The Inspector General’s report on Nuclear Safety and Radiation Protection 2016
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 plants are operated safely.

My assessment is based on information gathered and observations made during the year, both in France and the UK, whether from workers in the field, or during visits to plants and meetings with the main stakeholders: managers, staff representatives, members of the medical profession, chairmen of local information commissions in France and of Site stakeholder groups (British equivalent of the French Local Information Commissions) in the UK, and contractors. It also makes use of visits and comparisons with other international players on the nuclear scene, and of dialogue with WANO (World Association of Nuclear Operators) and the nuclear safety authorities.

I would like to thank all those I met for their unstinting help and frankness, 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 the nuclear safety culture. I would also like to thank my assistants, Jean-Jacques Létalon, Jean-Michel Fourment, John Morrison and Bernard Le Guen, who have been relentless in their efforts, particularly in drafting this report. I would like to give a special mention to Bernard Maillard who left the team in 2016.

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, 15 February 2017
## CONTENTS

1 My view of 2016 3

2 Operational safety: encouraging results 9

3 High-profile focus on safety 13

4 Risk prevention: effort must be intensified 19

5 Team skills and commitment 25

6 Simplification 31

7 Maintenance quality 37

8 Nuclear fuel 41

9 New build 45

10 Protection against site security threats 51

Appendices 55
1 MY VIEW OF 2016

RECOVERY OF THE NUCLEAR INDUSTRY WORLDWIDE

More than five years after the Fukushima Daiichi accident and despite some stagnation in the demand for electricity, I am still seeing signs of recovery in the nuclear industry, notably:

- Announcements of new-build projects including two reactors at Hinkley Point C in the UK (see Chapter 9) and two others at Bouchehr in Iran, in addition to over 60 reactors currently under construction across the world, one of which, Leningrad II in Russia, I visited in 2016
- The commissioning of more than 10 reactors in 2016, most of which are in China and one in the US (Watts Bar 2), the first in this country for twenty years
- Studies on small modular reactors (SMRs) in several countries, including a project by EDF’s French and UK R&D and engineering teams.

There have also been some policy changes (Sweden, US, Switzerland) aimed at extending the service life of reactors (Nine Mile Point, Ginna, Fitzpatrick, Quad Cities, Clinton, Forsmark, Beznau and Mühleberg) whose future was uncertain just a few months ago. The list of reactors which have obtained licences from their nuclear safety authorities to operate beyond 40 years is lengthening: LaSalle 1 and 2 in the US, Takahama 3 and 4 in Japan, Doel 1 and 2 in Belgium, etc. In the US, following Surry in 2015, an application to operate beyond 60 years has been announced for the two Peach Bottom reactors.

In Japan, three more reactors resumed operation following modifications, bringing the number that now meet the requirements of the Japanese nuclear safety authority to five.

When I visited Fukushima Daiichi this year, I was struck by the extent of the resources mobilised to return the area to an acceptable situation and also by the volume of work still to be carried out. This visit was particularly useful for me to gain a fuller understanding of the major impact of a nuclear accident with radioactive discharges. It underlines the relevance of the EDF Group’s policy and justifies the measures taken to ensure that “no severe accident should result in the long-term contamination of extensive areas of land”.

In such a context, I stress again the key position of WANO in strengthening the central role of nuclear safety, in particular by supporting newcomers, carrying out site reviews and disseminating good practice.
EDF IN A TURBULENT ENVIRONMENT

The volatility of electricity prices in Europe limits resources and forces operators to review their expenditure. The threat of terrorism leads to more stringent site protection requirements, which the EDF Group is already engaged in strengthening (see Chapter 10). The planned exit of the UK from the European Union has prompted a number of questions within the Group. In France, the teams are expressing concern on how to implement the multi-year energy plan, approved in October 2016, notably on the future of Fessenheim and how to achieve the objective of 50% nuclear power by 2025. Work in France has also been severely disrupted by the investigations associated with the risks of carbon segregation (see inset). Added to this are the irregularities in the “marked files” (see inset) which, subject to the conclusions of the process underway, question the lack of rigour and transparency of such practices. I will be monitoring this closely in 2017.

Forging an ingot

Carbon segregation
A higher than expected carbon content was found in limited areas of the Flamanville 3 reactor vessel. This phenomenon, known as “positive segregation” may affect the mechanical strength of the vessel. A very comprehensive test programme was put in place to check its strength under normal and accident operating conditions. The tests have been completed and the results were sent to the French nuclear safety authority in December 2016. At the same time, checks were carried out on all forged components in the primary systems of EDF sites in service or being built which could be affected by such segregation. Defects affecting 18 reactors have been identified on some steam generators made by AREVA and by Japan Casting and Forging Corporation in Japan.
Following checks carried out in the second half of 2016, the French nuclear safety authority agreed that the reactors in question could be restarted, subject to specific operating arrangements and an additional test programme.

Marked files
Irregularities, some dating back many years, have been discovered in some documents, referred to as “marked files”, from the Creusot Forge plant which manufactures and supplies most of the major components for nuclear steam supply systems. These documents have been examined one by one by AREVA under the supervision of EDF: the irregularities vary widely in their nature and importance. Only one of the irregularities found (approximately 90) concerned a number of French plants and was potentially severe. It led to the reactor in question being shut down in June 2016 and the initiation of a test programme, the result of which will be sent to the French nuclear safety authority (ASN). In addition, a file on a replacement steam generator also contained a significant irregularity, which required delaying the assembly of the generator.
An examination of all of the Creusot Forge manufacturing files has also begun and will continue until the end of 2017.

Some positive news helped to balance things out in 2016.
As well as the building of two reactors at Hinkley Point in the UK, work has resumed on the first two reactors (Paluel and Cattenom) following their third ten-yearly inspection outages in the context of the Fleet upgrade programme. Closer cooperation with AREVA has become a reality with the signature of an agreement on 15 November 2016. EDF will take over control of an organisation covering the design and supply of AREVA nuclear steam supply systems by the end of 2017.

All of the above, especially the more negative events, have received a great deal of media attention. They have had a major impact on the composure of staff in the nuclear divisions of the EDF Group, who have nevertheless managed to keep the necessary distance to maintain good nuclear safety results.

REASSURING NUCLEAR SAFETY AND RISK PREVENTION RESULTS
First and foremost, I note that there were no major nuclear safety events in France and the UK in 2016. For the fourth year running, the EDF Group has not experienced any nuclear safety events rated level 2 or above on the International Nuclear Event Scale (INES).

IN FRANCE, CONSIDERABLE IMPROVEMENT
Following a negative trend in 2015, the nuclear safety results improved in 2016. The number of automatic reactor trips (28, against 38 in 2015 and 31 in 2014) is the best ever. This improvement is the result of rigorous control, together with a high degree of managerial involvement.
I note, however, that there is a continued increase in sub-standard maintenance work. The efforts made to halt this trend do not seem to have reached the plant (see Chapter 7).

An example of this is the fall of a steam generator while it was being replaced. This unprecedented event had no nuclear safety or radiological consequences, but it had a significant effect on the availability of the reactor. I will be looking to understand the many lessons being drawn from this event.

The radiation protection performance is continuing to improve, including a reduction in the number of workers (33 in 2016, as against 73 in 2013) having received a dose of more than 12 milliSievert (mSv) in a year. Finally, although the industrial safety results have slipped back this year, with an accident rate (per million hours worked) of 2.8 (as against 2.7 in 2015 and 3.2 in 2014), this rate is the second lowest ever achieved and I believe that the positive trend is continuing.

These results are all the more significant as they have been achieved at a time when the work programmes have been disrupted by the issues associated with “carbon segregation” and “marked files”. This work has frequently required sites to implement several unit outages simultaneously and teams to work under pressure.

**IN THE UK, A CONTINUING POSITIVE TREND**

The results in the fields of nuclear safety, radiation protection and industrial safety are good and the improvement which began in 2015 is continuing. I particularly noted the tightening up of the nuclear safety results between the sites and the assistance and leadership of the corporate teams.

The decrease in the number of automatic reactor trips and non-compliance with technical specifications illustrates the continued progress.

The performance of two AGRs shows that the ongoing effort is bearing fruit: Heysham 2 achieved the world record operating period between two maintenance outages of 940 days, and Torness achieved 825 days.

However, I have noticed, as in France, the persistence in the level of sub-standard quality work. This is associated with operations, particularly with too many plant configuration errors, and with maintenance (see Chapter 7).

**CONTINUED ROBUST INDEPENDENT NUCLEAR SAFETY OVERSIGHT**

As I do every year, I made a point of checking that the internal nuclear safety oversight arrangements are operating well.

Their positioning, the attention paid to them and their professionalism are satisfactory. I am pleased that 2016 saw a continuing improvement in the skills of the nuclear safety engineers on the French sites and the robustness of the Independent nuclear assurance (INA) in the UK, which is taking on more experienced staff than before.

I also note that the Design authority (organisation which, according to INSAG 19 “is responsible for ensuring that the knowledge base is established, has been preserved and is expanded with experience”) has been set up at the Nuclear fleet engineering, decommissioning & environment division (DIPDE) for the fleet in France (see Chapter 3). This structure, whose relationship with the engineering organisations still has to be finalised, should play a major role in the knowledge and compliance of reactor designs in line with nuclear safety objectives.

The French ministerial order of 28 June 2016 on plant modifications will lead to greater operator responsibility. Its implementation by 1 January 2018 will require extensive work and could come up against resource issues (see Chapter 3).

**FOUR POINTS WHICH REQUIRE ATTENTION**

**MAINTENANCE QUALITY: A STEP TO BE ADDRESSED WITHOUT DELAY**

The amount of sub-standard maintenance work has been at too high a level for several years, and has in fact increased across both fleets (see Chapter 7). The significant effort made to address this has met with some success: improvement in plant unplanned unavailability, better management of outage durations, reduction in defect backlogs (repair work remaining to be carried out), and reduction in the nuclear safety impact of this sub-standard work and its impact on production. However, the trend has not been turned around.

An essential prerequisite is to analyse the causes of this trend as they seem to be deep-rooted and complex, and no doubt have differences between France and the UK. I noted in particular:

- Inadequate preparation of workers prior to carrying out work
- Difficulty in monitoring work, due to both a shortfall in knowledge and to the large volumes of maintenance work associated with the Fleet upgrade programme in France
- Choice of managers based too much on management ability rather than technical skills.

In France, following a significant increase in the amount of maintenance work between 2006 and 2012 (60%), the trend was reversed in 2014. I believe it is important to continue efforts to rationalise and reduce maintenance documentation. Simplification of processes and standards, with the specific objective of providing plant technicians with job documentation that is of a manageable size, will also reduce the risk of sub-standard work.

The value attached to technical skills should also be enhanced.
In both fleets, the quality of risk analyses and work preparation needs to be improved, and the training mock-ups, which are increasingly well-equipped, need to be used as much as possible. Since a large proportion of work is sub-contracted, the process to include contract partners as early as possible in preparation and getting them involved in completing this work successfully must be intensified. This should be addressed in contracts.

Finally, I believe that the active presence of managers and leaders on the plant is fundamental for success. On both sides of the Channel, first-line managers are not there enough to clarify and explain objectives. This reduces effectiveness, slows down the incorporation of operating experience, and can even cause workers not to apply human performance tools.

SIMPLIFICATION: SOME PRINCIPLES TO CONSIDER

This is the third consecutive year I have had to mention the need for simplification (see Chapter 6). I believe that complexity in many areas (organisation, methods, procedures and work orders) has reached a level that is detrimental to both nuclear safety and efficiency.

I have come across several examples of complicated organisations, requiring numerous committees, meetings, briefing documents, reports, etc. All this dilutes responsibilities, making a collective vision and consistency of action difficult.

However, it is with regard to specifications, originating both within and outside EDF, that complexity seems to be at its worst. Very stringent requirements are the natural counterpart of work that is infrequently performed. Specifiers “build up layers”, especially to deal with pressing matters or to avoid going “back to basics”. These additional specifications affect workers in the field, often resulting in increased complexity that is beyond their capacity. I am convinced that the number of problems encountered in recent years across the French nuclear fleet is linked to this excessive specification.

Corporate management is strongly advocating simplification in order to put an end to these negative trends. However, I have yet to see much impact at plant level. Reversing such a trend is no easy matter and will require sustained long-term effort.

In this context, I recommend refocusing on a few simple principles:

- Strengthen the link between specifiers and those on the plant, to ensure solutions are realistic
- Limit the number of priorities, by knowing how to say no and restricting the list of tasks (for each new requirement at least one other requirement should be eliminated)
- Force cross-functional working, such as in open-plan environments or hackathons (events in which a large number of people meet to carry out collaborative computer programming)
- Promote standardisation by supporting and empowering people rather than being prescriptive.

HUMAN RESOURCES: KEEPING UP THE EFFORT

It can never be repeated often enough: nuclear safety depends to a great extent on the quality of the staff involved at all stages in the life of nuclear plants.

I note a very positive aspect: in both France and the UK, the Group has maintained its attractiveness in an environment where technical skills and scientific disciplines attract less interest (see Chapter 5).

This attractiveness has enabled EDF SA to achieve a large-scale rejuvenation of the workforce. Although it is not yet finished, the main part has been completed. Almost half the Nuclear generation division (DPN) staff joined less than ten years ago. This has not been straightforward, but the high quality of the training process has contributed significantly to addressing an inadequate overlap between generations. The new recruits are now hard at work and responsible for many of the Company’s results.

In France, although the current situation is satisfactory overall, I note some points which require attention.

I believe that a certain level of recruitment and training should continue, with a significant proportion of new employees being hired from outside the company. This is because it will take a further one or two years to achieve the renewal of the workforce, and also human resources management cannot react easily to sudden changes due to the long-term process involved.

Although the requirements have been met as a whole, there are some specific issues, in particular regarding operations, maintenance preparation teams, test specialists at Flamanville 3, and some site joint teams (mixed engineering and operations teams responsible for implementing modifications in the French NPPs).

The right mind-set is there, for moving from a phase of expansion to a period of slight reduction in manpower, though it has not been without problems. The new situation is leading to sites prioritising their own needs, to the detriment of the flexibility of inter-site exchange, which is a way of gaining experience and developing
skills. To counteract this inward-looking attitude, a more proactive approach to mobility should be adopted. Varied career paths are needed within the company so that it has the necessary skills when required.

At EDF Energy, which has not experienced the same disruption as EDF SA, the influx of new employees is relatively low. I note that, in a labour market which is more difficult than in France, EDF Energy also knows how to attract high-quality staff and has a remarkable professionalisation process.

However, major changes lie ahead. With the shutdown of the AGRs scheduled for between 2023 and 2030, the EDF Energy workforce will undergo considerable change:
- A large reduction in the nuclear operations workforce
- A transformation in the remaining staff, with skills moving from gas-cooled reactors to that of pressurised water reactors.

Of course, this change will take ten or so years, but it will clearly be complex. EDF Energy is fully aware of this issue and is starting to make preparations.

**RELATIONS WITH THE NUCLEAR SAFETY AUTHORITIES: A NEED FOR TRUST**

Effective nuclear safety necessarily involves a strong nuclear safety authority which maintains balanced dialogue with the operators.

In France, relations between EDF SA and the French nuclear safety authority have been unsatisfactory for several years. Each camp seems to have its own position. The causes of this are complex. In fact, dialogue is limited to the essentials, i.e. discussing compliance with regulations which cannot express the diversity of the situations and issues, to the detriment of technical dialogue which is key to progress. Misunderstandings inevitably arise, creating a climate that is prejudicial to nuclear safety.

A field as complex and sensitive as the nuclear power industry must of course be tightly regulated, but a desire to write everything down is impractical. It leads to a plethora of regulations which are always flawed and constantly changing. What is worse, a body of documentation of such complexity is beyond human capacity to assimilate and does not improve nuclear safety.

I believe it is preferable to target those regulations which establish principles, provide general rules and enable specific procedures for situations that are not covered. The application of such regulations requires ongoing dialogue in which technical matters are prioritised and where the consequences for nuclear safety are the deciding factor.

I believe that this technical dialogue and these discussions on the essentials are a precondition for returning to more equitable and empowering relations for the operator. This will initiate a virtuous circle, but it will take some time: trust does not just happen; it is built together, gradually. It should be carried out in stages, starting with identifying subjects for discussion that have a limited scope.

Lessons can be learned from the relations between EDF Energy and the UK nuclear safety authority, the Office for Nuclear Regulation (ONR). Following difficulties fifteen or so years ago, the ONR and the operators have successfully re-established proper, trusting relations, respecting each other’s responsibilities. I consider the current situation to be equitable and beneficial. In particular, it encourages operators to take responsibility. For example, two years ago, following the detection of a crack on a steam generator support, EDF Energy alone decided to shut down three other reactors as a precautionary measure.

The HPC project (Hinkley Point C project for two EPRs in Somerset, in the UK), which is now entering an active phase, with very stringent requirements, will have to establish relations that are appropriate for this new stage.
OPERATIONAL SAFETY:
ENCOURAGING RESULTS

The 2016 results for the French fleet were satisfactory and testament to effective prioritisation.

Results in the UK were also satisfactory, buoyed by nationwide support which helped to close the performance gap between sites considerably.

OPERATIONAL RESULTS

FRENCH FLEET

First and foremost, I would like to point out the absence of nuclear safety-significant events rated Level 2 or higher on the INES for the fourth year running.

The number of Level 1 INES events fell to 0.98 per reactor in 2016 (compared with 1.16 in 2015) despite the total number of nuclear safety-significant events remaining at a normal level (around 10 Level 0 and 1 events per reactor). Both these values reflect the quality of operations and the transparency achieved by each site.

I flagged up a deterioration in fire safety results and automatic reactor trips in my 2015 report and I am pleased to note the progress made this year. Nevertheless, I shall be keeping a watchful eye throughout 2017 on the continuing efforts to implement fire prevention measures.

These encouraging results have been achieved against the backdrop of major issues (carbon segregation, the nuclear pressure equipment order, and the containment issue on the Bugey 5 reactor which has been offline since 7 August 2015, etc.), serving only to compound the situation in a year in which there was already a high volume of planned maintenance activities. Such a situation can have a destabilising impact on teams at both plant and corporate level. I congratulate everyone involved on their ability to keep things in perspective and on continuing to prioritise nuclear safety. Given that this situation is likely to extend into 2017, it is important for leaders to be in the field supporting their teams.
Grounds for satisfaction

The number of automatic trips per reactor fell in 2016 to 28, compared with 38 in 2015; this is the lowest number achieved by the fleet to date. This breakthrough was possible by exercising tighter control, and in particular through addressing ‘key focus areas’ which helped mobilise efforts. This proactive approach to preventing avoidable shutdowns should help sustain this sound performance over the longer term. I urge everyone to keep this momentum going and ensure that all stakeholders have greater accountability.

