIS) carries out safety assessments.
Le Creusot also launched a research and development programme that aims at eliminating carbon segregation issues with forged components by optimising the manufacturing processes.

At the Ugine site, the IG examined the industrial safety conditions and the follow-up of the action plan implemented after the explosion in furnace No. 4 in July 2016. The industrial safety has been significantly improved as a result of the measures put in place after the Framatome analysis which also took account of Ineris expertise. Reinforcement of the accident management plan, which now includes an evacuation procedure that can be completed in under 5 minutes, has also substantially improved industrial safety. Modifications made to the facilities and processes have greatly reduced the level of severity/probability of the chemical accident scenario defined in the site's hazard risk study.

More generally, the commitments and actions plans on the sites could be better monitored. Under the direction of their management, the sites must prioritise actions and identify milestones, deliverables and critical paths. In addition to running the business more efficiently, this

[1] *Health, safety and environmental and security division*

approach should help develop a critical analysis of the risks existing on each site.

Creusot Forge compliance project (PCCF)

In 2018, the compliance project team (PCCF) appointed to review the files of 3,754 forged parts manufactured at Le Creusot reached the end of its task. Every non-conformity has now undergone technical analysis. None of the analyses called into question the integrity of component service lives. Affected clients were issued with the non-conformity reports. About 80% of the manufacturing reports for ongoing contracts have been updated, while the remaining 20% will be completed in 2019.
A summary file on the components installed in the EDF fleet has been drafted for each reactor and sent to the ASN, who has since validated 53 of the 58 files. The remaining files are being reviewed.
Following the ASN decision issued on 15 September 2017 and the requirement on EDF, the PCCF has reviewed the files of 504 cast parts manufactured at Le Creusot and installed in the EDF fleet. This review was completed in 2018 and did not reveal non-conformities that affected the service life of the parts. The non-conformities detected are expected to be processed by early 2019.

Any gaps identified during compliance assessments of equipment and facilities must undergo a risk analysis that supports the site directors in defining both prevention measures and their compliance recovery plan. I recommend that this approach be systematically implemented.

Manufacturing operation at the Le Creusot site

This complex issue with high health and safety stakes led to the recruitment of an expert to the 3SEP division to assist sites with this work.

STRETCHED WORKFORCE

I noted during my inspections that the workforce was overstretched at several sites, generally the smaller ones which tend to feel the impact more acutely.

This is the case at the Montreuil Juigné site where following the resignation of experienced members of staff, several positions have remained vacant, even though production targets have increased. Despite major recruitment efforts, the required skillsets are still difficult to find.

The management of human resources is also proving complex at Le Creusot site when it comes to hiring and developing specialised skills.

SUMMARY OF RECOMMENDATIONS

In 2018, the IG issued 38 recommendations that can be divided into three key areas:

- Operational rigour (58%), particularly the capacity to comply with standards
- Regulatory compliance (18%)
- Management of non-conformities (24%), particularly the analysis and sharing of lessons learned.

This breakdown is consistent with the classification of the 93 recommendations currently being implemented.

Follow-up inspections have led to the completion of 37 recommendations.

The 2018 action plan to reduce the number of recommendations that had still not been completed after three years, led to the closure of 35% of them. Those recommendations calling for in situ checks were the subject of site inspections by the IG. The Framatome executive committee uses a business unit performance indicator to track recommendations that take more than three years to implement. These measures will be continued in 2019.

COLLABORATION WITH OTHER GENERAL INSPECTORATES IS CRUCIAL

Owing to the similarity of certain activities involved in the fuel cycle, the Framatome IG has continued to collaborate with its counterpart at Orano within an agreement framework. This collaboration has led to cross-participation of inspectors in inspections led by each of the IGs and to regular sharing of feedback. Such exchanges will continue in 2019.

Framatome's incorporation into the EDF Group has strengthened collaboration between the two IG's. Joint visits have been organised. This collaboration has allowed me to become familiar with the principle of the visits conducted by the EDF IG and to appreciate the value of such an approach in terms of improving the feedback of weak signals and the frequency of site visits. On this basis, the Framatome IG has programmed several such visits into its 2019 schedule.

