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# NATIONAL REPORT OF FRANCE FOR THE COMBINED 8TH AND 9TH REVIEW MEETING IN 2023

**Convention on Nuclear Safety**

France - August 2022

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## Foreword

France signed the Convention on Nuclear Safety (CNS) on 20 September 1994, the date on which it was opened for signature during the IAEA General Conference. The Convention was ratified by France one year later, on 11 September 1995, and entered into force on 24 October 1996.

This report is the ninth French report presented for review, in compliance with the provisions of Article 5 of the Convention, before the combined review meeting for the eighth and ninth cycles, which is to be held at the International Atomic Energy Agency (IAEA) from 20 to 31 March 2023. As the 8th review meeting could not be held in 2020 owing to the Covid-19 pandemic, the contracting parties decided to combine the 8th and 9th review meetings. This ninth report therefore covers the reference period from August 2016 to June 2022.

It is based on the report issued for the 8th review meeting and takes account of the questions posed by the contracting parties during the uncompleted 8th review cycle. It has been updated and structured in accordance with the guidelines for the national reports required by the Convention, focusing on the provisions implemented by France in order to meet each of the obligations of the Convention. It more particularly includes boxes to clarify the concrete application of these provisions, boxes that are indicated by ⌜ ⌟.

This report consists of 3 parts:

- introductory Part A, which presents the context of France's nuclear power program, nuclear safety policy and energy policy;
- Part B, which summarises the report. It notably includes a summary of the major achievements of the period August 2016 to June 2022, an overview of the questions France was asked to cover in its eighth national report during the seventh review meeting, the future main activities for the coming three years and the steps taken to meet the obligations of the Vienna Declaration;
- Part C, in which the numbering of the chapters corresponds to that of Article 6 to 19 of the Convention. It presents the provisions demonstrating that France meets the obligations of the Convention, Article by Article, each of which is covered by a separate chapter, at the beginning of which the corresponding text of the Article of the Convention is recalled in grey.

This report was produced by ASN, the French nuclear safety authority, acting as coordinator, with contributions from the nuclear reactor licensees, Électricité de France (EDF), the French Alternative Energies and Atomic Energy Commission (CEA) and the Laue Langevin institute (ILL), following consultation with the other parties concerned (government authorities, IRSN).

France's presentation to the Convention's combined review meeting for the eighth and ninth cycles will be based on this report, supplemented by information about any pertinent developments that may have occurred in the meantime.

# A. INTRODUCTION

## 1. The nuclear programme

The first decision by the French government concerning nuclear energy was to create a public research organisation in 1945, the French Atomic Energy Commission, which was renamed the French Alternative Energies and Atomic Energy Commission (CEA) on 10 March 2010.

The first French experimental nuclear reactor Zoé went critical in December 1948, thus paving the way for the construction of other research reactors, followed by reactors designed to generate electricity.

The French civil nuclear programme started during the third five-year plan (1957-1961), with the construction of reactors operating with natural uranium, referred to as gas-cooled reactors (GCR). This technology was then abandoned and replaced by light water reactors, through an interministerial decision in 1969. These GCR reactors are currently being decommissioned.

In 1974, following the oil crisis of 1973, France initiated a vast programme to have EDF build nuclear power plants, based on the pressurised light water reactor (PWR) technology and model standardisation around a license provided by Westinghouse, with up to 5 plant units being built every year in the 1980s. This programme led to the construction of 58 pressurised water reactors distributed over 19 sites and generating about 75% of the electricity produced in France.

A new type of reactor was launched in 2005, the EPR (European Pressurised Reactor), developed by Areva, with a design based on that of the existing French N4 type and German Konvoi reactors. It thus benefited from proven technologies and operating experience feedback from these predecessors. Significant safety changes were however introduced in relation to the existing reactors, in order to reinforce accident prevention, protect the facility more effectively against internal and external hazards and mitigate the possible consequences of an accident with core melt, with regard to the high safety goals defined. Construction of the EPR reactor in France began in December 2007 at Flamanville (Manche *département*[1]).

France also developed a fast neutron reactor series, currently being decommissioned:

- in 1967, the Rapsodie (24 MWth) prototype was commissioned at the Cadarache research centre (Bouches-du-Rhône *département*) and shut down in 1983;
- in 1973, the Phénix reactor (250 MWe) in Marcoule (Gard *département*) produced electricity until being shutdown in 2010, and constituted part of the design study for the “generation IV” reactors;
- in 1977, construction of the 1200 MWe Superphénix fast breeder reactor began on the Creys-Malville site. It was commissioned in 1985 and shut down in 1998.

The project called ASTRID (Advanced Sodium Technological Reactor for Industrial Demonstration) a 600 MWe sodium-cooled fast breeder reactor prototype was initiated in 2010, but abandoned in 2019.

[1] *Administrative region headed by the Prefect*

## 2. Nuclear safety policy

In France, nuclear safety policy is built around the following principles:

- the prime responsibility of the licensee of a nuclear facility,
- the independence of the authority responsible for oversight and regulation and its transparency with regard to the public,
- continuous improvement of nuclear safety.