Fire safety is another area which has shown signs of improvement over the past year. I note the significant decrease in the number of major events, which fell from 18 in 2015 to 6 in 2016. Nevertheless, this progress should not overshadow many weak signals concerning fire prevention (oil leaks, inappropriate storage of fire burdens, etc.) which should serve to spur on continued efforts.

Despite the challenging context, I have also observed progress in outage planning, due in the most part to a recently implemented multi-year programme. This progress relates to the duration of refuelling outages which remain at a satisfactory level (averaging 4.7 days in 2016 compared with 10 in 2013). There is, however, still room for improvement with respect to partial inspection outages (VP) and ten-yearly inspection outages (VD). The unplanned unavailability rate continues to improve (falling to 2.02 in 2016 versus 2.48 in 2015), which is testament to the successful implementation of the “running unit project”.

I would also like to draw attention to the very low unavailability of safety systems: reactor safety injection system at 0.11%, auxiliary feedwater system at 0.01% and standby diesel generators at 0.04%.

This year again, the uptake of recommendations from the Nuclear Inspectorate (78%), WANO peer reviews (88%) and Significant Operating Experience Reports (83%), has remained at a good level.

Areas of concern

I have observed a year-on-year increase in maintenance non-conformities over the past three years. This is a troubling upward trend and is the focus of a dedicated work programme, covered in a separate chapter (see Chapter 7).

Conversely, the number of operational non-conformities has fallen. Like last year, however, the number of N3C (isolation and circuit configuration errors) remains too high: 1.03 nuclear safety-significant events per reactor in 2016 versus 1.05 in 2015. This is higher than in previous years where values hovered around 0.7. Although there are numerous causes for N3C errors, they all reflect inadequate compliance with requirements, primarily in terms of the application of error prevention tools (such as pre-job briefings or time-outs). These discrepancies, which represent around 40% of the total number of operational non-conformities, underline the need to provide the same level of support to plant operators as that afforded to control room staff.

Following a reduction in 2015, the number of nuclear safety-significant events attributable to non-compliance with technical specifications has risen again, i.e. 1.48 nuclear safety-significant events per reactor, around half of which were classified Level 1, compared with 1.24 in 2015. Without wishing to sound alarmist, this value warrants a robust response to ensure performance is not allowed to slip further. I noticed that roughly 50% of these events are associated with repairs taking longer than the time stipulated in the technical specifications, while 30% relate to N3C errors and the remaining 20% to reactor control issues (excursions outside the operating envelope). These reactor control issues are often the result of inadequate management and control of plant parameters and a misunderstanding of the physical phenomena involved; accordingly, they should receive special attention.

UK FLEET

I applaud the fact that, similar to France, not a single nuclear safety-significant event rated Level 2 or higher on the INES has occurred in the UK within the past seven years.

The number of Level 1 safety-significant events is lower than that recorded in 2015, i.e. 0.27 nuclear safety-significant events per reactor in 2016 versus 0.47 in 2015. The discrepancy in comparison with the French results can be explained by the different declaration criteria required by the nuclear safety authorities.
All indicators are either showing signs of improvement or are stable, as is the case for automatic reactor trips, which have fallen for the second year running. This strikes me as testament to a certain degree of maturity capable of ensuring sustainable results.

This overall improvement has been accompanied by the ongoing closing of the gap in performance across the different sites. I have seen the concerted efforts made by fleet managers especially, who are challenging the sites collectively every month and providing support in the field where it is needed.

The fire safety results are satisfactory but, as in France, there is still room for improvement in fire prevention and efforts must be sustained in the long run. This will be one of my specific focus areas during my visits in 2017.

**Grounds for satisfaction**

The number of automatic reactor trips (0.3 per reactor) continues to fall (compared with 0.57 in 2015) and is the best result seen to date. Of particular note here is the roll-out of the single point vulnerability (SPV) initiative, whereby clear, strategically placed warning signs are used to alert front-line workers (plant touchers) to the direct risk of automatic reactor trip when working on the equipment in question.

The number of events attributable to non-compliance with technical specifications is also continuing its downward trend, falling from 1 nuclear safety-significant event per reactor in 2015 to 0.8 in 2016. This result highlights the increasing importance given to this indicator in matters of nuclear safety.

Unit outage extensions remain at a satisfactory level: the 4 statutory outages in 2016 were planned at 312 days with a total extension of 14 days which constitutes the best performance in a decade. This points to a high degree of schedule stability that is more conducive to team composure and thus to safety. I applaud the world record set by Heysham 2 for the longest continuous operating run between two planned maintenance shutdowns (940 days), reflecting the reliability of both equipment and operations.

This year again, the uptake of recommendations from the WANO peer reviews (95%) and Significant Operating Experience Reports (93%) is at an excellent level.

**Areas of concern**

The number of alignment errors has not reduced, sticking at around 2.8 to 3.0 errors per reactor for the past three years. I will be monitoring the implementation of the action plan led by the Operations fleet manager very closely in 2017. Although the number of automatic reactor trips has fallen, the number of manual trips is on the increase, rising to 0.42 per reactor in 2016 compared with 0.19 in 2015. This remains a key focus area.

Non-conformities, and particularly maintenance non-conformities, are just as much of an issue in the UK as they are in France (see Chapter 7). Even if their impact on safety and production has reduced, sub-standard work of this kind emphasises the difficulties in complying with requirements at the workplace. Exchanges on this point between France and the UK will be helpful.

On the subject of reactor graphite, inspections carried out in 2016 at Hunterston B revealed a new keyway root crack in addition to the three discovered previously. The appearance of cracks is an expected phenomenon, and the total number is still well below the limits stipulated in the safety case. Although the situation is under control, it serves as a reminder of how important it is to conduct regular inspections and to adapt the inspection frequency to the level of risk.

**Tackling a hydrogen fire**

During recent maintenance work in the gas cylinder storage area at a nuclear power plant, a technician noticed small flames coming from a pipe carrying hydrogen close to where he was working. He alerted the control room immediately, which instigated the necessary actions: surveillance of the area, isolation of the circuit to extinguish the flame and investigation using a thermal imaging camera. The pipe was then filled with inert gas to prevent the risk of explosion prior to repairs being carried out.

This event presents a good example of the specific nature of a hydrogen fire:

- The flame is invisible (the flame seen was due to burning paint on the pipe)
- Hydrogen has a very low activation energy (friction caused by the sole of a shoe on carpet is sufficient to ignite it)
- The gas supply must be isolated to prevent the risk of explosion before attempting to extinguish the flame.

No apparent hole was detected in the pipe; it was concluded that the hydrogen diffused through porosities in the metal.

Subsequent analysis recommended revisions to the periodic pipe inspection procedures and advised that hydrogen system pipework in coastal plants be replaced with stainless steel.

The availability of safety systems remains high at Sizewell. Sound progress has been made throughout 2016 on the AGR carbon dioxide supply systems and electrical supplies. Boiler water feed system performance, however,
is deteriorating and merits the attention it is getting from the plant manager's peer group (PMPG).

**ANALYSIS OF PRECURSOR EVENTS**

This analysis is based on operating experience from the most significant precursor events, i.e. those with an annual core meltdown probability greater than $10^{-6}$ per reactor. Events with a probability greater than $10^{-4}$ are classed as “important” whilst those with a probability greater than $10^{-3}$ are classed as “significant”. This assessment method is practised by many operators worldwide. Analyses and international operating experience show that power supplies remain the primary focus area. I will be paying even closer attention to this issue over the coming year in light of the growth of renewable energies which is complicating transmission networks.

The number of precursor events in France remains at the 2015 level: 7 precursor events out of a total of 614 nuclear safety-significant events were identified in the last analysis period (July 2015 to July 2016). Of these, only one event exceeded the $10^{-4}$ threshold. This was specific to one unit which has since been the subject of recovery measures.

**FUEL PERFORMANCE**

I attach considerable importance to fuel as it constitutes the first barrier between the radioactive products and the environment; hence a chapter has been dedicated to fuel in this year’s report (see Chapter 8).

To summarise the key points for 2016, the fuel assembly failure rate remains satisfactory in both France (9/8,305 assemblies) and the UK (20/40,000 elements in the AGR fleet and no failures recorded at Sizewell B). I will, however, be keeping a close watch on AGRs, where 16 fuel failures occurred in a single reactor.
HIGH-PROFILE FOCUS ON SAFETY

In what have proved to be testing times recently for the energy industry, nuclear safety remains the number one priority.

The current operational focus is helping drive up nuclear safety results.

A concerted effort is now required in the field to maintain the momentum.

A STRONG NUCLEAR SAFETY ETHOS DESPITE THE CHALLENGING CLIMATE

The year 2016 was not easy for the nuclear industry. It was marked not only by the technical problems experienced on steam generators (see Chapter 1), but also by the low price of electricity, which imposed restrictions on both human and financial resources. I have therefore been keeping a watchful eye on the impact that this challenging climate has had on safety considerations at both plant and corporate level.

Nuclear safety remains the top priority and is firmly entrenched in all sites. I continue to see effective delivery of safety-related actions by the company leadership. The example set by them has filtered down the management chain and out to teams in the field.

Furthermore, the tension over resources, which is evident in the business units, is being tackled responsibly by means of innovative solutions to utilise available resources more efficiently without adversely impacting nuclear safety.

In France, I have been particularly impressed, for example, by work carried out at the Engineering & new-build projects directorate (DIPNN) in collaboration with the Nuclear & conventional fleet directorate (DPNT) to help prioritise modifications according to their contribution to safety based on a safety cost/benefit analysis approach. This is very much in keeping with Articles 1.1 and 1.2 of the Licensed Nuclear Facilities Order, which call for “a risk-proportionate approach” and “a level of risk that is as low as is reasonably practicable in economically viable conditions”. I would urge the teams involved to build on this initial good work and follow it up with the ASN.
In the same spirit of optimisation, I have also been struck by how well work to simplify the proposed solutions implemented as part of the Fleet upgrade programme has progressed. These efforts will go a long way in facilitating the deployment and operation of such solutions, whilst at the same time optimising resources.

In the UK, despite the pending closure dates, I have noted the continued investment in AGRs and a desire, here too, to deliver in terms of nuclear safety and plant reliability.

New edition of the DPN nuclear safety handbook

The DPN nuclear safety handbook was updated in 2016. The update of the document is an opportunity to make it available to all EDF staff and contract partners. It summarises the main aspects of nuclear safety.

ADVANCES IN THE SUPERVISION OF OPERATIONS

During my plant visits in France and the UK, I regularly sit in on operations meetings, which are well organised and have a strong operational focus, particularly on matters of nuclear and industrial safety.

Indicator-based control methods, already well developed in the UK, are becoming more widespread in France. I have been shown around various DPN indicator control rooms: the Generation 420 project control room, the safety indicator control room, and the production indicator control room (which also monitors the handling of quality and housekeeping issues). The engineering centres also have their indicator control rooms, most notably at the Nuclear fleet engineering, decommissioning & environment division (DIPDE) for the last-resort diesel generator project, at the Nuclear design & construction department (CNEN), and at the Electromechanical & plant engineering support department (CNEPE).

I have been impressed by these methods which will be developed further over the coming year. The challenge here is to make sure that the number of indicators is kept fairly low and that the link between corporate support functions and business units is strengthened. I would like to see this “visual management” approach extended to teams in the field in France.

PRESENCE IN THE FIELD IN NEED OF A BOOST

In 2015, I mentioned the need for managers to increase their presence in the field. This year, the situation seems to be largely unchanged (see Chapter 5). Staff are still complaining of a lack of manager availability for meaningful discussions. This observation has been confirmed during visits by the Nuclear Inspectorate and MAAP (the DPNT’s performance support unit).

That said, there is evidence of progress, illustrated by the example set by the dedicated field teams (EDT), which are becoming increasingly prevalent on French sites. These teams, which bring together all levels of management and sometimes contract partners, offer the chance to spend a significant amount of time in the field. They provide the opportunity to accompany managers who may not feel entirely comfortable out in the field and can thereby help to set a virtuous circle in motion. This represents good practice, although does pose the potential risk of becoming the only time that managers are present in the field.

A PROMISING DESIGN AUTHORITY IN FRANCE

At the DIPDE, I was shown the set-up of the Design Authority (DesA - see inset) for the French fleet. In seeking to ensure the design integrity of nuclear reactors throughout their operating life, the DesA provides operators with the necessary tools to make sure they are adequately informed and in a position to ask the right questions at the design modification stage. The “unit nuclear safety identity card”, provided for every reactor, strikes me as a highly promising practice. I am particularly impressed by the DesA’s competencies in both operational matters and independent nuclear safety inspections.
Nevertheless, this new organisation - and particularly the role of Responsible designer (undertaken by the engineering centres) and their interaction with the DesA - is yet to be finalised and validated. I will be keeping a watchful eye on how it operates, focusing especially on its independence. The French DesA teams have sought assistance from the UK where a more mature system is in place, which should serve to underpin the overall success of this initiative.

NUCLEAR SAFETY CULTURE - PUTTING THEORY INTO PRACTICE

I am aware of a number of initiatives that have been put forward to further develop the nuclear safety culture.

The plant manager training programme developed jointly by EDF Energy, EDF SA and the Canadian operator Ontario Power Generation, covers the ten INPO/WANO traits of a healthy nuclear safety culture.

Elsewhere, at the DPN, the Operations nuclear safety performance group (GPSN) is promoting the deployment of its guide underpinned by six principles (see chart) inspired by international practices. I note the effective control by the Operations nuclear safety review committee (CSNE) as part of the pursuit of excellence. The GPSN is aiming for a 3-year roll-out programme with gradual and structured implementation. It has positioned itself in a supporting role offering safety culture workshops and feedback sessions such as those conducted at Flamanville 3. The Safety & Quality manager network is the main channel for rolling out this initiative.

INDEPENDENT NUCLEAR SAFETY OVERSIGHT AT EDF SA

A CORPORATE-LEVEL, SITE-FOCUSED INDEPENDENT NUCLEAR SAFETY OVERSIGHT TEAM

The DPN’s corporate-level independent nuclear safety oversight team has a clearly defined purpose and a good accountability framework. The Director for nuclear safety and his team have maintained a high profile in the field, which helps gain a clearer understanding of reality and of the difficulties faced by staff on site enabling better targeting of priorities.

Design Authority (DesA)

The INSAG-19\(^1\) (International Nuclear Safety Advisory Group) guide recommends that all nuclear operators establish a Design Authority for their reactor fleet. The objective of this body is to ensure that operations comply with the fundamental design principles for several decades to come, seamlessly integrating any modifications associated with design changes whilst giving full consideration to the safety implications. The reasons for modifications are varied, such as technological advances, regulatory requirements and obsolescence.

In France, the DPNT has implemented the guide’s recommendations by setting up a Design Authority within the DIPDE responsible for verifying the design integrity of operational plants and assisting the DPN, in its role as project owner, with decision making. It is supported by engineering centres from the DPNT and DIPNN acting as Responsible designers in their respective fields of expertise.

The Design Authority consults with the directorates on all matters concerning modifications which impact nuclear safety. It provides support to operators in the form of a “nuclear safety identity card” for each reactor which is the baseline for design changes. It also helps operators define their periodic safety review objectives and verify the appropriateness and adequacy of measures taken.

At EDF Energy, the Design Authority resides in the Engineering division, which is part of the Central technical organisation and reports to the Engineering director. Safety requirements are checked on two levels, the first involving a substantiation of changes to basic systems against the original design, and the second comprising an overall validation of the safety function.

\(^1\) Recommendations that address the lifetime management of a plant design

Nuclear safety governance is well-coordinated at corporate level where consistently effective support is provided by the GPSN.

I have observed high-quality discussions held within the CSNE. Although the committee has effective communication and information sharing mechanisms,
it would still benefit from reinforcing its operational management role by making sites and central functions more accountable.

I also noted stronger interactions between the corporate independent nuclear safety oversight team and the ASN towards the end of 2016.

AN EFFECTIVE NUCLEAR INSPECTORATE

This year again I can report that we have a sound, well-managed Nuclear Inspectorate in place. The site take-up rate of Inspectorate recommendations is currently good and on the rise. The nuclear inspection programme is still heavily loaded, yet the schedule has been met thanks to the Inspectorate’s desire to target and prioritise its actions and recommendations. It maintains its openness internationally and has had ongoing exchanges with China General Nuclear Power Corporation (CGN) this year.

SAFETY & QUALITY MANAGERS RISE TO THE CHALLENGE

Safety & quality managers overall provide sound, independent safety oversight for site management. They are coordinated and challenged by the corporate Independent nuclear safety oversight team, particularly in terms of reporting performance gaps. I am not aware of any recruitment concerns in this group.

MORE EXPERIENCED SAFETY ENGINEERS

This year has seen an increase in experience and a greater spread of backgrounds in site safety engineers. This is a trend I would like to see continue over the coming year, along with a strengthening in the maintenance area. The engineers are listened to by site management and the corporate Independent nuclear safety oversight team during their site visits. The safety engineers immersed in “running” and “outage” unit projects provide genuine added value support on nuclear safety matters. There are good exchanges between the safety and quality function and operations. They play a key part in communicating the nuclear safety vision in their day-to-day role. Long may this positive trend continue.

AUDITORS ON THE RIGHT TRACK

The progress made by the audit teams reported in 2015 has been reaffirmed throughout 2016 at most sites. I suggest that actions for 2017 focus on measures aimed at preventing quality non-conformities, particularly in maintenance.

EVOLVING INTERNAL OVERSIGHT IN THE ENGINEERING DIVISION

An Operational supervision & risk management (MOMR) group has been set up this year at the DIPNN which includes the Engineering audit unit (MAE) and covers industrial safety and radiation protection. The MAE continues to assess the site-based combined engineering and operations teams in collaboration with the Nuclear Inspectorate. I will be keeping a close eye on how well this group functions over the course of 2017, as well as on the introduction of an oversight team for the DIPDE.