APPENDICES

RESULTS FOR THE EDF SA FLEET

No.	Indicator	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	Number of significant nuclear safety events graded 1 or greater on INES per reactor[1]	1.17	1.17	0.91	1.55	1.19	1.14	1.16	0.98	1.21	1.28
2	Number of significant nuclear safety events (0 or greater on INES). per reactor[1]	10.93	10.45	10.57	11.90	11.60	10.8	10.03	9.78	11.59	12.6
3	Number of cases of non-compliance with technical specifications. per reactor	1.39	1.55	1.36	1.52	1.34	1.55	1.24	1.48	1.41	1.69
4	Number of alignment errors[2] per reactor	0.53	0.77	0.71	0.70	0.66	0.60	1.03	1.04	1.84	1.24
5	Number of trips per reactor (for 7.000 hours of criticality[3]) • Automatic • Manual	 0.71 0	 0.69 0.01	 0.50 0.05	 0.55 0.03	 0.59 0.03	 0.53 0.07	 0.66 0	 0.48 0	 0.41 0.04	 0.31 0
6	Average operational collective dose. per nuclear unit in service (in man-Sv)	0.69	0.62	0.71	0.67	0.79	0.72	0.71	0.76	0.61	0.67
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 10 -	 0 3 60	 0 2 43	 0 2 22	 0 0 18	 0 0 5	 0 0 2	 0 0 1	 0 0 0	 0 0 1
8	Number of significant radiation protection events	102	91	92	114	116	113	109	117	131	170
9	Availability (%)	78.0	78.5	80.7	79.7	78.0	80.9	80.76	79.6	77.1	76.5
10	Unplanned unavailability (%)	4.6	5.2	2.2	2.8	2.6	2.4	2.48	2.02	3.26	3.7
11	Occupational accident rate with sick leave (per million hours worked)[4]	4.3	4.1	3.9	3.5	3.3	3.2	2.7	2.8	2.2	2.3

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 SA and its contractors*

RESULTS FOR THE EDF ENERGY FLEET

No.	Indicator	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	Number of events ranked 1 or higher on INES. per reactor	0.80	0.93	1.33	0.80	0.80	0.33	0.47	0.27	0.40	0.53
2	Number of nuclear safety events ranked 0 or higher on INES. per reactor	5.47	5.60	4.7	4.6	5.1	4.5	7.40	9.6	6.07	5.73
3	Number of cases of non-compliance with technical specifications. per reactor	0.13	0.60	0.33	1.67	0.67	1.53	1.00	0.80	0.60	0.53
4	Number of alignment errors. per reactor	0.13	0.60	0.33	3.07	3.33	2.80	2.87	3.07	0.93	1.60
5	Number of unscheduled trips. per reactor (for 7.000 hours of criticality)										
	• Automatic	0.82	0.58	0.74	0.64	0.45	1.17	0.57	0.3	0.49	0.89
	• Manual	1.44	1.68	1.22	0.84	1.03	0.62	0.19	0.42	0.37	0.20
6	Average collective dose. per unit in service (in man-Sv)										
	• PWR	0.337	0.271	0.537	0.037	0.386	0.365	0.048	0.544	0.296	0.100
	• AGR	0.100	0.018	0.084	0.063	0.034	0.074	0.067	0.021	0.020	0.050
7	• Number of individuals with doses above 15 mSv	0	0	0	0	0	0	0	0	0	0
8	Number of significant radiation protection events	31	43	43	50	27	27	18	20	10	23
9	Availability (%):										
	• EDF Energy fleet	71.0	65.7	72.0	78.0	78.9	72.1	77.30	83.0	81.6	76.1
	• PWR	87.4	45.6	82.5	89.2	83.0	84.1	100	82.0	83.8	89.4
	• AGR	69.8	67.1	71.3	76.3	78.2	70.2	73.7	83.1	81.2	74.0
10	Unplanned inoperability (%)										
	• EDF Energy fleet	13.2	19.6	13.0	8.9	6.9	10.7	2.3	5.1	5.0	3.1
	• PWR	0.9	54.3	3.4	9.9	0.2	0.7	0	0.1	0.0	2.2
	• AGR	14.0	17.1	13.7	8.7	7.9	12.3	2.7	5.8	5.7	3.3
11	Occupational accident rate with sick leave (per million hours worked)[1]	0.6	0.4	0.6	0.5	0.2	0.2	0.4	0.3	0.2	0.5