Implementation of this policy led to:

- the merging of the two organisations in charge of regulatory oversight of nuclear safety and radiation protection: this was done with the 2002 creation of the General Directorate for Nuclear Safety and Radiation Protection (DGSNR), the precursor of ASN;
- the independence of the regulation and oversight authority from the Government and the bodies promoting nuclear energy: this was achieved with the 2006 creation of ASN as an independent administrative authority;
- the creation of a specific and integrated oversight regime for basic nuclear installations (BNI) aligning BNI environmental protection with the provisions in force for installations classified for protection of the environment (ICPE): this was done with the "Transparency and Nuclear Safety" (TSN) Act in 2006;
- separation of the regulatory oversight entrusted to ASN in the civil field and the expert technical analysis entrusted primarily to the Institute for Radiation Protection and Nuclear Safety (IRSN);
- information and transparency with regard to the public: this led notably to the creation of the Local Information Committees (CLI) and the High Committee for Transparency and Information on Nuclear Safety (HCTISN);
- regular peer reviews of regulation and oversight practices: this began in 2006 with the hosting of the first IRRS "full-scope" mission, and then continued with application of Council Directive 2009/71/Euratom of 25 June 2009 for the safety of nuclear installations, amended in 2014.

## 3. Energy policy

In order to deal with the major climatic and energy challenges it will have to face in the coming decades, France has defined ambitious medium and long-term national energy transition objectives. These are implemented through the Energy Transition for Green Growth Act published in 2015, supplemented by the Energy Climate Act, adopted in 2019, with the main aims of closing the coal-fired power plants by 2022, achieving a 40% reduction in greenhouse gas emissions between 1990 and 2030 and achieving carbon neutrality by 2050.

Two additional documents formally set out French energy and climate strategy. They were adopted by Decree in April 2020 following a public inquiry:

- the multi-year energy programme (MEP) implements France's energy policy objectives in the operational roadmaps for all sources of energy;
- the national low carbon strategy (SNBC) defines a roadmap concerning the coordination of policy to attenuate climate change in France, by providing guidelines for its transition in all activity sectors.

The 2019-2023 MEP comprises several structuring actions for the future of nuclear energy:

- the continued operation of the nuclear reactors beyond 40 years, subject to the position statements issued by ASN;
- the restatement of the nuclear fuel reprocessing strategy until 2040;
- the start of a number of programmes to define the position of nuclear power in the electricity mix by the 2050 time-frame;
- the diversification of nuclear technologies with support for the development of Small Modular Reactor (SMR) technology.

As provided for in the MEP, the two nuclear reactors at the Fessenheim NPP were permanently shut down on February 22 and June 30, 2020, respectively. The perspective for shutting down the nuclear reactors currently in operation will have to be specified, taking into account safety requirements and the security of supply criterion. Studies for the moxing of certain 1300 MWe reactors are continuing, as are those relating to the deployment of multi-recycling of fuel in the current fleet of reactors.

In accordance with the 2019-2023 MEP, the national power grid operator, RTE, published the *"Energy Pathways 2050"* report in October 2021, following work that extensively involved all the stakeholders concerned. This report presents six different electricity mix scenarios, three which include the development of new nuclear reactors, to reach a maximum nuclear share of 50% in the 2050 electricity mix, and three others that do not; one of these latter leads to a mix based exclusively on renewable electricity sources by 2050. This study comprises an overall economic evaluation of the various scenarios and considers that a share of nuclear energy in the French electricity mix offers a more robust industrial solution for meeting the objectives, notably in terms of carbon neutrality.

In November 2021 and February 2022, the President of the Republic announced the start of a new nuclear reactor construction programme, in addition to the continued large-scale development of renewable energy sources, to guarantee France's energy independence and achieve carbon neutrality by 2050.

An new energy and climate planning Act is scheduled for debate in Parliament in 2023 to reflect French strategy in these fields for the period 2024-2028, and the MEP and SNBC should be updated accordingly in 2024.

# B. SUMMARY

## 4. Summary

### 4.1. Major achievements since the 7th review meeting

#### 4.1.1. Management of the Covid-19 epidemic on the nuclear power plants

The Covid-19 epidemic health crisis made it necessary to adopt special measures to guarantee the safety of the EDF NPPs.

During the first lockdown phase in the spring of 2020, EDF deployed a local activity continuity plan coordinated at national level.

In terms of organisation, EDF adopted measures to guarantee the safety of the installations while complying with the health rules in force. Many employees were assigned to working from home. For the employees whose presence on the NPP sites was indispensable, such as the operating teams, measures were taken to reduce contacts within teams and to prevent the different teams from crossing each other (deployment of "A/B" teams on site in alternation to limit physical contact, shift crew rostering to maintain a "reserve" of staff, limitation of control room access, instituting maximum capacities in enclosed spaces to meet the government demands to reduce staff numbers in the NPPs, integration of physical distancing and protective measures in the performance of activities). Steps were taken to guarantee an emergency response capability. ASN found that EDF paid particular attention to ensuring that the safety of the facilities remained the number one priority for everyone.