A LACK OF RECOGNITION FOR THE OIU

The Internal inspection organisation (OIU) attached to the Expertise & inspection department for manufacturing & operation (CEIDRE) at the DIPNN assesses the conformity of pressure equipment, mainly at the Flamanville 3 site.

When I went to meet the teams working in this organisation, I was struck by just how independently and diligently they were operating. A review conducted at the start of 2016 mentioned a failure on behalf of EDF divisions (the DPNT and DIPNN in particular) to seek advice from the OIU despite the potential benefits offered by the strong and established links with other regulatory bodies, the likes of APAVE and Bureau VERITAS. I noticed a dip in morale in this team, no doubt in part linked to the challenging programme at Flamanville 3. Some support as well as clarification of the OIU’s future – which could be addressed via the Industrial policy committee in 2017 – would improve the situation.

A BROADER INTERNAL LICENSING SYSTEM

The internal licensing system (SAI) for temporary changes to technical specifications continues to have a positive impact. It is meeting site requirements to a high nuclear safety standard. Dealing with an average of two requests per week, the SAI is now fully up and running and the quality of modifications prepared by the sites continues to improve. It provides the opportunity for frank and open discussions with the ASN.

French Decree No. 0846 dated 28 June 2016 (see inset) prescribes the extension of operator responsibilities through the establishment of an independent system of control. I am impressed by this initiative which serves to make the operator more accountable. Consultations are currently in progress with the ASN to clarify both the limits of this new system and the level of control desired based on the importance of the modifications involved. Nevertheless, I would like to highlight the volume of
work involved in completing this task by 1 January 2018, and the need to propose realistic solutions, resources for which may well be restricted in terms of expertise and independence. I doubt that it will be possible to handle all modifications to the current standard given the existing, heavy SAI demands in processing temporary technical specification changes.

Amendment to regulatory requirements governing modifications

The Decree of 2 November 2007 (known as the procedures decree) passed under the French Nuclear Safety and Transparency Act (TSN) stipulates that an operator wishing to modify facilities or operating documents in any way must either inform the ASN in the case of a low-impact change (Article 27) or obtain a license for a high-impact change (Article 26).

To limit the number of licensing requests and increase operator accountability, the concept of the internal licensing system (SAI) was conceived (ASN resolution No. 2008-DC-0106). This authorises operators to approve their own modifications provided they have ASN-approved independent oversight arrangements in place to meet the required level of quality assurance. Three SAIs were subsequently licensed; one handling temporary technical specification changes, a second for fuel, and the third for decommissioning. Decree No. 0846 dated 28 June 2016 amended these provisions by extending operator responsibilities through the establishment of an independent oversight system. Work is currently under way in collaboration with the ASN to define the limits of this system and the level of control according to the importance of the modifications involved. This work is expected to be completed by 1 January 2018.

INDEPENDENT NUCLEAR SAFETY OVERSIGHT AT EDF ENERGY

DYNAMIC CORPORATE-LEVEL SAFETY GOVERNANCE

I am pleased with the effectiveness of the corporate-level safety governance involving six Fleet managers tasked with coordinating industrial safety, fire safety, environmental safety, radiation protection, emergency preparedness and site security. They have forged strong links with the corresponding groups at each site.

SOLID INDEPENDENT NUCLEAR ASSURANCE (INA)

The INA has shown good progress this year. It is responsible for conducting independent, high-quality site safety assessments (a role similar to that of safety engineers in France). It also carries out targeted assessments, comparable to those conducted by the French Nuclear Inspectorate, which call upon the support of INA teams across all sites, thus promoting opportunities for shared experience and practices.

There is currently a move to install a lead inspector within the INA team at each site, tasked with coordinating the group. This would then strengthen links with the plant director, the site management team and the CNO (Chief nuclear officer, equivalent to the Director of operations at the DPN).

There are close ties between the INA and the ONR who conduct joint visits for example, reflecting a high level of confidence.

Recruitment does not seem to pose a problem for the INA: I have met highly experienced inspectors, often recruited from companies outside EDF Energy (and sometimes from overseas) which lends a greater degree of impartiality and open-mindedness to their actions. Many career development opportunities are available, notably in conjunction with WANO or the DPN’s Nuclear Inspectorate.

WELL-POSITIONED TECHNICAL AND SAFETY SUPPORT MANAGERS

This year again, I note that the Technical and safety support managers (TSSMs) are very well positioned to provide operational nuclear safety support and direction as well as advising management teams on safety matters. The TSSM peer group, led by one of the plant directors, provides a good environment for sharing experience.

The TSSMs are supported in part by their Nuclear safety groups which comprise specialists with expertise in various operational fields, such as fuel and reactor physics, who can also provide independent assessment and categorisation of plant modifications.

EFFECTIVE SAFETY STEERING GROUPS

Safety steering groups, such as the corporate and site-level SODTs (Safety oversight delivery teams), meet regularly to review and drive action on matters of safety. The meetings I attended were well run and focused on safety results and the challenges faced by the various sites. The monthly corporate-level SODT meeting is run by one of the plant directors, and provides an opportunity to challenge the sites about their results and provide support, particularly through shared experience. The NSRB (Nuclear safety review board) assesses each site every two years.

PRAGMATIC FRANCO-BRITISH EXCHANGES

In my 2015 report I commended the progress made by the French and British fleets in terms of the synergy between the two, yet called for stronger links between teams. I am pleased to report that there were plenty of examples of interaction at plant level throughout 2016 across several disciplines, including the outage organisation between the Penly and Sizewell sites, fire prevention and numerous examples in the area of industrial safety (see Chapter 4). I have been impressed by the pragmatic nature of these opportunities to share good practices. I will be monitoring these initiatives closely over the coming year, and assessing how well they are managed at the highest...
level (primarily by the Collaboration program board) and transferred into the field.

These exchanges would certainly benefit from a stronger engineering input which I believe is currently the weak link, perhaps due to the difficulty the British staff have found in identifying appropriate interfaces within the revised French organisation.

**MY RECOMMENDATIONS**

In the context of pressure on resources, I urge the Director of the DPNT, in collaboration with the ASN, to prioritise and optimise nuclear safety-related modifications based on a safety cost/benefit analysis approach.

In France, transformation of internal oversight within engineering is maintaining its momentum. I recommend that the Director of the DIPDE put in place an oversight structure consistent with that of the DIPNN's Engineering audit team.
In the UK, a robust safety culture has enabled the very good results to be maintained. In France, the safety results are not improving and the shared vigilance initiative is proving difficult to implement, even though some improvements have been observed in the management of significant risks. Good radiation protection performance levels have been achieved in both fleets, but sensitive activities (radiography, red and orange hazard areas) require increased attention in France.

SAFETY RESULTS

IN FRANCE, SIGNIFICANT DISPARITY BETWEEN SITES

In the DPN, the safety results are not improving overall, even though they are the second best ever achieved. The accident rate (lost-time industrial accidents per million hours worked) was 2.8 for EDF and its contract partners. Significant disparity has been observed between sites: the difference between the accident rates of the best and the worst NPPs is almost 5. Only 10 of the 20 NPPs have shown a steady improvement in their results over the last three years.

However, I note substantial improvement in the management of significant risks: lifting, working at heights, electrical hazards (26 injured in 2016, as against 32 in 2015 and 40 in 2014). Compliance with the Life saving rules has helped towards this result, although some effort is still required with regard to falls from height, which accounted for 15 of the 26 workers injured.

In 2016, a steam generator was dropped while it was being handled in a reactor building. The fact that there were no serious injuries is a reminder of the importance...
of complying with the Life saving rule requiring workers to be some distance away from loads being lifted.

I also note a significant increase in minor accidents at the DPN, in particular slips, trips and falls which accounted for 38% of lost-time accidents in 2016 (30% in 2015).

In Engineering, the results of the DIPNN are encouraging (accident rate: 2.6) but those at the DIPDE are still too high (accident rate: 4.5). I also note mixed, poor results in the site joint teams (combined operations and engineering teams responsible for implementing modifications on site). I would like to draw particular attention to civil engineering worksites, such as those involving work on the ultimate emergency diesel generators, where several lifting incidents and falls from height could have had terrible consequences.

At Flamanville 3, where a large volume of work is being carried out (assembly and testing), the results are continuing to improve: accident rate of 4.4 (5.8 in 2015). This improvement is the result of a firm proactive approach supported by project management, which must continue if it is to catch up with the fleet.

For the decommissioning sites, following a good 2015, the results for a smaller workforce have deteriorated significantly (an accident rate of 5.8 in 2016 as against 4.6 in 2015).

IN THE UK, CONTINUING EXCELLENT RESULTS

The accident rate in the UK remains very low at 0.3 (0.40 in 2015).

This excellent result has been achieved thanks to the zero harm initiative, in particular regarding the risk of slips, trips and fall accidents, and to effective collaboration with contract partners with the aim of achieving zero harm. For contract partners, the level has fallen from 40 injuries in 2010 to 5 in 2015, and to 4 in 2016.

I noted the resumption, at the request of contractor staff, of the good practice of using a simplified “time-out for personal safety” sheet to check that there are no safety risks before a task is started. This revised initiative has given new impetus to the approach to safety on worksites.

SAFETY MANAGEMENT

IN FRANCE, VARIABLE SUPPORT FROM MANAGERS

The safety results, and above all the disparity between units, call into question management commitment in this area. Although I note from comments made that managers firmly believe in the need to improve expectations in terms of safety, I have come across a number of weaknesses:

- Large differences from one NPP to another in how management deals with gaps concerning significant risks (zero tolerance)
- Management of isolations, for which the Nuclear Inspectorate has noted a lack of rigour on several sites, in particular with regard to special work permits (special procedures permitting work to be carried out under certain conditions on equipment on which the voltage, pressure, etc. has not been isolated)
- Significant disparity in the depth of analysis of accidents or near-miss accidents, despite the existence of the DPN guide to in-depth analysis of incidents
- Conclusions of analyses inadequately checked and passed on to the workforce by leaders.

Keeping employees at work by offering restricted duties (see inset) is still inconsistently accepted, due to a lack of adequate forward planning and discussion with stakeholders (employees, managers, occupational health and employee organisations).

I noted that the introduction of area supervisors has been very well received at plant level. Through the advice they give, they improve workers’ compliance with safety rules. However, care must be taken to ensure that this support does not take the place of the actions of managers.

IN THE UK, A MOMENTUM TO BE MAINTAINED

I have observed strong demand at plant level to close safety performance gaps. Managers are uncompromising about compliance with requirements, the zero harm tools are applied throughout, and there is regular, relevant communication. For example, the strong commitment of the contract partners at one site has meant there have not been any accidents on that site for nine years.

I would, however, like to draw attention to the risk of these good results being allowed to erode. Fresh momentum must be injected periodically, as with the introduction of a revised “time-out for personal safety” sheet.
Keeping employees at work

This is part of the EDF Group’s health and safety policy. Its aim is to enable workers to continue working, or to make their return to work easier, by offering restricted duties. This approach, which involves employees, managers and occupational health staff, applies in the event of accident, illness or permanent disability.

SHARED VIGILANCE: THE NEED TO SET A GOOD EXAMPLE

This approach of challenging each other about safe practices, which has strong support from all managers, has gradually developed at EDF Energy over the last ten years, initially being limited to just a few behaviours to be followed, such as “hold the handrail”. It has enabled staff to effectively embed the practices of being observed and being comfortable to challenge.

The decision to introduce shared vigilance in NPPs was taken at the end of 2015 at the DPN, however it has still not been implemented thoroughly enough to change workers’ behaviour and improve results. I noted that it has been implemented unevenly across sites, often with better compliance from contract partners. These differences are in danger of demotivating the contractor staff that work across a number of sites.

I encourage EDF SA to adopt a pragmatic approach, supported by all managers in the field and initially limited to a few (one or two) behaviours to be followed by everyone. I will pay particular attention to this point in 2017.

FRANCO-BRITISH DISCUSSIONS PROGRESSING WELL

I have observed considerably more sharing of safety information with the active involvement of the sites (joint communication campaigns, joint safety messages, TSMs (Technical support missions organised by WANO), CAP 2030 safety seminar, staff exchanges and sharing of good practice, etc.). These exchanges should help to create a synergy that is beneficial to both fleets.

RADIATION PROTECTION: CONTINUING GOOD RESULTS

IN FRANCE, PROGRESS, WITH A FEW POINTS WHERE VIGILANCE IS REQUIRED

The average yearly individual dose is satisfactory and has remained stable at around 1 milliSievert (mSv) since 2011 (see graph). The number of workers, both EDF and contract partners, receiving a total dose of more than 10 mSv is increasing (274 in 2016, as against 200 in 2015). This trend, associated with the extension of outage times in the last quarter, will require close monitoring in 2017. No workers were exposed to a dose of more than 14 mSv in 2016. I note the reduction in the early warning threshold from 14 to 13 mSv so as to maintain the momentum.

The collective dose remains at a satisfactory level in view of the greater volume of maintenance work than in 2015: 0.76 man-Sv/unit (0.71 man-Sv/unit in 2015). The average hourly dose level within the fleet has fallen by 25% in ten years, and has remained at a low level since 2010: 6.43 µSv/h in 2016 (see graph).

The radiological cleanliness indicators remain good:
- The trip rate of the controlled area exit radiation monitors (0.46%) is stable (0.45% in 2015)
- The trip rate of the pedestrian site exit radiation monitors is low and falling (less than one trip per 50,000 people who have worked in controlled areas)
- 2 significant radiation protection events involving contamination of an on-site road (1 event in 2015)
- 2 significant radiation protection events associated with skin contamination
- Of a total of 11 significant events involving transport, only 2 with a radiological impact.

These events are mostly associated with inappropriate behaviour. I also note that there has been less body contamination (0.12%) on EVEREST sites (where workers are allowed to enter controlled areas wearing ordinary work clothes) than on other sites with similarly rated plants (0.19%). I believe that these improved results arise from making workers more accountable for controlling contamination at source.

Vigilance is more than ever necessary for hazardous activities (orange and red hazard areas and radiography) for which the results have deteriorated:
- 45 events in orange hazard areas in 2016 (29 in 2015)
- 4 significant events for activities in red hazard areas in 2016 (0 in 2015)
• 9 significant radiation protection events associated with radiography in 2016, as in 2015, despite more radiography being carried out.

The types of events noted for radiography involved: 5 demarcation faults, 3 deliberate entries into demarcated areas in breach of the fifth vital rule (irradiation by radiography), and 2 presences in a demarcated area. The Nuclear Inspectorate observed an overall deterioration in the organisation of radiography on the sites assessed. I call for the action plan implemented between 2013 and 2015 to be re-examined.

Following an initial experiment in 2015, the use of selenium sources is gradually spreading: 15 to 20% of all radiography is now being carried out using selenium. Using a lower energy source minimises the risks.

**IN THE UK, SUSTAINED GOOD RESULTS**

Collective exposure on the AGR reactors, which is limited due to their design, remains very low in comparison with international levels: 0.021 man-Sv/reactor. The collective dose for the Sizewell B PWR site also remained very low in 2016 (0.554 man-Sv).

The maximum individual exposure is 5.2 mSv per worker.

I also note good results for the controlled area exit radiation monitors, with a trip rate of 0.09%, which is stable in relation to 2015. The UK sites do not have site exit radiation monitors.

The number of significant radiation protection events has risen to 21 events (18 in 2015), none of which were classified in the category of very serious contamination incidents.

**MANAGEMENT OF RADIATION PROTECTION IN FRANCE**

**DOSE RESTRICTION FOR IMPROVEMENT**

In 2016, the DPN set a maximum collective dose for each NPP lower than the initial estimate carried out by the site. This dose restriction required NPPs to implement stricter optimisation of radiation protection and has helped to avoid 5% of the total dose.

More generally, a fleet-level analysis has identified possible sources of optimisation and enabled better forward planning of the support required on the sites.

**CONVINCING SITES OF THE BENEFIT OF SYSTEM CLEAN-UPS**

System clean-ups, decided on after a cost-benefit analysis, are scheduled and monitored by the Central technical support department (UTO) of the DPN. I note that, in 2016, two of the initially planned four sites postponed their system clean-ups because of planning or organisational difficulties. This activity, which is effective in reducing the source term, does not seem to have been adequately encouraged and organised. In the multi-year planning of outages, I would like to see more emphasis given to these doses “avoided” so the NPPs are made aware of them.

**NEW PROTECTION TOOLS**

A great deal of innovative work has been carried out to introduce modern tools into the fleet. These include:

- Units for monitoring worksites remotely to improve the radiation protection and safety of workers. They have been installed at 8 sites, with 7 more to follow in 2017
- The “gamma camera” to detect and display hot spots on screen. This good practice received a Pulse award (EDF award for innovation) in 2016
- In one NPP, testing of a robot for cleaning the bottom of the pond, avoiding the need for a person to be present in a highly contaminated area
- The CADOR tool (decision support code for optimising radiation protection) which optimises the installation of biological shielding. This could however benefit from being simplified.

These tools make workers’ lives easier and improve their radiation protection.

**FRENCH REGULATIONS ARE CHANGING**

The transposition of the European directive (2013/59) on radiation protection (see inset) into French law has started.
For the French public health code alone, this could lead to a doubling of the volume of regulations, without taking into account the implementation documents (ministerial orders and ASN regulatory decisions). The requirements in these regulations add to those already in the INB (licensed nuclear facilities) regulations relative to the French environmental code.

Some of these regulations go beyond simple compliance with objectives, moving towards a more detailed specification of requirements, which is likely to make operators less accountable. But above all, this whole body of regulations seems excessively complex and difficult to implement. It is based on a number of codes, which makes consistency of implementation difficult.

An example of this complexity is the desire to deal with the radiation protection of workers on decommissioning worksites as a protection-important activity (PIA). Why would you want to apply the requirements of the French environmental code to an activity that is already covered by the French labour code? This approach also seems disproportionate to the issues involved.

Transposition of the 2013 Basic Safety Standards directive

Since the Euratom treaty in 1957, the protection of the health of workers and the public against hazards resulting from exposure to ionising radiation has been covered by directives that have been updated regularly to take account of changing scientific knowledge, in line with the recommendations of the International Commission on Radiological Protection (ICRP) and based on operating experience. The latest European directive, 2013/59, lays down basic safety standards for protection against the dangers arising from exposure to ionising radiation. The French administration has started to transpose it into the French labour code (protection of workers) and the French public health code (protection of patients and the public). After consultation with the stakeholders, these regulations must be sent to the Conseil d’Etat (Council of State) before their planned publication in 2017. Ministerial orders and ASN decisions will then be added to the process.