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*

Factors to be taken into account in comparing the results of EDF SA with those of EDF Energy:

- **Line 2:** the procedure for declaring events to the UK safety authority **changed in 2015.** which means more events are now declared than in the past
- **Lines 3, 4 and 8:** the event declaration procedures are not the same in the United Kingdom and France as a result of the respective nuclear safety authority requirements. **EDF Energy and EDF SA harmonised their event classification practices in 2012**
- **Line 6:** the reactors of the two fleets do not share the same technology (mostly AGRs in the UK and PWRs in France). The AGR design means that radiation exposure is some 10 times lower (source: WANO)

KEY DATES FOR EACH OF THE EDF SA NUCLEAR UNITS

Year in service	Nuclear Unit	Power in MWe*	VD1	VD2	VD3
1977	Fessenheim 1	880	1989	1999	2009
1977	Fessenheim 2	880	1990	2000	2011
1978	Bugey 2	910	1989	2000	2010
1978	Bugey 3	910	1991	2002	2013
1979	Bugey 4	880	1990	2001	2011
1979	Bugey 5	880	1991	2001	2011
1980	Dampierre 1	890	1990	2000	2011
1980	Dampierre 2	890	1991	2002	2012
1980	Gravelines 1	910	1990	2001	2011
1980	Gravelines 2	910	1991	2002	2013
1980	Gravelines 3	910	1992	2001	2012
1980	Tricastin 1	915	1990	1998	2009
1980	Tricastin 2	915	1991	2000	2011
1980	Tricastin 3	915	1992	2001	2012
1981	Blayais 1	910	1992	2002	2012
1981	Dampierre 3	890	1992	2003	2013
1981	Dampierre 4	890	1993	2004	2014
1981	Gravelines 4	910	1992	2003	2014
1981	St-Laurent B1	915	1995	2005	2015
1981	St-Laurent B2	915	1993	2003	2013
1981	Tricastin 4	915	1992	2004	2014
1982	Blayais 2	910	1993	2003	2013
1982	Chinon B1	905	1994	2003	2013
1983	Blayais 3	910	1994	2004	2015
1983	Blayais 4	910	1995	2005	2015
1983	Chinon B2	905	1996	2006	2016
1983	Cruas 1	915	1995	2005	2015
1984	Cruas 2	915	1997	2007	2018
1984	Cruas 3	915	1994	2004	2014

Year in service	Nuclear Unit	Power in MWe*	VD1	VD2	VD3
1984	Cruas 4	915	1996	2006	2016
1984	Gravelines 5	910	1996	2006	2016
1984	Paluel 1	1330	1996	2006	2016
1984	Paluel 2	1330	1995	2005	2018
1985	Flamanville 1	1330	1997	2008	2018
1985	Gravelines 6	910	1997	2007	2018
1985	Paluel 3	1330	1997	2007	2017
1985	St-Alban 1	1335	1997	2007	2017
1986	Cattenom 1	1300	1997	2006	2016
1986	Chinon B3	905	1999	2009	-
1986	Flamanville 2	1330	1998	2008	-
1986	Paluel 4	1330	1998	2008	-
1986	St-Alban 2	1335	1998	2008	2018
1987	Belleville 1	1310	1999	2010	-
1987	Cattenom 2	1300	1998	2008	2018
1987	Chinon B4	905	2000	2010	-
1987	Nogent 1	1310	1998	2009	-
1988	Belleville 2	1310	1999	2009	-
1988	Nogent 2	1310	1999	2010	-
1990	Cattenom 3	1300	2001	2011	-
1990	Golfech 1	1310	2001	2012	-
1990	Penly 1	1330	2002	2011	-
1991	Cattenom 4	1300	2003	2013	-
1992	Penly 2	1330	2004	2014	-
1993	Golfech 2	1310	2004	2014	-
1996	Chooz B1	1500	2010	-	-
1997	Chooz B2	1500	2009	-	-
1997	Civaux 1	1495	2011	-	-
1999	Civaux 2	1495	2012	-	-