MY RECOMMENDATIONS

In France, the introduction of shared vigilance has turned out to be difficult. To make this easier, I recommend that the directors of the DPNT and the DIPNN choose a small number of straightforward, representative activities to be implemented simultaneously across all sites.

Due to the potential seriousness of shortcomings concerning radiography and red hazard areas, I would ask the directors at plants and construction sites in France to increase their support of the demands in these areas and to improve the organisation of radiography.
TEAM SKILLS AND COMMITMENT

In France, after a massive recruitment drive, the professionalisation process is still ongoing and supported by a set of robust arrangements. In the UK, teams are preparing for the transition between AGR and EPR technologies.

Motivation remains strong despite the complex backdrop.

Now more than ever, the role of managers and their presence in the field are essential so they can get their message across and support their teams.

RENEWAL OF SKILLS

The EDF Group remains an attractive employer. The new recruits I meet, both in France and in the UK, are well integrated into the teams. They are benefiting from robust professionalisation arrangements.

AN EFFORT THAT EDF SA NEEDS TO MAINTAIN

The very important skills renewal process, which began some years ago, is coming to an end. It has been a success.

The large numbers of new recruits has rejuvenated the workforce: more than a quarter of the DPN’s staff has less than 5 years’ service in the Group. In 2016, staff reductions were implemented, differing according to the sites and professions. I see that the impact of these reductions on the DPNT, the DIPNN and R&D is, for the moment, under control.

These reductions have not caused any major problems in the NPPs because they were mainly achieved by reducing the number of staff entering training (pipelines), which is as expected at the end of a generation change. I would, however, like to draw attention to the tensions I perceived in the DPN, between maintenance preparation teams and, in certain plants, the operations teams who have not yet integrated all the recommendations from the core competency guidelines (guides specifying the aims, organisations and job roles for a given profession).
Managing manpower cuts is somewhat more complex in the engineering centres. I have been informed, for example, of weaknesses in the skills of test engineers for Flamanville 3, in recruits to the OIU (Internal inspection organisation) and in the site joint teams (mixed engineering and operations teams responsible for implementing modifications in the NPPs) whose workload is due to increase in the coming years with the Fleet upgrade programme.

I would like to draw attention to the risks for nuclear safety of significant manpower cuts or stop-go recruitment, mainly because of the timescales necessary in becoming suitably qualified and experienced.

The pressure affecting the workforce is resulting in less inter-site mobility, with the risk that sites protect themselves by preventing people from leaving. In this context, firm management is needed to support both in-house and external mobility in France and internationally. This support is also required to assist the redeployment of staff from non-nuclear divisions into nuclear.

PREPARING FOR THE MOVE FROM AGRs TO EPRs AT EDF ENERGY

Unlike the practice at EDF SA, staff at EDF Energy, except for the management teams, usually spend their entire careers on the same site and often in the same job. This approach gives leaders solid technical legitimacy and the means to provide effective coaching to their teams, but limits the enrichment provided by a cross-career pathway.

In addition to training, skills are sometimes passed on by recent or imminent retirees.

For technicians, I note the positive effects of apprenticeships: there is no doubt that they reinforce the appeal of technology and attachment to ‘their’ plant equipment, improving the quality of work (see Chapter 7).

I have also been informed of the initial thinking on the transition between AGR and EPR technologies.

For the Hinkley Point B site, I perceived the sense of anticipation on how the transition will be carried out. By the end of the service life of both reactors (2023), everyone will be in one of three categories: a third of the staff will remain on site to undertake decommissioning, another third will be involved in the Hinkley Point C EPRs, and the final third will retire. Such a plan makes it possible to anticipate the skills development required and will contribute to the peace of mind of the teams.

For the other AGR plants, there is a different issue: not only will there be a very significant staff reduction by the end of their service life, expected through to 2030 depending on the plant, but there will also be changes in the type of skills needed. I am aware that an analysis is ongoing and solutions are emerging. I encourage the senior managers of EDF Energy and NNB (Nuclear New Build, a subsidiary of EDF responsible for new reactor projects in the UK) to continue on this approach.

ROBUST SKILLS DEVELOPMENT ARRANGEMENTS

The approaches adopted continue to prove effective, whether it be the Skills programme in the DPN or the Systematic approach to training in the UK. The professionalism of newly-hired staff has increased in recent years, thanks mainly to vocational academies, simulator training and the opportunity to share experiences with older staff.

In French plants, the use of craft training centres is growing, but is still somewhat inconsistent. I again encourage their increased use, by both EDF staff members and contractors.

Since the announcement by INPO of the closure of its international programme at the end of 2016, EDF Energy has implemented a training plan for plant managers, in conjunction with the Canadian operator Ontario Power Generation. I welcome this international cooperation, developed with the support of WANO.

Moreover, the tension over budgets is also affecting training. After the peak influx of new employees in recent years, expenditure on initial training will reduce naturally. I cannot stress how important it is to take account of the very specific nature of nuclear skills and the challenges in the short and long term of maintaining them.

In order to maintain the impetus in establishing suitably qualified and experienced staff, I invite all the Divisions to continue with their employment and skills plan approaches. I encourage the engineering functions to make sure regular “competency checks” are embedded.

I again emphasise the importance of managers being hands-on and getting involved in the professionalisation and competency of their teams. In France, this involvement needs to be strengthened: their “back of the room” participation and their involvement in simulator training, with an uncompromising approach to applying the human performance tools, do not yet seem sufficient.

MAINTAINING TEAM COMMITMENT

A COMPLEX BACKDROP

In France in particular, managers and staff are working in an environment that sustains increasing anxiety.
Organisational changes, the merger with AREVA for example, or different working methods, with the introduction of new tools such as the Nuclear technical information system (SDIN) or the Plant lifecycle management (PLM), are just a few examples that continue to unsettle the workforce. The same can be said of the many internal and external discussions which preceded the decision to invest in the Hinkley Point C project.

In addition to these highly-charged circumstances, the issue of carbon segregation in 2016 added to the disquiet (see Chapter 1). The lack of visibility as to when the affected reactors would be restarted weakened the nuclear safety environment after such steady progress over the past years on unit outages. Faced with ongoing delays, some staff are weighing up the advantages of multi-year planning, of the modular approach, and of detailed preparation well in advance of outages.

The economic situation has also imposed improvements in productivity and restrictions on the workforce, budgets and schedules.

To this can be added the tendency of the media and social networks to exaggerate events, even minor ones. This constant pressure and the increasingly litigious nature of society are a burden on staff and managers. I have met teams who are worn out, especially those on sites in the public eye and those with managerial responsibilities.

In the UK, I have seen that the staff are generally more composed, and demonstrate a poised, pragmatic approach to problems, as do the stakeholders.

MOTIVATED TEAMS

In both France and the UK, staff are extremely committed, not just the young but also the more seasoned staff, including at plants under significant pressure. I encourage them to maintain their motivation, which is indispensable to future success.

Throughout the plants, nuclear safety is still the top priority, despite the many uncertainties and a challenging environment.

MANAGERS PLAYING A KEY ROLE

In this strained environment, staff need more than ever to appreciate what is asked of them, master the basics of their job and understand changes under way. Having managers by their side, from team leaders through to senior management, is fundamental to supporting them in achieving a high level of professionalism.

MANAGERS WHO ARE ALWAYS COMMITTED YET STRETCHED

Over a number of years I have seen that managers are often overwhelmed or caught up in detail: increasing bureaucracy, the burden of administrative tasks, time spent in meetings or on the computer, and the inadequacy of some computer tools, are all issues they have been talking about for some time. The recommendation in my 2014 report which aimed to “protect them against any demands distancing them from their teams and their priorities” is still valid. I noted the DPN’s desire for simplification so they can win back two hours a day.

In addition to their operational responsibilities, managers are subject to increasingly stringent and often conflicting demands. They may feel helpless to answer questions from their colleagues on activities for which EDF is not directly responsible, but from which they bear the brunt of the consequences. This situation generates a feeling of injustice in staff members and their managers.

Nonetheless, the managers are still strongly committed. I note that, thanks to their involvement, the results generally improved in 2016 (see Chapter 2). Operational focus is still evident, with clear simplification actions (see Chapter 6) being implemented by some managers and the solidarity between managers is strong on a number of sites.

In the teams I met, the priority of nuclear safety remains firmly upheld by leaders.

LEADERSHIP PRACTICES TO BE EMBEDDED IN FRANCE

Leadership can be defined simply as having the ability to mobilise resources to achieve the goals which have been set. In a difficult situation, with numerous demands and multiple changes, it is an essential quality for all leaders, who should be selected and assessed mainly on the basis of this criterion.

At EDF SA, I have seen a very diverse range of training, which is provided at EDF Group level, at the DPNT, at the DPN, and on the sites. It concerns the whole management hierarchy, from team leaders to senior management, and provides theoretical input as well as practical exercises.

Conversely, I have seen that the fundamentals of leadership are not sufficiently being put into practice out in the field. For example, some personnel safety
requirements are being overlooked, yet there is no reaction from managers. I wonder how such managers were mentored in real situations once their training was completed. Arrangements have been put in place, such as the dedicated field team (EDT), or ad hoc manager coaching, but they do not strike me as capable of bringing the whole management hierarchy up to a good level.

I urge site management teams to work on implementing the fundamentals of leadership and I encourage the EDF SA training module organisers to simplify the courses they run.

At EDF Energy, the various modules in the Leadership development programme have been updated. They apply to all levels, from first-line managers through to future plant managers. They allow plenty of time for practical experience in the field.

In addition, the amount of coaching has been expanded. It is done by the managers themselves, who are responsible for a limited number of people. A leader selection system is in place at all levels. Discussions between France and the UK on this matter would be productive.

The Senior manager leadership programme is well worth the effort (see inset). The first sessions, taken by managers from EDF Energy and EDF SA, were much appreciated.

**Senior manager leadership programme**

This programme, developed by EDF Energy and the DPN, aims to improve the leadership potential of their future top executives. It covers the key points of the INPO training scheme. The two 3-day modules exploring the various aspects of leadership allow trainees to build their own personal development plan and take advantage of sharing good practices.

**PRESENCE IN THE FIELD TO BE STRENGTHENED**

In both France and the UK, I still see a lack of leadership presence at all levels in the field.

The situation in France, which varies from site to site, was picked up on by the Nuclear Inspectorate and MAAP. It can concern all levels, from management teams to team leaders, including corporate-level support services.

Yet people are aware of how important it is to have leaders in the field. I also noted that, for example, in complex circumstances, that refocusing a business unit on activity in the field via its leaders has helped improve the situation.

I have also seen positive examples from the dedicated field teams (EDT) in France and the participation of managers in visits by Area safety coordinators during unit outages in the UK. These approaches force managers to be present in the field, thereby facilitating cross-organisational activities and experience-sharing. Nevertheless, it is important to make sure these moments are not considered as their only time to be on the plant, as this cannot replace a leader's presence alongside their team.

The MEEI (maintaining exemplary housekeeping) project in France and the UK equivalent, Site Excellence, are another illustration of the progress that can be made and maintained thanks to the strong presence of local leaders and corporate teams in the field.

In the engineering divisions, the situation also varies according to the different business units. Teams in an open plan environment clearly acquire the beneficial effects of making it easier for leaders to be close to their teams. This has long been the case for the EDF Energy teams at Barnwood and at SOFINEL (joint EDF and AREVA design teams) for example. I am delighted that this working method is becoming more widespread, for example at the DIPDE for the project team on the ultimate safety diesel generators, and at the CNEPE for the Hinkley Point C integrated team put in place at the end of 2015, etc.

In both France and the UK, I note that visual- or indicator-based management, involving teams in each business unit or divisional management teams, has had numerous positive effects in developing oversight, improving prioritisation, reducing silo mentalities, fostering solidarity between team members, etc. However, like the dedicated field teams (EDT) in the French NPPs, visual management is no substitute for managerial presence alongside their teams in the field.

Even though it is generally agreed to be essential, this presence is, however, still inadequate. Corporate-level management teams and support services must lead by example in this area and must free up time for all managers to be sufficiently present in the field. More generally, I encourage the managers themselves to ensure they have the means to implement this presence, by prioritising, simplifying and delegating more.
MY RECOMMENDATIONS

In France, against a background of manpower reductions, I recommend maintaining a minimum influx of new recruits. Again, I invite the senior managers of the DPNT and DIPNN to boost inter-site mobility of staff, ensuring also that jobs abroad are included and seen as a valuable opportunity in career paths.

In the UK, in order to minimise the impact on human resources associated with the end of life of the AGRs and the introduction into service of the EPRs, I encourage the CEO of EDF Energy to pay particular attention to the analysis of the means for this transition.

In a challenging context, the role of leaders, especially first-line managers, is more important than ever in getting the message across, listening to and supporting their teams. To help them fulfil their brief, I again recommend that their practical leadership skills be strengthened and their presence in the field be increased.
In an increasingly difficult environment, simplification is essential, especially for nuclear safety.

Long-awaited by everyone, it has begun but has yet to be adequately translated to the field.

A few basic principles could, however, help its progress.

**IT HAS BEEN TALKED ABOUT FOR A LONG TIME**

Simplification is a recurring topic. In 2003 one of my predecessors wrote: “Faced with ongoing change, the company must continually reorganise its operation. The desire to simplify, announced on these occasions at all levels, tends to be a simple declaration of intent. In fact, the organisation is becoming ever more complex with the result that personnel are finding it increasingly difficult to understand their role in the company.”

This still seems to be the case, in both France and the UK.

In addition to the complexity of the organisations, there are numerous, increasingly rigorous requirements. Both internal and external specifiers build up layers with the aim of improving quality. Of course, the nature of nuclear activities means there must be a detailed level of requirements and rigorous organisation, but I am convinced that, above a certain point, complexity actually compromises nuclear safety. There is a risk that workers will lose sight of the reasons for their actions and hence fail to behave correctly.

It appears that a cultural shift is essential to address people's natural tendency to always add things, without ever taking anything away. A balance must be found between the level of detail of specifications and how easy they are to apply. I am aware how difficult this will be to achieve and maintain.

Once again this year, I have observed high expectations and some attempts, somewhat sporadic but nonetheless promising, at simplification. This chapter looks at this issue and considers areas which merit further work.
NUMEROUS EXPECTATIONS

Wherever I go, I note high expectations from both senior management and staff who have identified concrete needs for simplification in their day-to-day work.

In the field, on sites or at the engineering centres, people I met complained about the excessive levels of procedures and requirements, and the complexity of the decision-making bodies, which adversely affect the quality of their work. They are disappointed that some of their suggestions are never followed up. They are unhappy that real improvements that would make their work easier are not implemented quickly. I have also noticed that many examples of sub-standard work (see Chapter 7) are, at least in part, attributable to overly complex requirements or processes.

Nonetheless, different strategic projects, from CAP 2030 (EDF Group’s strategic project) through to team projects, including Generation 420 at the DPN, EDF Energy’s Nuclear generation business plan, the DIPNN’s vision and strategic plans of business units in France and the UK, all place great importance on simplification. They identify priorities and suggest possible areas for simplification (digitisation, processes, collaborative approaches, etc.).

People have mixed opinions about these simplification initiatives, and some have even told me that the desire to simplify sometimes leads to even greater complexity!

SOME ACHIEVEMENTS AND NUMEROUS POSSIBILITIES

I have been shown several simplification opportunities that have already been implemented. They contribute to the workers’ peace of mind, to the quality of their work, and to nuclear safety.

This is the case in France with the “one-stop shop”, equivalent to the Work execution centre in the UK, which enables workers on site to obtain all the permits they need from one place. Other simplification processes for subcontractors have also been introduced, such as reducing the number of whole-body gamma measurement checks (see inset). Likewise, “cadlocks” (registered trademark of single-use padlocks which can be closed with one hand) are currently being introduced. They greatly simplify the plant isolation process, doing away with the need to manage and use chains and padlocks.

In the UK, plant walk-downs (multidisciplinary work area visits) simplify the job for workers and minimise the likelihood of them being confronted with last-minute unexpected events. Likewise, to simplify some types of work, minor maintenance allows people with sufficient experience to avoid having to go through all of the standard process when carrying out certain tasks on non-sensitive equipment.

More generally, many local initiatives have resulted in some helpful simplifications, some of which have been promoted and brought to the attention of other sites through the annual DPN Challenge, the EDF Pulse awards or in the context of sharing experience. The collaboration programme between the French and UK fleets is a way of spreading good practices identified in each country. WANO and the INPO also provide an opportunity to find out about other operators’ initiatives which might simplify how things are done. However, I notice some reluctance at EDF SA to copy these improvements, which is no doubt, in part, cultural.

INADEQUATE EXCUSES

Some people hide behind a culture which is resistant to simplification. The French approach, which relies more on analysis and conceptualisation, does not lend itself to copying good practices that do not have a local origin. The DPN Challenge is an example of this: it is acclaimed by everyone and has led to a number of important innovations, but very few of them have been implemented across all sites. The DPN is aware of this situation and since 2016 it has required NPPs to implement at least 50% of the best innovations.

I am convinced that where culture is a factor, there is no question of inevitability or determinism, and that it is possible to change attitudes fairly quickly by concentrating on a few relevant enablers. The way EDF Energy embedded the idea of holding the handrail on stairs is an example of this. The widespread introduction
of this practice, which was not common in the UK ten years ago, just like in France today, only took one or two years, but it required the involvement of all levels of management.

I also hear it said that the size of companies means that complex organisations and working methods are necessary. I have seen complicated processes, committees, indicators, procedures and requirements, and I am still meeting far too many people at EDF SA who have no knowledge of the main objectives of their business units. Moreover, the distance between the various management levels and workers in the field results in managers’ responsibilities being diluted and messages being poorly received by workers (see Chapter 5).

As with culture, I do not believe that the size of organisations is an insurmountable obstacle to simplification. We can at least ensure that employees feel their business unit is on a human scale, making it easier for them to understand and adopt values and objectives, developing solidarity and boosting efficiency. I have met teams in the Group who have successfully developed this type of shared culture.

FOCUSING ON WORKERS

Simplification is frequently not sufficiently worker-oriented, resulting in them seeing little improvement in their daily work environment. However, when corporate functions put themselves in the workers’ place and visit plants, they do succeed in providing tools and services that are easy to use, and suited to requirements.

Processes such as MEEI (maintaining exemplary housekeeping) in France and Site Excellence in the UK are good examples of a worker-oriented approach. A solid approach, implemented in the field, and with a strong corporate-level presence, leads to remarkable progress.

Updating documentation is also a major simplification issue. The establishment of teams in the DPN responsible for drafting operating documents for a given plant series is a step in the right direction. It does not, however, seem to have fully achieved the objective of simplification, especially in terms of taking on board site requirements and providing a timely response.

Training should also be more adapted to workers’ needs. In France, although some progress has been made (e.g., targeted training), the Nuclear Inspectorate points out that the Systematic Approach to Training (SAT) initiative (focusing on performance and providing targeted training courses) has been inadequately implemented in all NPPs, even though it simplifies and optimises training.

Visual management is expanding in many divisions. It helps staff to take ownership of objectives and enables them to feed back their suggestions quickly. I would encourage continuation of this practice, ensuring that it remains simple (limited number of objectives and automated feedback of indicators, etc.).

The use of IT tools is also part of a worker’s daily routine. These tools include the Nuclear technical information system (SDIN), the integrated management system (SMI), simulators, PLM, computer software, and the asset management system used in the EDF Energy fleet to support preparation and management of work. I note the digitisation developed by R&D for inside the Cattenom 1 reactor building. By providing a visual representation of all the equipment and facilities, it helps workers prepare for the work they are to carry out. The widespread introduction of digitisation is a promising initiative.

Some users have told me that some IT tools are too complex or have inadequate functions, meaning that they have had to develop local workarounds. Although these tools are genuinely helpful, they still get criticised because of flaws often associated with either inadequate user involvement or poor integration of user expectations, during the life cycle.

Operating experience, in France, is another example. Although designed for plant-based users, the tool for making this information available is not very user-friendly and information is hard to find. Efforts should be made to improve it, making it simpler and more efficient.

In simple terms, those who design tools should put themselves in the place of the end-user. It is the key to prioritisation, removing silos and standardising appropriately.

PRIORITISING

Given the action plans implemented at all levels in the Group, I have to question whether we are not trying to do too much at once. Even with simplification programmes, there is often a desire to handle and control a huge number of good ideas. This takes too much effort, when the expected benefits of some of these ideas are minimal. Similarly, I have seen too many actions resulting from analysing events, which also involves unnecessary effort, often to the detriment of the most beneficial actions.

However, there are some effective prioritisation methods. In France, SEPTEN (the Nuclear & conventional design department) showed me the cost/benefit approach to nuclear safety (see Chapter 3). Already in use in other
countries, it helps set priorities for potential modifications according to the nuclear safety benefits they provide (80% of nuclear safety benefits obtained with 20% of the resources).

In addition, I note the promising nature of the collaborative method proposed by La Chocolaterie (an EDF support structure for implementing and testing ideas for collaborative methods) and the good results obtained using hackathons. These are a way of getting certain initiatives off the ground quickly by gathering the necessary people together for a limited period.

These examples show that methods for breaking down barriers do exist. I call for the various management levels to take them on board and apply them to priority topics requiring cross-functional cooperation.

ACHIEVING A BALANCE BETWEEN DELEGATION AND STANDARDISATION

During my visits, I have noticed significant disparities in methods, organisation, etc. in entities which are otherwise comparable. Yet do we have to impose standardisation? It is certainly necessary in some areas: operating rules, choice of key systems such as information systems, human resources management, etc. But it is not appropriate to deal with everything at corporate level, as this can demotivate workers in the field and stifle innovation.

I observe also that in France decisions are often taken at too high a level, thus complicating processes unnecessarily.

When an opportunity for improvement concerns all sites, standardisation is obviously beneficial. I believe that it is preferable to achieve this by engaging with workers in the field rather than imposing decisions at fleet level. A change is much more likely to be successful if those who are going to implement it are already on board. The perfect system would be maximum standardisation obtained with the minimum imposition of requirements, even if in practice this ideal is difficult to achieve.

Many local initiatives have contributed to simplification and I support them. When they are broad-ranging, it is regrettable that their widespread implementation across other sites is so slow (see the DPN Challenge innovations mentioned above).

Yet I have seen some examples of good practice.
Drone used to simplify scaffolding inspection

The shared outage support teams (see inset) in France are achieving a good national/local balance, with area supervisors who implement requirements common to the DPN across all sites. Despite not having any managerial authority, they are able to pass on good practice by coaching workers in the field.

In the UK, improvements are introduced by encouragement rather than imposition, by means of consultation and coordination with the different peer groups (carried out by the Fleet managers) working closely with the local and national cross-functional Delivery teams.

In summary, I believe that driving exchanges between all those involved, as well as levels of subsidiarity, should be increased to permit effective standardisation.

Shared outage support teams (EMAT)
Set up in 2013, these EDF SA teams provide support to sites during busy unit outages. They bring together people from a variety of backgrounds who have all completed a specific, comprehensive training programme. They provide the following services:
- Coordination of activities in the reactor building
- Checking, support/advice and facilitation of workers (area supervisor role)
- Planning support.
They work in five areas: radiation protection, safety, fire prevention, worksite logistics and housekeeping. Their work helps harmonise methods and practices for unit outages.

MY RECOMMENDATIONS

Although the need to simplify has long been recognised by everyone, there is little evidence of progress in the field. I recommend that managers in the Group implement an approach which:

- Strengthens the link between specifiers and those in the field, to ensure that solutions are realistic
- Limits the number of priorities, by knowing how to say no and restricting the list of tasks
- Forces cross-functional activity
- Promotes standardisation by supporting and empowering people rather than being prescriptive.
Despite the efforts that have been made, the quality of maintenance work at EDF SA and EDF Energy still requires improvement and barriers remain to be overcome.

Work is underway to refocus on worker preparation, together with a renewal of the maintenance strategy in France.

The quality of relations with suppliers remains essential for the success of maintenance activities.

**SUB-STANDARD MAINTENANCE STILL TOO FREQUENT**

For several years, I have stressed how important maintenance is for the successful completion of all the work associated with plant life extension in the French and UK fleets. The difficult context in which the energy industry finds itself increases the need for reliability and availability of generating plants.

I have observed many initiatives that have been undertaken to improve the quality of maintenance work:
- Development of training courses
- Organisational changes
- Clarification of standards and optimisation of maintenance procedures
- Use of human performance tools (pre-job briefing, time-out for personal safety, etc.)
- Reduction of backlogs
- Better management of the volume of maintenance work
- Multi-year planning and preparation for plant outages
- Commitment of and coordination with contract partners.

I am concerned by the gap between these efforts and the continuing high level of sub-standard maintenance work. There are clearly a number of outstanding issues to resolve.

The impact of sub-standard maintenance work is continuing to decrease in France (reduction in the number of automatic reactor trips caused by equipment, four-fold reduction in the equivalent full power days lost over 5 years), but there is a steady increase in the number of
events (see graph). A comparable trend can be seen in the UK: sub-standard maintenance work still persists, but it has less impact.

**Sub-standard work on a primary pump unit**

At the end of a reactor outage for maintenance, a seal was seriously damaged when a primary pump was returned to service, which led to a primary coolant leak followed by an automatic reactor trip. The cause was sub-standard maintenance work. During the outage, the pump’s electric motor was replaced and an error was made when it was aligned with the pump. The seriousness of this misalignment did not produce any reaction from the technicians involved. The consequences were that considerable repair work was required, leading to a 10-day extension of the outage, with all the attendant disruption. This example of sub-standard work led to an action plan to improve technician skills.

**ENSURING ORGANISATIONAL EFFECTIVENESS**

**COMPLEX PROCESSES AND LEVERS FOR IMPROVEMENT THAT ARE POORLY EXPLOITED**

In France, the maintenance quality process is the responsibility of a fleet manager reporting to the production director. Fleet indicators are monitored monthly in the production indicator control room. Each site has its own control structure and assesses its own performance.

However, achieving good results also depends on those in other fields: nuclear safety, which controls and organises the human performance processes, technical inspections and requalifications; engineering for the maintenance programmes; industrial policy for contract partners; the Skills advisory centre for organisational effectiveness (PCCEO) for organising the maintenance professions.

In the UK, the quality delivery programme is based on the existing maintenance process and principally involves the maintenance teams, unit outage organisation, engineering and the supply chain. A set of indicators is updated each month. Site self-assessment has been implemented and comparisons are made with France and North America. The programme is based on quality at the workplace and in terms of supplier performance in the factory and in the field, as well as on the prioritisation of maintenance work in order to manage its volume.

There are similar levers in both fleets to prevent sub-standard maintenance work, such as training which includes just-in-time (JIT) courses. Insufficient use seems to be made of some levers:

- Human performance tools are inadequately implemented
- Technical task observations are still not stringent enough
- Inadequate work preparation by technicians
- The oversight of suppliers is insufficiently developed
- Prevention of the risk of foreign material (FME) in systems still needs to be improved
- Poor task debriefing and communication of operating experience to front-line workers (plant touchers).

The involvement of the independent nuclear safety teams (safety engineers in France and INA in the UK) in maintenance is encouraging. It does still, however, lack maintenance experience in France and should be strengthened.
RESPONSIBILITIES DILUTED IN FRANCE

The objective (to minimise sub-standard work) and the priorities (to develop managerial involvement and prepare the workers, not just the work) are clear. I believe them to be relevant.

In France, many individuals belonging to different parts of the organisation are called on to deliver actions designed to reduce sub-standard maintenance work, which makes cross-functional working complex and responsibilities unclear. The delivery of each action is not sufficiently focused on the objectives. It is the same with operational control (vertical), where having a large number of intermediate levels weakens the link with what is happening in the field. In both cases, I have noticed that messages become weaker, even disappear or are revised, before they have reached their target.

As a result, change is slow and the expected break with the past does not happen. I recommend greater clarification of the contributions and responsibilities of those involved: I will follow the progress in this area with interest in 2017.

TOO MANY COMPLEX TOOLS IN FRANCE

The standardisation of procedures and tools is very helpful for maintenance. It enables maintenance teams to make use of feedback on best practices, promoting high quality and efficiency. In addition, it makes things easier for contract partners who work on several sites by reducing their learning time.

I have seen a mixed picture in the field. On the one hand, there is the deployment of modern tools that are deemed to be satisfactory, such as MOSAIC, which displays unit outage milestones (digital portal developed by the DPN and EDF's R&D). On the other hand, there are many systems, often considered to be complex, which are not always interconnected and ultimately lead to dissatisfaction (see Chapter 6). There seem to be many reasons for this situation and I often hear the argument that the simultaneous deployment of too many tools means that the IT teams are unable to provide support.

This could also be the result of the desire to deploy tools quickly across all sites before the pilot has been fully validated for use in the field.

A slowness to react when updating maintenance procedures is often mentioned: it leads to work frequently being carried out using procedures that have still not been corrected. Comments often highlight the standardised plant series structure: here too, workarounds are put in place such as returning to old site specific procedures.

It is difficult at this stage for me to judge the extent of these phenomena, which look like the beginning of a move away from standardisation. In any case, I believe that standardisation is important for improving quality and efficiency.

Sub-standard maintenance on a feed water control valve

An automatic reactor trip occurred following the loss of the feed water supply to one of the boilers. The cause was linked to a fault on one of the system's valves, identified as being sensitive: single point vulnerability (SPV) which means that the failure of this equipment can immediately cause a reactor trip.

There had been a problem with the controller on this valve for some time, covered by a defect repair request. Due to lack of experience and an appropriate diagnostic or repair procedure, the source of the fault was not identified soon enough. What is more, no spare part was available onsite despite the potential urgency to rectify such a failure.

Since then, the procedure has been revised and training carried out.

RE-ASSERTING THE IMPORTANCE OF MAINTENANCE

TEAMS IN HIGH DEMAND, A PRIDE TO BE RESTORED

Against the backdrop of a heavy workload, the maintenance professions are in the spotlight.

In France, I met staff with sound technical skills, but some of them are still expressing concerns about the importance accorded to their work. I believe they need to regain a feeling of pride. This requires clarity from a corporate-level of the overall vision for maintenance, as well as increased presence in the field and leadership from managers (see Chapter 5). As these professions rely on a strong technical identity, it is also advisable to continue offering targeted training courses and on-job training which will increase staff confidence and pride.

In contrast, in the UK I met committed teams, who are proud of their profession. This feeling, based on strong technical skills, is enhanced by the recognition of their role in obtaining business results.
PUTTING THE MAINTENANCE TECHNICIANS AT THE CENTRE

The logistical support project for sites has produced good results in France, enabling workers to focus on technical maintenance skills to achieve better quality. I was particularly impressed with the role of the shared outage support teams (EMAT), both for the consistent way they communicate requirements to staff and contractors and for how they share good practices.

During my visits, I made a point of meeting contract partners and I appreciate their commitment, in particular to improving quality. Long-term relationships, based on transparency and trust, are very important. For example, the integration of contract partners in the Value and Efficiency teams helps to promote innovation on UK sites.

Contract partners are becoming involved earlier and earlier in the preparation of unit outages. This systematic practice in the UK is also developing in France. It helps to identify any difficulties and come up with solutions. The workers - not just the work - can therefore be geared up to succeed. This is a promising approach that puts the workers at the centre of the job (see Chapter 6). It should enable major progress to be made in maintenance quality by both staff and contract partners, and I encourage its continuation.

MY RECOMMENDATIONS

In France, many individuals from various departments are involved in reducing the amount of sub-standard maintenance work. I recommend that the director of the DPN clarify and control the various contributions.

In France, I encourage the director of the DPN to increase the status of the maintenance professions, in particular by means of a document setting out the vision for maintenance, currently being written.

To reduce the amount of sub-standard maintenance work, greater emphasis is currently placed on the preparation of the work than on the preparation of the workers. I recommend that the directors of the DPN and of EDF Energy also target actions on preparing workers, both those from EDF and from contract partners.

Long-term relationships with contract partners, based on transparency and trust, promote quality. I call for contract partners to be involved more, and as early as possible in work.
NUCLEAR FUEL

Handling a PWR fuel assembly

Nuclear fuel plays a key role in the three nuclear safety requirements: reactivity control, cooling and containment.

It is studied, researched and developed extensively, with the purpose of enhancing its performance, which is already at a good level.

Fuel-related phenomena are complex, which is reflected through fuel leaks, assembly bowing in France, and carbon deposition in the UK.

GOOD PERFORMANCE LEVELS

Nuclear fuel plays a significant role in safety. Its cladding forms the first barrier designed to contain the nuclear material. The management of fuel assembly bowing in PWRs and of AGR graphite core structure determines how well reactivity control rods can be inserted into the core.

IN FRANCE

In 2016, the nuclear safety performance was satisfactory for nuclear fuel.

As in 2015, a small number of fuel assemblies were found to be leaking, i.e. 9 out 8,305. Only six reactors were found to have fuel rod leaks (an average of 10 per year over a period of 20 years). These results are similar to those of the US fleet.

Fuel rod leak issues over the past years have mostly been caused by foreign material, in particular the friction springs of fuel rod support grids, which can break due to corrosion under stress and irradiation. Identified as early as 2008, this phenomenon only affects certain types of fuel assemblies. The manufacturing process has been reviewed after extensive investigation, and the transition to the new type of fuel that will be commissioned from 2018 will continue beyond 2020.

To make sure the control rod can drop freely and thus control the nuclear reaction during a reactor shutdown, fuel assembly bowing must remain limited. A working group comprising DPN, DCN, SEPTEN, and EDF R&D staff has worked extensively to explain this phenomenon which mainly affects the largest reactors with 4 loops (1300 MW and N4 reactors). Besides the impact of hydraulic
phenomena, the degree of bowing depends on the power history of the fuel assemblies and their resistance to creep under irradiation. Equipping fuel assemblies with alloy guide tubes to limit bowing has produced some very encouraging results, both with the Q12 by AREVA (tested in N4 reactors) and the ZIRLO model by Westinghouse (in use since 2006 in the 1300 MW reactors). The ZIRLO model has already been deployed, while the process is still underway for the Q12 and is expected to be completed around 2022.

I have also noted a drop in refuelling machine incidents for several years now. In 2016, though they were responsible for lost time in handling operations, none affected the safety of the fuel assemblies.

IN THE UK
There have been no fuel rod failures in the Sizewell PWR since 2008.

Carbon deposition is a generic phenomenon in AGRs known to cause high cladding temperatures and investigation over several decades has still not fully explained it. Such high temperatures deteriorate the mechanical characteristics of the material and cause recrystallisation, which leads to cladding embrittlement and finally failure. This mechanism is all the more rapid with reactor power variations that result in higher temperatures and temperature fluctuations. Examination of discharged fuel has confirmed the occurrence of these phenomena. In 2016, 20 out of about 40,000 elements in the AGRs were found to have leaks, 16 of which were from the same reactor.

The problem has been alleviated in this particular reactor by reducing its power by 10%. The early failures could have highlighted this problem, but insufficient understanding of the phenomenon and a lack of clearly defined responsibilities prevented a faster response.

As regards AGR fuel routes, efforts undertaken by EDF Energy to consolidate their reliability have helped drive the performance indicator up from 50% to 85% in ten years. I encourage all efforts to continue in this direction, with a special focus on obsolescence.

A NEED FOR EXPERIMENTAL FACILITIES
To design and qualify new fuels, their performance must be assessed, particularly with respect to pellet-cladding interactions which are important in a French fleet subjected to significant power variations. These assessments must investigate both normal and accident operating conditions. This involves irradiating fuel rods and recreating power variations outside the normal power transient envelopes. To do this, specific experimental tools are required.

The Osiris research reactor was used for such purposes until its shutdown in late 2015. I was able to visit its replacement, the Jules Horowitz reactor (see inset), which is currently under construction and will not be operational until 2022. The nuclear fuel sector has found a temporary solution in the Halden test reactor in Norway.

A similar issue will be faced when it comes to replacing the CEA laboratory for irradiated fuel studies called the LECA-STAR whose closure is programmed for around 2025.

Jules Horowitz Reactor (JHR)
This research reactor is currently being built at the CEA Cadarache centre. It will be used to test materials and fuels employed in both current and future reactors so as to check their behaviour under irradiation in normal and accident conditions. In practice, the high neutron flux generated by this reactor will be used to bombard representative test samples. It will be possible to subject these samples to extremely high temperatures and pressures if necessary. In this manner, the ageing process of the materials can be accelerated beyond their normal lifetime so they can be qualified for safe use.