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

*Net continuous power

KEY DATES FOR THE EDF ENERGY NUCLEAR UNITS

Year in service	Nuclear Unit	Reactor Number	Power MWe RUP (1)	Planned date of withdrawal from service (2)
1976	Hinkley Point B	R3	480	2023
1976	Hinkley Point B	R4	475	2023
1976	Hunterston B	R3	480	2023
1976	Hunterston B	R4	485	2023
1983	Dungeness B	R21	525	2028
1983	Dungeness B	R22	525	2028
1983	Heysham 1	R1	580	2024
1983	Heysham 1	R2	575	2024
1983	Hartlepool	R1	595	2024
1983	Hartlepool	R2	585	2024
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

(1) Reference Unit Power (RUP): the rated electrical power of the generating unit as declared by EDF Energy in its daily transactions.

(2) Dates of withdrawal from service, including all life extension decisions. Updated in 2016 for the reactors at Heysham, Hartlepool and Torness.

EDF SA NUCLEAR SITES

FBR: Fast Breeder Reactor
GCR: Gas-Cooled Reactor
HW: Heavy Water Reactor

Closed loop cooling

Open loop cooling

Number per type	Pressurised Water Reactors					GCR	HW	FBR	Engineering
	300 MWe	900 MWe	1300 MWe	1450 MWe	1600 MWe (EPR)				
Construction					1				
Operation		34	20	4					
Decommissioning	1					6	1	1	
Engineering Centre									8

EDF ENERGY NUCLEAR SITES

AGR: Advanced Gas-cooled Reactor
PWR: Pressurised Water Reactor
EPR: European Pressurised Reactor

Number of reactor per type	AGR	PWR	EPR	Engineering
Construction or Project			4	
Operation	14	1		
Engineering Centre				2

FRAMATOME NUCLEAR SITES

United States

1. Benecia
2. Charlotte
3. Cranberry
4. Jacksonville
5. Houston
6. Lynchburg
7. Richland

Rest of the world

8. Japan: Tokyo
9. South Korea: Séoul
10. Czech Republic: Prague
11. Russia: Moscow
12. Ukraine: Kiev
13. Bulgaria: Sofia
14. Slovakia: Bratislava
15. Hungary
16. Sweden: Helsingborg
17. Spain: Zaragoza, Tarragona, Madrid
18. UK: London
19. South Africa: Capetown
20. Argentina
21. Brazil: Rio de Janeiro / Angra dos Reis
22. Canada: Pickering / Kincardine

France

1. Cadarache
2. Chalon-sur-Saône
3. Grenoble
4. Jarrie
5. Jeumont
6. Le Creusot
7. Lyon
8. Maubeuge
9. Montreuil-Juigné
10. Paimbœuf
11. Paris La Défense
12. Rugles
13. Romans- sur-Isère
14. Rungis
15. Saint-Marcel
16. Sully-sur-Loire
17. Ugine

China

1. Beijing
2. Lianyungang
3. Fuqing
4. Shanghai
5. Taishan
6. Deyang
7. Haiyan
8. Daya Bay

Germany

1. Berlin
2. Erlangen
3. Karlstein
4. Lingen

TABLE OF ABBREVIATIONS

A

AFI	Area for Improvement
AGR	Advanced Gas-cooled Reactor
ALARA	As Low As Reasonably Achievable
AMS	Asset Management System (EDF Energy)
AMT	EDF fleet maintenance agency
ANDRA	French National Radioactive Waste Management Agency
ASN	French Nuclear Safety Authority

B

BEST	Building Excellence in Safety Together

C

CAP 2030	EDF Group's overall strategic plan
CEA	French Alternative Energies and Atomic Energy Commission
CEFRI	French committee for the certification of companies in training and monitoring radiation workers
CETIC	PWR NSSS fieldwork technical validation experimental centre
CGN	China General Nuclear Power Corporation
CLI	Local information commission
CNC	Civil Nuclear Constabulary
CNEPE	Electromechanical & plant engineering support department
COLIMO	A DPN campaign to modernise isolation and alignment practices and methods
COMSAT	Unit outage nuclear safety commission
COPAT	Unit outage operational control committee
CRT	Technical standards committee
CSN	Council for Nuclear Safety
CSNE	DPN nuclear safety review committee