This reactor will provide Europe with a one-of-a-kind tool, which will be available to the nuclear industry, research organisations and nuclear medicine, as well as to nuclear safety authorities and their technical support.

INTERIM STORAGE OF SPENT FUEL
In France, the spent fuel storage ponds are still filling up quickly, even though the situation has improved in the past few years. This filling rate is conditioned by the capacity of the plant in La Hague which reprocesses the spent fuel, and the MELOX facility at Marcoule which manufactures the mixed oxide (MOX) fuel assemblies with reprocessed plutonium.
The construction of a centralised storage pond for spent fuel is being investigated as an option for expanding this storage capacity to provide for the next hundred years. I would like to highlight the stringent safety requirements that such a facility will have to meet, in particular to take into account lessons learnt from the Fukushima accident. This storage pond could be commissioned by 2028-2030. It would provide extra operational and safety margins by taking the pressure off NPP storage ponds and the plant in La Hague. In the meantime, the programme to transfer spent fuel to La Hague must be pursued at the same pace, and I would like to commend the consolidation measures in place since 2015.

In the UK, the strategy is to use the fuel to its maximum in the AGRs in preparation for their programmed shutdown from 2023. This would make it possible to smooth out spent fuel transfers to the Sellafield nuclear site.

As for the dry spent fuel interim storage facility at Sizewell B (see inset), the first spent fuel elements will be delivered in specially designed containers in 2017. This facility will be operational pending the availability of a disposal facility.

COLLECTIVE EXPERTISE

IN FRANCE

During my visits, I meet many EDF stakeholders involved in nuclear fuel activities: the DCN, staff at the DPN, UNIE-GECC, CNPE, EDF R&D, SEPTEN, and CEIDRE, etc., and the fuel manufacturers. This diversity can be explained by the range of activities involved: design, manufacturing and oversight, safety during normal and accident conditions, procurement, operations, transport and recycling. The core-fuel directorate co-chaired by the DPN, DCN and DIPNN coordinates across the subject area and provides overall consistency.

The core-fuel discipline has a skills development plan in place which is being driven by SEPTEN. A “health check” is carried out every three years to assess, amongst others, the robustness of governance and the related skills. I look forward to reading the next report. Fuel activities are assessed every year in the plants on the basis of managerial guidelines (GM 496), with special focus on skills management. On its side, the DCN provides its staff with training, every year, in safety issues related to nuclear fuel.

Sizewell dry spent fuel interim storage facility

Power generation at the Sizewell B site started in 1995 and its spent fuel has since been stored in the fuel pond, which was not designed to store irradiated fuel for the plant’s full operational lifetime. The choice of a medium-term solution (up to 100 years) has centred on dry interim storage pending the availability of a final disposal site. The project started in 2009 and its construction in 2013. The fuel is stored in stainless steel containers, which are welded and placed in drums containing 120 tonnes of shielding and concrete. Construction of the buildings and tests with unirradiated fuel were completed in 2016. The first drums of irradiated fuel should be transferred within the first half of 2017.

I was given a presentation on the arrangements for the Design Authority (see Chapter 3) responsible for the independent safety oversight of design changes in this field. This authority is supported by Responsible designers from the DCN, DPN, SEPTEN and CEIDRE.

IN THE UK

Training has been deployed to cover the specific requirements of AGR fuels. A mentor guide is in place which specifies the basic activities that any nuclear fuel engineer must be able to perform. Experienced mentors have also been appointed to validate the acquisition and assimilation of knowledge in the field.

In 2016, I was given a presentation on the refuelling machine simulator set up at Dungeness in 2015. It is a simple yet practical training tool which could progressively be made available to staff on all AGR sites belonging EDF Energy.

MY RECOMMENDATION

Progress has been made in better understanding the phenomena causing fuel assembly bowing in France and fuel cladding failure in both France and the UK. I encourage the work to be continued in this field.
9 NEW BUILD

In France, the engineering departments are still undergoing changes as part of the process to merge the reactor businesses of AREVA and EDF.

A positive momentum is driving the Taishan and Flamanville 3 projects and their cooperation is strong.

The decision to invest in the Hinkley Point C project has strengthened the future of the British and French fleets.

New engineering methods are being deployed for the EPR NM project to overcome the hurdles ahead.

ORGANISATION OF THE DIPNN

In 2015, the Group reorganisation resulted in two new directorates: the Engineering & new-build projects directorate (DIPNN), and the Nuclear & conventional fleet directorate (DPNT). The DIPNN includes all the new-build project management and four engineering centres which have been assigned to these projects and to the fleet in service.

FINISHING TOUCHES TO BE MADE TO THE NEW ORGANISATION

The positive impact of this organisation is clearly visible, particularly for the management of new-build projects.

Now that the roles and responsibilities of each have been clearly defined, it has been possible to move ahead with formalising commitments and meeting deadlines.

In 2015, I drew attention to the changes in emphasis in engineering support: clarification of working methods, escalation, as well as the risk of distancing new-build engineering from the nuclear fleet with respect to technical standards and industrial policies. In 2016, I saw no decline in the involvement of the DIPNN departments in their activities for the NPPs. I will nonetheless be looking to see that this balance is preserved.
Mock-up built at CEIDRE-TEGG

Some methods of working remain to be finalised, such as the definition and organisation of discussions on how the fleet will evolve beyond the Fleet upgrade programme. The same applies to the relationship between the Design Authority (see Chapter 3) and the engineering functions. Furthermore, the aftermath of the reorganisation has not been completely absorbed in some business units and the teams still need to be supported through these changes.

THE DIPNN’S STRATEGIC PROJECT

The major works launched by the DIPNN as part of its strategic project are still ongoing, with each being sponsored by two members of the executive team:
- Our culture: results and opportunities
- Projects and professions: skills and industrial know-how
- Simplification and digitalisation
- An efficient, extended enterprise
- International success
- Nuclear energy: a choice for the future.

I value the way in which the managers and their teams are involved in developing and rolling out this project.

A PROMISING UNION WITH AREVA ENGINEERING

Pending the change in AREVA NP ownership, EDF and AREVA have appointed a number of officials to set up a joint subsidiary, presently called NICE (Nuclear Island Common Engineering). It will be controlled by EDF and will manage the engineering and construction of nuclear islands in France and internationally.

I would like to highlight the advantages of this merger for nuclear safety in the industry. By bringing together teams, there are fewer interfaces and processes can be rationalised. It should also make it easier to manage skills and share operating experience between projects.

In addition to the many opportunities, there are some issues worth mentioning:
- Bringing together existing projects (Flamanville 3, Hinkley Point C and the EPR NM) within NICE without affecting the current momentum
- Impact of this merger on the organisation of the DIPNN and its departments
- Internal oversight arrangements

- Support for the staff in question to help them through the changes.

In 2017, I will be closely monitoring the creation of this subsidiary because of its potential impact on nuclear safety.

PROGRESS OF EPRS IN CHINA AND FRANCE

SUSTAINED PACE AT TAISHAN 1 AND 2

This year again, significant progress has been made on the Taishan construction site. In 2016, a number of key milestones were achieved for unit 1: cold tests with the reactor vessel open, leaktight tests in the reactor building on which the General technical division (DTG) collaborated, and the start of functional tests. The second unit will follow closely behind and benefit from the experience accumulated.

I have seen visible progress in the general condition of the site: clean outside areas and buildings, tidiness of plant rooms, identification and separation of equipment being tested from the equipment being assembled. All these factors lead me to believe that the installation will be in a good general condition to start fuel loading operations.

Taishan NPP in China

The feedback from China General Nuclear power corporation (CGN), having commissioned several units per year, is proving extremely beneficial to the preparatory work and start-up tests, as is the support from about fifty EDF expatriates who are well integrated into the teams.

The operators have been working 8-hour shifts in the control room since December 2015, after having completed extensive training both on the simulator and on plants either starting up or already in service. After examination by a learned panel, they were granted an EPR licence by the Chinese nuclear safety authority.

The independent nuclear safety oversight organisation is still gathering momentum. The safety engineers have a solid background and are actively involved in the start-up tests. The Chief safety officer’s remit covers all areas of nuclear safety and quality, and he reports directly to the General Manager of the Taishan Nuclear Power Joint Venture Company (TNPJVC), a subsidiary of CGN (majority shareholder) and EDF (30%), who will operate the plant.
During my trip to Shenzhen, the management team at CGN gave me a presentation on the organisation being put in place for the fleet, which is based on principles similar to those of the independent nuclear safety oversight at EDF SA. This straightforward and promising approach is a reflection of the importance being given to nuclear safety.

**WANO crew performance observation (CPO)**

When experienced peers (one per operator) can observe the control room operations team during simulator training, both on an individual and collective basis, the team's capabilities can be assessed in depth.

I appreciate the open-mindedness of TNPJVC to international practices, such as those of the International Atomic Energy Agency (IAEA), in preparing for review by the pre-Operational Safety Review Team (OSART). The same holds true with WANO when it comes to adopting SOERs and carrying out CPOs (see inset), which the EDF SA expatriates and Flamanville 3 teams helped to prepare.

I note the site management's overall approach is to start up the plant based on a solid culture of openness and a commitment to nuclear safety, which the teams have embedded.

**ENCOURAGING DEVELOPMENTS AT FLAMANVILLE 3**

Despite the significant level of activity, the construction site's safety results continue to progress (see Chapter 4) mainly thanks to strong support from management.

After a lull in activities over summer, the pace of construction has picked up again. The effort must nonetheless be sustained, not least in helping some contractors better manage their sub-contractors or meet certain requirements, such as the regulations governing nuclear pressure equipment.

Plant testing is still in full swing. Once completed, the sequence of system tests will follow, including reactor vessel flushing in 2017. I wholeheartedly endorse the “OneTime” project to digitise test documents: using tablets which provide access to all procedures and where measurements can be recorded directly into the document while in the field and immediately shared for analysis. Standardisation, a single database, shared data, mobility and time savings are just a few of the advantages of this approach which consolidates the overall level of quality.

In 2016, I was shown several examples of better cooperation between construction site teams and operations staff, which are all grounds for satisfaction:

- Formation of a joint independent nuclear safety oversight team whose role during the test phase remains to be fully clarified
- Handover of the control room to the operator on 1 August 2016 as planned
- Increase in the number of seconded staff to help with testing
- Designation of a manager appointed jointly by the site and plant management to speed up the handover of systems for isolation then commissioning operation.

Design documentation is being delivered without any major issues, and the role of management has been strengthened in this field too. As in previous years, I would like to stress the importance of configuration management, from design through to operation, including assembly and testing. I note that this issue remains a top priority for the project.

As for the licensing process, the ASN is still examining the safety case to put the plant into service, aided by its technical support. With respect to the carbon segregation issue (see Chapter 1), there have been satisfactory results for the numerous tests performed on the reactor vessel. Furthermore, only one component manufactured in the AREVA plant in Le Creusot has thus far required a review to justify its fitness for service.

I can see that all those involved are still highly motivated. Focused on reaching the next milestones, open to innovation and international practices, and driven by the prevailing positive attitude, the project is set for success.
STRONG SYNERGY BETWEEN PROJECTS

I am pleased to see the teams at Flamanville 3 and Taishan pooling their experience and organising the secondment of staff on the basis of a win-win approach. This synergy is being driven through the support of sponsors and regular reporting. I encourage more managers to get involved in this positive development.

HINKLEY POINT C MOVES INTO CONSTRUCTION PHASE

Approval from the British government in September 2016 has made it possible to continue the project and push ahead with signing the main contracts. Driven by a subsidiary of EDF (66.5%) and CGN (33.5%) called Nuclear New Build (NNB), the British EPRs will provide the UK with low-carbon power, while bridging the gap for the EDF Group between Flamanville 3 and the renewal of the French nuclear fleet.

NEW CHALLENGES, NEW STRUCTURES

I was given a presentation on the project’s new organisation founded on three different command centres:

- The Engineering command centre (ECC) based in Montrouge is responsible for design and monitoring the manufacturing
- The Delivery command centre (DCC), which I was able to visit in Bristol, is responsible for project management, schedule management, contract management and support functions
- The Site command centre (SCC) based at Hinkley Point C is in charge of construction.

The ECC relies on four integrated multi-disciplinary teams for design that include staff from the DIPNN, NNB and the key contractors, all based at the same location. These teams are responsible for part of the design work: the conventional island buildings at CNEPE (EDF’s electromechanical & plant engineering support department), the nuclear island buildings at SOFINEL, process and I&C at CNEN (EDF’s nuclear engineering department), and monitoring of manufacturing activities at CEIDRE (EDF’s expertise and inspection department for manufacturing & operation).

I was able to meet some very motivated, resourceful people during my visit to the integrated team at CNEPE which has been in place since the summer of 2015. I was impressed by the effectiveness of this collaborative approach which enables the harmonisation of practices. The first objectives in terms of document production have been met to plan, with the delivery of 700 gallery construction drawings.

By getting the main contractors on board at an early stage, thanks to the ‘Early contractor involvement’ initiative, it has also been possible to align methods and clarify interfaces from early in the design.

SOME POINTS TO WATCH

Simplification is key to the success of the project. Despite the sizes and geographic distances separating the teams in France and the UK, I believe it is essential to continue simplifying the organisation and interfaces between players: NNB (particularly its Design Authority), the engineering departments and suppliers.

The reinforced harmonisation of methods and tools, system engineering (see inset), PLM, planning or document management, for instance, will also help improve the quality of design while boosting team solidarity and morale. The technical and organisational feedback from the other EPRs will provide invaluable support to the HPC project in all these areas.

In 2016, I observed that the assimilation of requirements specific to the British context remained a difficult task for the French teams, especially when drafting documents required by the ONR. In addition to the content and form of deliverables which need to be clarified and standardised, the cultural aspects of the British context appear to be key to understanding. The French teams will need to pay more heed to this dimension of the problem, which is new to them, not least by relying on SOFINEL’s experience in Bristol.

Such an approach could help them get a better grasp on the expectations of the Design Authority and the ONR, while fostering mutual trust.

EPR NM PROJECT: AN AMBITIOUS TARGET

The purpose of the project, led by EDF and AREVA, is to design a safe, competitive reactor with a view to replacing the French nuclear fleet and for export. A safety case was submitted in April 2016, which is currently being examined by the ASN. The project is providing the information needed to make the investment decision and to prepare the licensing application for future NPPs.

ENCOURAGING RESULTS

The project’s governance is already in place, involving monthly meetings by the steering committee co-chaired by the DIPNN Director and the CEO of AREVA NP. The DPN is represented by its Maintenance director.
The design phase is moving ahead, with good cooperation between the EDF and AREVA teams, as I was able to observe during my visit to their joint office.

**System engineering**

The purpose of this interdisciplinary approach - already prevalent in aerospace and aeronautics - is to better manage the requirements applicable to complex products. Once the breakdown into sub-products (e.g. buildings, systems or equipment) has been defined for the entire lifecycle, the RADIV process (V model) can be rolled out starting with the functional requirements:

- Formalisation of Requirements
- Definition of the Architecture
- Detailed Design
- Integration of components
- Verification of compliance with requirements.

Combined with the efficient management of large volumes of evolving data, system engineering helps to improve requirement traceability and configuration management, while providing the operator with consolidated data.

Following my remark in the 2015 report, I have since been informed of the greater operator involvement in the project through the secondment of three staff members. I would like to stress the importance of the operator's role in achieving satisfactory operability of future reactors.

The three enablers to reduce the cost and construction duration were explained to me. They work in favour of nuclear safety and are: integration of supplier issues from the preliminary design phase, improvement of engineering effectiveness, and simplification of design compared with the EPR. For instance, system engineering and PLM will improve the quality and traceability of designs. Though already in place at the project office, they continue to be deployed in the other groups involved.

**SOME POINTS TO WATCH**

The impact of new methods and tools on the teams must not be underestimated. When they are rolled out, it is important that all those involved are using them in a consistent manner.

I have also been told of some issues with skills in the engineering teams. They are finding it difficult to meet the growing demands of the EPR NM, as they are committed to various other projects. In this context of uncertainty, it is also a concern to be able to maintain the skills coming from AREVA NP.

Fixing the nuclear safety standards, as recommended by the French High commissioner for atomic energy in his strategic review in late 2015, is yet another key aspect to succeeding with the EPR NM project. Even though the project does not have control over all the influencing factors, such as the ASN’s schedule for examining the safety case, it is important to advance with care.

More generally, the technical, economic and planning targets are ambitious, which needs rigorous management and anticipation of the risks ahead.

**MY RECOMMENDATIONS**

The organisation at Hinkley Point C is now establishing itself. I recommend that the DIPNN and NNB directors continue with their process of optimisation, making sure to further simplify decision-making, work methods and interfaces.

Regarding the existing British nuclear fleet, EDF Energy and the ONR have built up strong relations based on trust which are favourable to nuclear safety. The HPC project has now embarked on a new phase. I invite the NNB Director to build relations with the ONR which are appropriate for this new phase and consistent with those of the operational fleet.

New engineering methods are currently being rolled out to secure the success of the EPR NM project. The DIPNN director will need to make sure that all contributing groups are using them in a consistent manner.
Nuclear safety and protection against site security threats are closely linked, particularly in cultural approach.

Protecting facilities against security threats such as cyber-attacks implies an adaptive and responsive approach.

This area is a constant concern for EDF and has been the focus of many advances over recent years.

In France, the Nuclear Safety and Transparency Act of 13 June 2006 states that nuclear security involves: nuclear safety, radiation protection, the prevention of malicious acts and measures to combat them, and measures to protect the public in the event of an accident. In the UK, protection against malicious capabilities is governed by the Nuclear industries security regulations (NISR) 2003 passed under the Anti-terrorism, Crime and Security Act 2003 to combat the threat of terrorism and sabotage.

The issue of site security, whilst not specific to nuclear installations, is nevertheless particularly important in the nuclear industry because of the potential impact of malicious acts on nuclear safety. This essentially is the rationale behind this chapter. It provides an overview of this constantly evolving area of concern, not mentioned in previous reports in spite of my interest in security matters on all my site visits.

Given the confidential nature of this subject area, certain aspects will obviously not be covered.

A STRUCTURED ORGANISATION

CORPORATE SERVICES

In France, the organisation is structured into two levels:

- The security executive - responsible for civil security and reporting directly to the CEO of EDF - which proposes measures to combat the threat of malicious acts and incorporates an information security executive responsible for cyber-security
• At the DPN, the security group - charged with the physical protection of nuclear sites - and a team for coordinating cyber-security actions, both of which report to the nuclear safety organisation.

Governance is assured by the industrial security committee for thermal or nuclear power operators (CSIPNT) in France. It is complemented by a committee which supervises the roll-out of modifications required and, in the DPN, by a nuclear information security committee.

In the UK, administration at corporate level is centred on a security department responsible for the operational aspects, including cyber-security. Governance is assured by the Security programme board which provides challenge in the area and aims to align it with the structure and principles employed for nuclear safety. The site security function is also represented in the Safety operational delivery teams (SODTs).

The DPN’s security office is responsible for updating the substantial volume of internal standards in line with frequent legislative changes. It has strengthened its support to the sites and receives input from the specific engineering departments (CNEPE, DIPE, SEPTEN) in charge of equipment modifications and cyber-security. I am well aware of the heavy commitment involved in breaking down the organisational silos and striving to embed a culture of site security across the fleet. I have also seen the same dynamism and willingness to embrace cyber-security throughout the entire organisation, illustrated by the creation of a post in each site’s independent nuclear safety team dedicated to information security.

On the British side, I visited EDF Energy’s security department and found a high level of commitment in evidence, not only from managers but also from support staff responsible for protection strategies, which are already firmly integrated in existing processes.

In France, I was informed about the balanced and constructive relationship with the inspection authorities, namely:

• The departments attached to the senior defence official for the Ministry of the Environment, Energy and Marine Affairs, responsible for inspecting physical protection

In the UK, my meeting with the ONR - which carries out both of these types of inspection - and my plant visits, have helped me appreciate just how much consideration is given to this issue and the quality of discussions with the operator.

**AT SITE LEVEL**

In France and the UK alike, sound progress has been made in all departments responsible for site security. Recruitment and training have been reinforced. There is a very close working relationship with the security organisations. All plants are currently undergoing a programme of modifications adapted to each site to further improve defence in depth. Training exercises and drills are conducted based on increasingly complex scenarios. Governance is also improving, including in matters of cyber-security.

Civil nuclear facilities are protected by dedicated security units - the specialist armed police force (PSPG) in France and the Civil Nuclear Constabulary (CNC) in the UK. These units specialise in high-intensity conflict, especially counter-terrorism interventions. As an integral part of the national response to the threat of terrorism, they are trained using the most up-to-date methods tailored to the nuclear industry. These special forces are well integrated at plant level, where their excellent knowledge of sites and personnel alike underpins their effectiveness.

**SIGNIFICANT DEVELOPMENTS**

The threat is continual and rapidly evolving. It feeds off the current geopolitical and social situation, and exploits the latest technological developments (utilising drones for example). This calls for a greater level of responsiveness and preparedness to adapt as the threats evolve.

**BACKGROUND**

The aircraft hijackings and September 11 attacks in New York in 2001; the bomb attacks in Madrid (March 2004) and London (July 2005); the shootings in Paris (January and November 2015); the three attacks in Brussels (March 2016); the truck attacks in Nice (July 2016) and Berlin (December 2016): all these events underline the gravity and diversity of this threat.

Cyber-crime - although a quite different form of threat - is also on the rise as a result of our increasingly digital society, dominated by computers, smartphones, networks, USB flash drives and the like.

**REFORMING LEGISLATION**

In France, nuclear facilities have been protected from the outset against various threat scenarios (under the terms of the 1959 Order). Legislation has evolved and a considerable amount of work has been undertaken recently to reform and clarify these texts. EDF SA, AREVA and the CEA, to name but a few, have been involved in this work which incorporates international opinions, particularly from the IAEA. The Defence Code has subsequently been reworked and the provisions of the Vigipirate plan (France’s national security alert
system) have been reinforced (2005). The nuclear sector is covered in the French National Security Directive (DNS August 2009), which defines objectives and scenarios and stipulates the associated facility protection measures. Similar work has also been carried out in the protection of radioactive materials. The legal framework has been enhanced by the creation of a specific offence relating to breaching restricted access areas on nuclear sites.

In terms of cyber-security, the 2014-2019 Military Programme Act incorporated into the Defence Code has laid down requirements. The civil nuclear industry is covered in a civil nuclear energy ministerial order which introduces the notion of critically important information systems and defines the rules associated with establishing and maintaining such a system.

In the UK, the Energy Act 2004 was closely followed by the Serious Organised Crime and Police Act 2005 and the Terrorism Act 2006. These are all covered in detail in a document published by the ONR entitled the ‘Nuclear Industries Malicious Capabilities Planning Assumptions’ or NIMCA, which describes the types of attack a civil nuclear facility’s security measures should be capable of defeating. It provides a common basis for determining the industry’s nuclear security needs. Several policies and standards apply to cyber-security, including the Government’s national security policy, ONR guidelines and requirements and the ISO 27000 standard best practice recommendations.

TRANSFORMATIONS WITHIN EDF

All these external developments are reflected in what has happened internally in EDF.

The main actions implemented at the French plants include the introduction of a specialist armed police force in 2007, the strengthening of site protection resources and competencies, and the launch of an extensive modification programme. A specific governance framework has been established to tackle cyber-security and the relevant competences and human and material resources have been strengthened. All these actions should be actively sustained.

In the UK, these developments are reflected in the increasing presence of CNC officers on nuclear installations (the first armed officers commenced duties in 2004) and the implementation of a modification programme. Cyber-security governance has been reinforced, such as through the introduction of a Senior information risk owner (SIRO), who holds EDF Energy to account on matters of information security. Particular attention is being paid to reporting and closing of any gaps.

A CULTURE OF PROTECTION TO BE SHARED BY ALL

Even if some functions have greater responsibility for site security, I believe that - just like nuclear safety - it is everyone’s concern.

LEARNING FROM THE NUCLEAR SAFETY CULTURE MODEL

I have noticed during my plant visits, and at corporate level too, that even though progress has been made in this area, protection against malicious acts still remains the domain of specialists, especially in France. Although efforts have been made to model the structure on that of the nuclear safety culture, there is still much more that can be done, starting with the creation of an independent inspection team. In the UK, a similar desire to align protection against malicious acts with the approach to nuclear safety means that the Independent Nuclear Assurance (INA) is now charged with conducting independent inspections.

Plant modifications can have an impact on site protection systems, such as security fencing or video surveillance cameras. I am pleased to report that greater consideration has been afforded to the potential consequences of these modifications, although there is still room for improvement.

All these organisational developments need to be accompanied by a change in behaviour, whereby nuclear safety culture principles are adopted globally: a questioning attitude towards abnormal actions or events should be cultivated; procedures for summoning the security services similar to those already in place for the emergency services must be tightened; and there needs to be greater consideration of information protection principles (correct use of USB flash drives, etc.). This cultural shift requires security to become inherent in corporate culture; to be integrated into training and refresher courses and defect repair processes; to be as embedded as nuclear safety is through the management chain and out into the field; and that it is backed up by regular communications.

CONDUCTING EXERCISES

I have witnessed various security exercises, some of which have been carried out in conjunction with nuclear safety exercises. These are an occasion for staff to gain a greater
understanding of the importance of site protection and to learn how to integrate security threat awareness into normal business.

These practical training exercises help improve leadership culture in matters of protection against malicious acts. They also offer the opportunity to consolidate links between nuclear plants and the public authorities in preparing the emergency response to this type of situation.

**STRENGTHENING TIES**

I was updated on the meeting on cyber-security which took place between EDF SA and EDF Energy at Civaux. This pooling of ideas should be extended throughout the entire organisation responsible for site security, including the protection forces which operate in a similar manner.

I am keen for this type of exchange to be developed further to take advantage of experience from other countries and to ensure greater capability in anticipating the risks.

**MY RECOMMENDATIONS**

A significant amount of work has been carried out in recent years to protect against malicious acts and long may this continue.

I strongly support the continued development of a culture of site protection modelled on that of the nuclear safety culture and urge, in France, the consideration of an independent inspection team.
APPENDICES

RESULTS FOR THE NUCLEAR FleETS
  EDF SA
  EDF ENERGY

THE NUCLEAR SITES
  EDF SA
  EDF ENERGY

KEY DATES FOR THE NUCLEAR UNITS
  EDF SA
  EDF ENERGY

ABBREVIATIONS
## RESULTS FOR THE EDF SA FLEET

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Number of significant nuclear safety events graded 1 or greater on INES per reactor&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0,80</td>
<td>1,15</td>
<td>1,17</td>
<td>1,17</td>
<td>0,91</td>
<td>1,55</td>
<td>1,19</td>
<td>1,14</td>
<td>1,16</td>
<td>0,98</td>
</tr>
<tr>
<td>2</td>
<td>Number of significant nuclear safety events (0 or greater on INES), per reactor&lt;sup&gt;1&lt;/sup&gt;</td>
<td>10,80</td>
<td>10,34</td>
<td>10,93</td>
<td>10,45</td>
<td>10,57</td>
<td>11,90</td>
<td>11,60</td>
<td>10,8</td>
<td>10,03</td>
<td>9,78</td>
</tr>
<tr>
<td>3</td>
<td>Number of cases of non-compliance with technical specifications, per reactor</td>
<td>1,70</td>
<td>1,70</td>
<td>1,39</td>
<td>1,55</td>
<td>1,36</td>
<td>1,52</td>
<td>1,34</td>
<td>1,55</td>
<td>1,24</td>
<td>1,48</td>
</tr>
<tr>
<td>4</td>
<td>Number of alignment errors&lt;sup&gt;2&lt;/sup&gt; per reactor</td>
<td>0,57</td>
<td>0,62</td>
<td>0,53</td>
<td>0,77</td>
<td>0,71</td>
<td>0,70</td>
<td>0,66</td>
<td>0,60</td>
<td>1,03</td>
<td>1,04</td>
</tr>
<tr>
<td>5</td>
<td>Number of trips per reactor (for 7,000 hours of criticality&lt;sup&gt;3&lt;/sup&gt;)</td>
<td>0,87</td>
<td>0,51</td>
<td>0,71</td>
<td>0,69</td>
<td>0,56</td>
<td>0,67</td>
<td>0,79</td>
<td>0,71</td>
<td>0,76</td>
<td>0,76</td>
</tr>
<tr>
<td></td>
<td>• Automatic</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>• Manual</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>Average operational collective dose, per nuclear unit in service (in man-Sv)</td>
<td>0,63</td>
<td>0,66</td>
<td>0,69</td>
<td>0,69</td>
<td>0,71</td>
<td>0,71</td>
<td>0,79</td>
<td>0,72</td>
<td>0,71</td>
<td>0,76</td>
</tr>
<tr>
<td>7</td>
<td>Exposure of individuals:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Number of individuals with doses above 20 mSv</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>• Number of individuals with doses between 16 and 20 mSv</td>
<td>20</td>
<td>14</td>
<td>10</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>• Number of individuals with doses between 14 and 16 mSv</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>60</td>
<td>43</td>
<td>22</td>
<td>18</td>
<td>5</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Number of significant radiation protection events</td>
<td>99</td>
<td>107</td>
<td>102</td>
<td>91</td>
<td>92</td>
<td>114</td>
<td>116</td>
<td>113</td>
<td>109</td>
<td>117</td>
</tr>
<tr>
<td>9</td>
<td>Availability (%)</td>
<td>80,2</td>
<td>79,2</td>
<td>78,0</td>
<td>78,5</td>
<td>80,7</td>
<td>79,7</td>
<td>78,0</td>
<td>80,9</td>
<td>80,76</td>
<td>79,6</td>
</tr>
<tr>
<td>10</td>
<td>Unplanned unavailability (%)</td>
<td>3,7</td>
<td>4,4</td>
<td>4,6</td>
<td>5,2</td>
<td>2,2</td>
<td>2,8</td>
<td>2,6</td>
<td>2,4</td>
<td>2,48</td>
<td>2,02</td>
</tr>
<tr>
<td>11</td>
<td>Occupational accident rate with sick leave (per million hours worked)&lt;sup&gt;4&lt;/sup&gt;</td>
<td>4,6</td>
<td>4,4</td>
<td>4,3</td>
<td>4,1</td>
<td>3,9</td>
<td>3,5</td>
<td>3,3</td>
<td>3,2</td>
<td>2,7</td>
<td>2,8</td>
</tr>
</tbody>
</table>

---

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

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Number of events ranked 1 or higher on INES, per reactor</td>
<td>1.20</td>
<td>1.13</td>
<td>0.80</td>
<td>0.93</td>
<td>1.33</td>
<td>0.80</td>
<td>0.80</td>
<td>0.33</td>
<td>0.47</td>
<td>0.27</td>
</tr>
<tr>
<td>2</td>
<td>Number of nuclear safety events ranked 0 or higher on INES, per reactor</td>
<td>4.93</td>
<td>4.53</td>
<td>5.47</td>
<td>5.60</td>
<td>4.7</td>
<td>4.6</td>
<td>5.1</td>
<td>4.5</td>
<td>7.40</td>
<td>9.6</td>
</tr>
<tr>
<td>3</td>
<td>Number of cases of non-compliance with technical specifications, per reactor</td>
<td>0.13</td>
<td>0.27</td>
<td>0.13</td>
<td>0.60</td>
<td>0.33</td>
<td>1.67</td>
<td>0.67</td>
<td>1.53</td>
<td>1.00</td>
<td>0.80</td>
</tr>
<tr>
<td>4</td>
<td>Number of alignment errors, per reactor</td>
<td>0.13</td>
<td>0.27</td>
<td>0.13</td>
<td>0.60</td>
<td>0.33</td>
<td>3.07</td>
<td>3.33</td>
<td>2.80</td>
<td>2.87</td>
<td>3.07</td>
</tr>
<tr>
<td>5</td>
<td>Number of unscheduled trips, per reactor (for 7,000 hours of criticality)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Automatic</td>
<td>0.44</td>
<td>1.13</td>
<td>0.82</td>
<td>0.58</td>
<td>0.74</td>
<td>0.64</td>
<td>0.45</td>
<td>1.17</td>
<td>0.57</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>• Manual</td>
<td>1.48</td>
<td>1.04</td>
<td>1.44</td>
<td>1.68</td>
<td>1.22</td>
<td>0.84</td>
<td>1.03</td>
<td>0.62</td>
<td>0.19</td>
<td>0.42</td>
</tr>
<tr>
<td>6</td>
<td>Average collective dose, per unit in service (in mSv)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PWR</td>
<td>0.045</td>
<td>0.037</td>
<td>0.377</td>
<td>0.537</td>
<td>0.037</td>
<td>0.386</td>
<td>0.365</td>
<td>0.048</td>
<td>0.544</td>
<td>0.544</td>
</tr>
<tr>
<td></td>
<td>• AGR</td>
<td>0.071</td>
<td>0.063</td>
<td>0.018</td>
<td>0.084</td>
<td>0.063</td>
<td>0.034</td>
<td>0.075</td>
<td>0.067</td>
<td>0.021</td>
<td>0.021</td>
</tr>
<tr>
<td>7</td>
<td>Exposure of individuals:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Number of individuals with doses above 20 mSv</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>• Number of individuals with doses above 15 mSv</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>Number of significant radiation protection events</td>
<td>58</td>
<td>38</td>
<td>31</td>
<td>43</td>
<td>43</td>
<td>50</td>
<td>27</td>
<td>27</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>9</td>
<td>Availability (%):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• EDF Energy fleet</td>
<td>62.8</td>
<td>51.2</td>
<td>71.0</td>
<td>65.7</td>
<td>72.0</td>
<td>78.0</td>
<td>78.9</td>
<td>72.1</td>
<td>77.30</td>
<td>83.0</td>
</tr>
<tr>
<td></td>
<td>• PWR</td>
<td>98.4</td>
<td>89.2</td>
<td>87.4</td>
<td>45.6</td>
<td>82.5</td>
<td>89.2</td>
<td>83.0</td>
<td>84.1</td>
<td>100</td>
<td>82.0</td>
</tr>
<tr>
<td></td>
<td>• AGR</td>
<td>60.2</td>
<td>48.5</td>
<td>69.8</td>
<td>67.1</td>
<td>71.3</td>
<td>76.3</td>
<td>78.2</td>
<td>70.2</td>
<td>73.7</td>
<td>83.1</td>
</tr>
<tr>
<td>10</td>
<td>Unplanned inoperability (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• EDF Energy fleet</td>
<td>20.3</td>
<td>20.4</td>
<td>13.2</td>
<td>19.6</td>
<td>13.0</td>
<td>8.9</td>
<td>6.9</td>
<td>10.7</td>
<td>2.3</td>
<td>5.1</td>
</tr>
<tr>
<td></td>
<td>• PWR</td>
<td>0.4</td>
<td>2.1</td>
<td>0.9</td>
<td>54.3</td>
<td>3.4</td>
<td>9.9</td>
<td>0.2</td>
<td>0.7</td>
<td>0</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>• AGR</td>
<td>21.7</td>
<td>21.8</td>
<td>14.0</td>
<td>17.1</td>
<td>13.7</td>
<td>8.7</td>
<td>7.9</td>
<td>12.3</td>
<td>2.7</td>
<td>5.8</td>
</tr>
<tr>
<td>11</td>
<td>Occupational accident rate with sick leave (per million hours worked) 1</td>
<td>1.4</td>
<td>1.8</td>
<td>0.6</td>
<td>0.4</td>
<td>0.6</td>
<td>0.5</td>
<td>0.2</td>
<td>0.2</td>
<td>0.4</td>
<td>0.3</td>
</tr>
</tbody>
</table>

1 Accident rate for EDF Energy 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)
EDF ENERGY NUCLEAR SITES

**Number of reactor per type**

<table>
<thead>
<tr>
<th></th>
<th>AGR</th>
<th>PWR</th>
<th>EPR</th>
<th>Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction/Project</td>
<td></td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Operation</td>
<td>14</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering Centre</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

AGR: Advanced Gas cooled Reactor  
PWR: Pressurised Water Reactor  
EPR: European Pressurised Reactor
### KEY DATES FOR EACH OF THE EDF SA NUCLEAR UNITS