D

DACI	Independent oversight directorate for Edvance
DCN	Nuclear fuel division
DFISQ	Independent nuclear safety and quality oversight department (DIPNN)
DI	Industrial division (DIPNN)
DIPDE	Nuclear fleet engineering, decommissioning & environment division
DIPNN	Engineering & new-build projects directorate
DMES	Commissioning approval documentation
DOE	Department Of Energy (US)
DP2D	Decommissioning & waste directorate
DPN	Nuclear generation division
DPNT	Nuclear & conventional fleet directorate
DRS	Nuclear safety standards 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

EDT	Dedicated field team (F)
Edvance	Joint venture between EDF and Framatome (80% and 20% respectively)
EGE	Overall nuclear safety assessment
EMAT	Shared teams providing support during unit outages
ENISS	European Nuclear Installations Safety Standards
EPPC	Engineering, Procurement, Construction, Commissioning
EPR	European Pressurised Reactor
EPRI	Electric Power Research Institute (US)
ESPN	Nuclear pressure equipment regulations (F)
ESR	Significant radiation protection event
ESS	Significant nuclear safety event
EVEREST	EDF project to allow workers to enter controlled areas wearing ordinary work clothes

F

FARN	Nuclear rapid reaction force
FIS	Independent nuclear safety oversight
FME	Foreign Material Exclusion

G

GDA	Generic Design Assessment (UK)
GIFEN	French Nuclear Energy Industry Group
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
HPC	Hinkley Point C (UK)

I

IAEA	International Atomic Energy Agency
ICPE	Environmentally regulated facility (F)
ICRP	International Commission on Radiological Protection
IG	General Inspectorate team (Framatome)
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 (DPN)
IRSN	French Institute for radiation protection and nuclear safety

L

LTIR	Lost-Time Injury Rate
LTO	Long-Term Operation

M

MAAP	DPNT performance assessment and support team
MARN	Nuclear hazard management support team
MEEI	Campaign for maintaining exemplary housekeeping (DPN initiative)
MME	Operations and maintenance methods
MQME	Campaign to raise the standards in maintenance and operation (DPN)

N

NCC	Operations core skills handbook
NCME	Maintenance core skills handbook
NDA	Nuclear Decommissioning Authority (UK)
NEI	Nuclear Energy Institute (US)
NNB	Nuclear New Build (EDF Energy)
NNSA	National Nuclear Safety Administration (China)
NPP	Nuclear Power Plant
NRC	Nuclear Regulatory Commission (US)
NSSS	Nuclear Steam Supply System

O

OIU	Internal inspection organisation (DIPNN)
ONR	Office for Nuclear Regulation (UK)
OPEX	Operating experience
OSART	Operational Safety Review Team (IAEA)

P

PBMP	Basic preventive maintenance programme
PCCF	Creusot Forge compliance project
PDC	Nuclear engineering key skills development plan
PGAC	Worksite general assistance services
PLM	Plant Lifecycle Management
PPAS	Multi-year nuclear safety improvement plan (Framatome)
PSPG	Special police site protection unit (F)
PUI	Onsite emergency response plan
PWR	Pressurised Water Reactor

R

R&D	Research & Development directorate
RTE	Power grid company (F)
RTI	Engineering technical standards (F)

S

SAT	Systematic Approach to Training
SDIN	Nuclear technical information system (EDF SA)
SDIS	Local fire and rescue services (F)
SIR	Internal inspection department (DPN)
SMART	Digitalisation programme at the DIPDE
SMI	Integrated management system
SODT	Safety Oversight Delivery Team
SOER	Significant Operating Experience Report issued by WANO
SOH	Socio-organizational and human approach
SP	Standardised plant series teams
SPR	Risk management department
STE	Technical specifications
SWITCH	Digitalisation programme at the DIPNN
SYGMA	Computerised maintenance management system (DPN)

T

TNPJVC	Joint venture between the Chinese company CGNPC (51%), Guangdong Yudean Group Co. (19%) and EDF (30%)
TRIR	Total Recordable Injury Rate
TSM	Technical Support Mission by peers organised by WANO
TSN	French nuclear safety & transparency act
TVO	Teollisuuden Voima Oyj (Finland)

U

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

V

VD	Ten-yearly inspection outage
VP	Partial inspection outage

W

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

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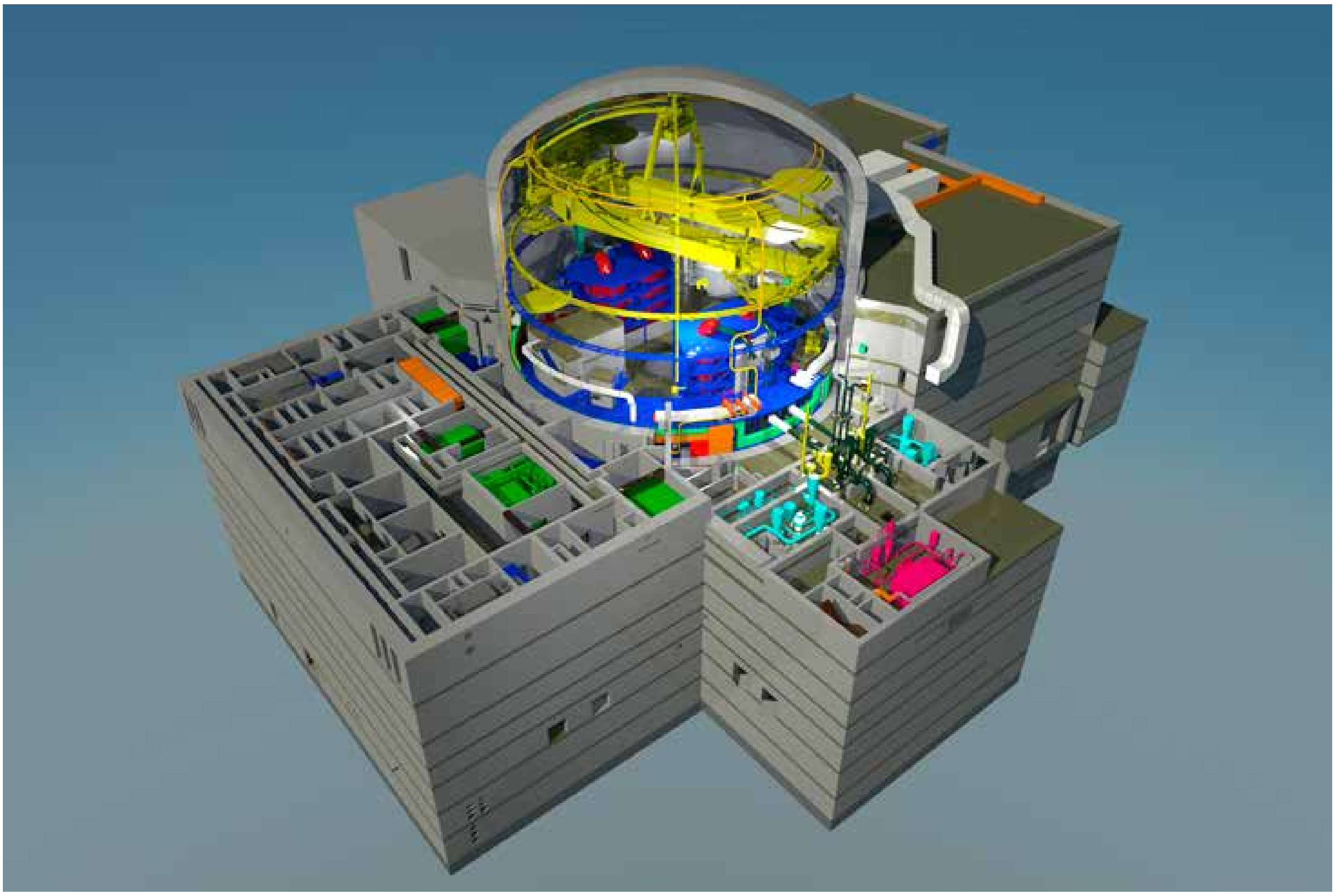

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