<table>
<thead>
<tr>
<th>Year commissioned</th>
<th>Nuclear Unit</th>
<th>Power in MWe*</th>
<th>VD1</th>
<th>VD2</th>
<th>VD3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979</td>
<td>Bugey 4</td>
<td>880</td>
<td>1990</td>
<td>2001</td>
<td>2011</td>
</tr>
<tr>
<td>1979</td>
<td>Bugey 5</td>
<td>880</td>
<td>1991</td>
<td>2001</td>
<td>2011</td>
</tr>
<tr>
<td>1983</td>
<td>Cruas 1</td>
<td>915</td>
<td>1995</td>
<td>2005</td>
<td>2015</td>
</tr>
<tr>
<td>1984</td>
<td>Crus 2</td>
<td>915</td>
<td>1997</td>
<td>2007</td>
<td>-</td>
</tr>
<tr>
<td>1985</td>
<td>Flamanville 1</td>
<td>1330</td>
<td>1997</td>
<td>2008</td>
<td>-</td>
</tr>
<tr>
<td>1985</td>
<td>Flamanville 2</td>
<td>1330</td>
<td>1997</td>
<td>2008</td>
<td>-</td>
</tr>
<tr>
<td>1985</td>
<td>Gravelines 6</td>
<td>910</td>
<td>1997</td>
<td>2007</td>
<td>-</td>
</tr>
<tr>
<td>1985</td>
<td>Gravelines 7</td>
<td>910</td>
<td>1997</td>
<td>2007</td>
<td>-</td>
</tr>
<tr>
<td>1986</td>
<td>Chinon B3</td>
<td>905</td>
<td>1999</td>
<td>2009</td>
<td>-</td>
</tr>
<tr>
<td>1986</td>
<td>Chinon B4</td>
<td>905</td>
<td>2000</td>
<td>2010</td>
<td>-</td>
</tr>
<tr>
<td>1986</td>
<td>Flamanville 2</td>
<td>1330</td>
<td>1998</td>
<td>2008</td>
<td>-</td>
</tr>
<tr>
<td>1986</td>
<td>Paluel 4</td>
<td>1330</td>
<td>1998</td>
<td>2008</td>
<td>-</td>
</tr>
<tr>
<td>1986</td>
<td>St-Alban 1</td>
<td>1335</td>
<td>1998</td>
<td>2008</td>
<td>-</td>
</tr>
<tr>
<td>1986</td>
<td>St-Alban 2</td>
<td>1335</td>
<td>1998</td>
<td>2008</td>
<td>-</td>
</tr>
<tr>
<td>1987</td>
<td>Belleville 1</td>
<td>1310</td>
<td>1999</td>
<td>2010</td>
<td>-</td>
</tr>
<tr>
<td>1988</td>
<td>Bellives 2</td>
<td>1310</td>
<td>1999</td>
<td>2009</td>
<td>-</td>
</tr>
<tr>
<td>1988</td>
<td>Nogent 2</td>
<td>1310</td>
<td>1999</td>
<td>2010</td>
<td>-</td>
</tr>
<tr>
<td>1990</td>
<td>Cattenom 3</td>
<td>1300</td>
<td>2001</td>
<td>2011</td>
<td>-</td>
</tr>
<tr>
<td>1990</td>
<td>Golfech 1</td>
<td>1310</td>
<td>2001</td>
<td>2012</td>
<td>-</td>
</tr>
<tr>
<td>1991</td>
<td>Cattenom 4</td>
<td>1300</td>
<td>2003</td>
<td>2013</td>
<td>-</td>
</tr>
<tr>
<td>1992</td>
<td>Penly 2</td>
<td>1330</td>
<td>2004</td>
<td>2014</td>
<td>-</td>
</tr>
<tr>
<td>1993</td>
<td>Golfech 2</td>
<td>1310</td>
<td>2004</td>
<td>2014</td>
<td>-</td>
</tr>
<tr>
<td>1996</td>
<td>Chooz B1</td>
<td>1500</td>
<td>2010</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1997</td>
<td>Chooz B2</td>
<td>1500</td>
<td>2009</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1997</td>
<td>Civaux 1</td>
<td>1495</td>
<td>2011</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1999</td>
<td>Civaux 2</td>
<td>1495</td>
<td>2012</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**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

<table>
<thead>
<tr>
<th>Year commissioned service</th>
<th>Nuclear Unit</th>
<th>Reactor Number</th>
<th>Power MWe RUP (1)</th>
<th>Planned date of withdrawal from service (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976</td>
<td>Hinkley Point B</td>
<td>R3</td>
<td>480</td>
<td>2023</td>
</tr>
<tr>
<td>1976</td>
<td>Hinkley Point B</td>
<td>R4</td>
<td>475</td>
<td>2023</td>
</tr>
<tr>
<td>1976</td>
<td>Hunterston B</td>
<td>R3</td>
<td>480</td>
<td>2023</td>
</tr>
<tr>
<td>1976</td>
<td>Hunterston B</td>
<td>R4</td>
<td>485</td>
<td>2023</td>
</tr>
<tr>
<td>1983</td>
<td>Dungeness B</td>
<td>R21</td>
<td>525</td>
<td>2028</td>
</tr>
<tr>
<td>1983</td>
<td>Dungeness B</td>
<td>R22</td>
<td>525</td>
<td>2028</td>
</tr>
<tr>
<td>1983</td>
<td>Heysham 1</td>
<td>R1</td>
<td>580</td>
<td>2024</td>
</tr>
<tr>
<td>1983</td>
<td>Heysham 1</td>
<td>R2</td>
<td>575</td>
<td>2024</td>
</tr>
<tr>
<td>1983</td>
<td>Hartlepool</td>
<td>R1</td>
<td>595</td>
<td>2024</td>
</tr>
<tr>
<td>1983</td>
<td>Hartlepool</td>
<td>R2</td>
<td>585</td>
<td>2024</td>
</tr>
<tr>
<td>1988</td>
<td>Heysham 2</td>
<td>R7</td>
<td>615</td>
<td>2030</td>
</tr>
<tr>
<td>1988</td>
<td>Heysham 2</td>
<td>R8</td>
<td>615</td>
<td>2030</td>
</tr>
<tr>
<td>1988</td>
<td>Torness</td>
<td>R1</td>
<td>590</td>
<td>2030</td>
</tr>
<tr>
<td>1988</td>
<td>Torness</td>
<td>R2</td>
<td>595</td>
<td>2030</td>
</tr>
<tr>
<td>1995</td>
<td>Sizewell B</td>
<td></td>
<td>1198</td>
<td>2035</td>
</tr>
</tbody>
</table>

(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.
## ABBREVIATIONS

### A

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGR</td>
<td>Advanced Gas-cooled Reactor</td>
</tr>
<tr>
<td>ALARA</td>
<td>As Low As Reasonably Achievable</td>
</tr>
<tr>
<td>AMELIE</td>
<td>DPN project to transform the logistics of spare parts</td>
</tr>
<tr>
<td>AMT</td>
<td>EDF fleet maintenance agency</td>
</tr>
<tr>
<td>ANDRA</td>
<td>French National Radioactive Waste Management Agency</td>
</tr>
<tr>
<td>ASG</td>
<td>Steam generator auxiliary feedwater supply</td>
</tr>
<tr>
<td>ASN</td>
<td>French Nuclear Safety Authority</td>
</tr>
<tr>
<td>BMA</td>
<td>Standardised activity model library</td>
</tr>
<tr>
<td>BWR</td>
<td>Boiling water reactor</td>
</tr>
<tr>
<td>CAP</td>
<td>Annual performance contract</td>
</tr>
<tr>
<td>CEFRI</td>
<td>French committee for the certification of companies in training and monitoring radiation workers</td>
</tr>
<tr>
<td>CEIDRE</td>
<td>Expertise and inspection department for manufacturing and operation</td>
</tr>
<tr>
<td>CENG</td>
<td>Constellation Energy Nuclear Group (US)</td>
</tr>
<tr>
<td>CETIC</td>
<td>PWR NSSS fieldwork technical validation experimental centre</td>
</tr>
<tr>
<td>CGN</td>
<td>China General Nuclear Power Corporation</td>
</tr>
<tr>
<td>CLI</td>
<td>Local information commission</td>
</tr>
<tr>
<td>CNC</td>
<td>Civil Nuclear Constabulary</td>
</tr>
<tr>
<td>CNEN</td>
<td>Nuclear engineering department</td>
</tr>
<tr>
<td>CNEPE</td>
<td>Electromechanical &amp; plant engineering support department</td>
</tr>
<tr>
<td>COLIMO</td>
<td>A DPN project to modernise isolation and alignment practices and methods</td>
</tr>
<tr>
<td>COMSAT</td>
<td>Unit outage safety commission</td>
</tr>
<tr>
<td>COPAT</td>
<td>Unit outage operational control committee</td>
</tr>
<tr>
<td>CSN</td>
<td>Council for Nuclear Safety</td>
</tr>
<tr>
<td>CSNE</td>
<td>DPN nuclear safety review committee</td>
</tr>
</tbody>
</table>

### B

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMA</td>
<td>Standardised activity model library</td>
</tr>
<tr>
<td>BWR</td>
<td>Boiling water reactor</td>
</tr>
</tbody>
</table>

### C

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAP</td>
<td>Annual performance contract</td>
</tr>
<tr>
<td>CEFRI</td>
<td>French committee for the certification of companies in training and monitoring radiation workers</td>
</tr>
<tr>
<td>CEIDRE</td>
<td>Expertise and inspection department for manufacturing and operation</td>
</tr>
<tr>
<td>CENG</td>
<td>Constellation Energy Nuclear Group (US)</td>
</tr>
<tr>
<td>CETIC</td>
<td>PWR NSSS fieldwork technical validation experimental centre</td>
</tr>
<tr>
<td>CGN</td>
<td>China General Nuclear Power Corporation</td>
</tr>
<tr>
<td>CLI</td>
<td>Local information commission</td>
</tr>
<tr>
<td>CNC</td>
<td>Civil Nuclear Constabulary</td>
</tr>
<tr>
<td>CNEN</td>
<td>Nuclear engineering department</td>
</tr>
<tr>
<td>CNEPE</td>
<td>Electromechanical &amp; plant engineering support department</td>
</tr>
<tr>
<td>COLIMO</td>
<td>A DPN project to modernise isolation and alignment practices and methods</td>
</tr>
<tr>
<td>COMSAT</td>
<td>Unit outage safety commission</td>
</tr>
<tr>
<td>COPAT</td>
<td>Unit outage operational control committee</td>
</tr>
<tr>
<td>CSN</td>
<td>Council for Nuclear Safety</td>
</tr>
<tr>
<td>CSNE</td>
<td>DPN nuclear safety review committee</td>
</tr>
</tbody>
</table>

### D

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAIP</td>
<td>Industrial support for production division</td>
</tr>
<tr>
<td>DCN</td>
<td>Nuclear fuel division</td>
</tr>
<tr>
<td>DIPDE</td>
<td>Nuclear fleet engineering, decommissioning &amp; environment division</td>
</tr>
<tr>
<td>DIPNN</td>
<td>Engineering &amp; new-build projects directorate</td>
</tr>
<tr>
<td>DMES</td>
<td>Commissioning documentation</td>
</tr>
<tr>
<td>DOE</td>
<td>Department Of Energy (US)</td>
</tr>
<tr>
<td>DP2D</td>
<td>Decommissioning &amp; waste directorate</td>
</tr>
<tr>
<td>DPN</td>
<td>Nuclear generation division</td>
</tr>
<tr>
<td>DPNT</td>
<td>Nuclear &amp; conventional fleet directorate</td>
</tr>
<tr>
<td>DRS</td>
<td>Nuclear safety standards directorate</td>
</tr>
<tr>
<td>DTG</td>
<td>General technical department</td>
</tr>
</tbody>
</table>

### E

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EIPS</td>
<td>Equipment protected for nuclear safety reasons</td>
</tr>
<tr>
<td>EGE</td>
<td>Overall nuclear safety assessment</td>
</tr>
<tr>
<td>EDT</td>
<td>Dedicated field team</td>
</tr>
<tr>
<td>EMAT</td>
<td>Shared teams providing support during unit outages</td>
</tr>
<tr>
<td>ENISS</td>
<td>European Nuclear Installations Safety Standards</td>
</tr>
<tr>
<td>ESPN</td>
<td>Nuclear pressure equipment</td>
</tr>
<tr>
<td>EPR NM</td>
<td>European Pressurised Reactor New Model</td>
</tr>
<tr>
<td>EPRI</td>
<td>Electric Power Research Institute (US)</td>
</tr>
<tr>
<td>ESR</td>
<td>Significant radiation research event</td>
</tr>
<tr>
<td>ESS</td>
<td>Significant nuclear safety event</td>
</tr>
<tr>
<td>EVEREST</td>
<td>EDF project to allow workers to enter controlled areas wearing ordinary work clothes</td>
</tr>
<tr>
<td>ENSREG</td>
<td>European Nuclear Safety Regulators Group</td>
</tr>
<tr>
<td>EXELON</td>
<td>Electric utility (US)</td>
</tr>
</tbody>
</table>

### F

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIS</td>
<td>Independent nuclear safety oversight</td>
</tr>
<tr>
<td>FME</td>
<td>Foreign Material Exclusion</td>
</tr>
</tbody>
</table>

### G

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDA</td>
<td>Generic Design Assessment (UK)</td>
</tr>
<tr>
<td>GIEC</td>
<td>Intergovernmental panel on climate change (UN)</td>
</tr>
<tr>
<td>GPEC</td>
<td>Advanced planning of jobs and skills</td>
</tr>
<tr>
<td>GPSN</td>
<td>Nuclear safety performance group (UNIE)</td>
</tr>
<tr>
<td>HCTISN</td>
<td>High committee for transparency and information on nuclear matters</td>
</tr>
</tbody>
</table>

### I

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAEA</td>
<td>International Atomic Energy Agency</td>
</tr>
<tr>
<td>ICRP</td>
<td>International Commission on Radiological Protection</td>
</tr>
<tr>
<td>IN</td>
<td>Nuclear inspectorate (DPN)</td>
</tr>
<tr>
<td>INA</td>
<td>Independent Nuclear Assurance (EDF Energy)</td>
</tr>
<tr>
<td>INB</td>
<td>Licensed nuclear facility</td>
</tr>
<tr>
<td>INES</td>
<td>International Nuclear Event Scale</td>
</tr>
<tr>
<td>INPO</td>
<td>Institute of Nuclear Power Operators (US)</td>
</tr>
<tr>
<td>INSAG</td>
<td>International Safety Advisory Group (IAEA)</td>
</tr>
<tr>
<td>IOP</td>
<td>Operations engineering</td>
</tr>
<tr>
<td>IRAS</td>
<td>Plant engineer assigned to relations with the ASN (NPPs)</td>
</tr>
</tbody>
</table>

### J

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>JANSI</td>
<td>Japan Nuclear Safety Institute</td>
</tr>
<tr>
<td>JNES</td>
<td>Japan Nuclear Energy Safety organisation</td>
</tr>
</tbody>
</table>

### L

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LWRS</td>
<td>Light Water Reactor Sustainability programme</td>
</tr>
</tbody>
</table>
**M**

MAE Engineering audit team at the DIPNN
MAAP DPNT performance assessment and support team
MARN Nuclear hazard management support team
MDEP Multinational Design Evaluation Programme
MEEI Campaign for maintaining exemplary housekeeping (DPN initiative)
MOPIA Project to set in place an attractive business policy
MME Operations and maintenance methods
MQME Campaign to raise the standards in maintenance and operation (DPN)
MOMR Operational supervision and risk management (DIPNN)

**N**

NCC Operations professions common core
NCME In-service maintenance professions common core
NDA Nuclear Decommissioning Authority (UK)
NEA OECD Nuclear Energy Agency
NEI Nuclear Energy Institute (US)
NNB Nuclear New Build (EDF Energy)
NNSA National Nuclear Safety Administration (China)
NPP Nuclear Power Plant
NRA Nuclear Regulation Authority (Japan)
NRC Nuclear Regulatory Commission (US)
NSSC Nuclear Safety and Security Commission (South Korea)

**O**

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

**P**

PARTNER Ecologically-sensitive nuclear plant administrative facility refurbishment
PBMP Basic preventive maintenance programme
PDC Nuclear engineering key skills development plan
PGAC Worksite general assistance services
PUI Onsite emergency plan
PWR Pressurised Water Reactor
PSPG Police site protection unit

**R**

RCP Primary cooling system of the reactor
RCV Chemical and volume control system of the reactor’s main primary system
R&D Research & Development directorate
RIS Emergency water injection system for reactor cooling
RET Exceptional work permit
RGV Steam generator replacement

**S**

SAT Systematic Approach to Training
SDIN Nuclear technical information system
SDIS Local fire and rescue services
SGDSN National committee of public safety and defence
SEPTEN Nuclear and conventional design department
SIR Authorised internal inspection department
SMI Integrated management system
SODT Safety Oversight Delivery Team
SOER Significant Operating Experience Report issued by WANO
SOFINEL Joint EDF and AREVA design office
SOH Socio-organisational and human approach
SPR Risk management department
SSG Site stakeholder group
STE Technical specifications
SYGMA Computerised maintenance management system

**T**

TEPCO Tokyo Electric Power Company (Japan)
TNPJV Joint venture between the Chinese company CGN (51%), Guangdong Yuedean Group Company (19%) and EDF (30%)
TSM Technical Support Mission by peers organised by WANO
TSN French nuclear safety & transparency act
TVO Teollisuuden Voima Oy (Finland)

**U**

UFPI Operations & engineering training unit (DAIP)
UNIE Operations engineering unit (DPN)
UNGG Gas-cooled graphite-moderated reactor
UTO Central technical support department (DPN)

**V**

VD Ten-yearly inspection outage
VP Partial inspection outage

**W**

WENRA West European Nuclear Regulators Association
WNA World Nuclear Association
WANO World Association of Nuclear Operators
PHOTO CREDITS

Patrice DHUMES, Alexis MORIN, Monty RAKUSEN, Philippe ERANIAN, Aldo SPERBER, CEIDRE, Julien GOLDSTEIN, John MORRISON, Centrale de HEYSHAM, Stéphanie JAYET, Marc CARAVEO, Cyril CRESPEAU, Antoine SOUBIGOU, Anthony RAKUSEN, Christophe AUBRY, David BORNSTAIN, François LAFFORGUE, Damien CHARFEDDINE, Centrale de Taishan, Léa MAZOUZI, The Design Company, CEA Cadarache, EDF Energy Sizewell, Hayes DAVIDSON, Jimmy HICKS, Rodolphe JOBARD.