The travel restrictions put in place by the Government during the first lockdown in spring 2020 initially severely reduced EDF's ability to carry out scheduled maintenance work within the planned times during the reactor refuelling outages. Faced with this situation, EDF decided to extend the provisional durations of all the scheduled outages and to postpone or cancel certain others. ASN made sure that the maintenance and outage operations were pushed back by EDF in compliance with the applicable safety rules.

See as well Appendix E.

#### 4.1.2. Consultation for the 4th periodic safety review of the 900 MWe reactors

Several steps were taken to involve the public in the generic phase[2] of the 4th periodic safety review of the 900 MWe reactors. These steps aimed to inform the public, facilitate understanding of the safety issues, explain the ASN requirements associated with the review and find out the expectations, queries, questions and positions of the various contributors.

ASN thus involved the public as of 2016 in the development of its position on the "major objectives" of the 4th periodic safety review of the 900 MWe reactors. It then pursued this approach in the development of its generic resolution on the 4th periodic safety review of the 900 MWe reactors in early 2021.

[2] In view of the similarities between the reactors of a plant series, the periodic safety review of the reactors is in practice carried out in two complementary phases: a first "generic" phase common to all the reactors of a given series, as they were all designed to a similar model, and a second "specific" phase which takes into account the characteristics specific to each installation, notably the geographical location.

Alongside this, acting on an ASN proposal, the High Committee for Transparency and Information on Nuclear Safety (HCTISN), by virtue of its mandate to promote information, consultation and discussion on the risks related to nuclear activities, decided to launch a consultation on the generic phase of the 4th periodic safety review of the 900 MWe reactors in the French NPP fleet (32 reactors operated by EDF on 8 sites).

This unprecedented consultation approach was timed to coincide with their 40th year of operation, in order to obtain the opinion of the public both on-line and at local consultation meetings, regarding the conditions for continued operation of these 900 MWe reactors. The consultation process was organised with the aid of a number of players (HCTISN, ASN, IRSN, EDF, ANCCLI, CLI).

The consultation was held from 6 September 2018 to 31 March 2019. The public was informed and questions and opinions were gathered at both regional and national levels, via a digital platform. A total of 16 meetings attended by 1,300 participants were held around each of the 8 sites concerned, as well as within a number of higher education facilities.

Lastly, ASN issued the Cahiers de l'ASN entitled "Nuclear power plants beyond 40 years: the issues of the 4th periodic safety review of the 900 MWe nuclear power reactors". The Cahiers de l'ASN is new collection part of a pedagogical information approach on topics related to nuclear safety and radiation protection.

See Focus 13 in § 8.1.3.

### 4.1.3. ASN resolution on the conditions for continued operation of the 900 MWe nuclear reactors

Within the framework of the 4$^{th}$ periodic safety review of the 900 MWe reactors, ASN issued a position statement on the level of safety to achieve for continued operation of the reactors: the safety objectives adopted for this review have been defined with regard to the objectives applicable to the new generation reactors, particularly the reduction of the radiological consequences in the event of an accident (with or without core melt).

In 2020, with the assistance of IRSN, ASN finalised its examination of the generic studies linked to the 4$^{th}$ periodic safety review. On completion of this examination, ASN issued a resolution in early 2021 on the conditions of continued operation of the reactors; ASN underlined the ambitious objectives of the fourth periodic safety review of the 900 MWe reactors and the substantial studies undertaken by EDF in the general phase to determine the modifications. It also underlines the scale of the modifications planned by EDF, which will bring significant safety improvements. These improvements more specifically concern the risks linked to hazards (fire, explosion, flooding, earthquake, etc.), the safety of the fuel spent fuel pool and the mitigation of accidents with core melt.

ASN has ordered the introduction of major safety improvements on the 900 MWe reactors so that the level of safety approaches that of the most recent reactors (third generation). These modifications (see Focus 17 in Chapter 14) aim to:

1. Limit the radiological consequences of accidents without core melt;
2. Avoid massive releases and the long-term environmental effects of accidents with core melt;
3. Reduce the risk of spent fuel assemblies melting in the storage pool;
4. Improve the hazard resistance of the installation.

At the end of this generic phase, EDF will carry out the specific phase of the 4th periodic safety review on each 900 MWe reactor. The measures proposed by EDF for each reactor will be subject to a public inquiry. ASN will then submit for public consultation the draft requirements it considers necessary for continued operation of each of the reactors.

See Focus 21 in Chapter 14.

### 4.1.4. Flamanville 3 EPR

Construction of the Flamanville EPR reactor began in September 2007. EDF plans fuel loading and reactor startup by mid-2023.

ASN's oversight of the Flamanville EPR reactor comprises inspection of the activities carried out on site and in the factory, and examination of the installation commissioning application file.

ASN thus conducts inspections which encompass site preparation after the creation authorisation decree, manufacture, construction, qualification, assembly and testing of structures, systems and components, both on the construction site and on the manufacturers' premises, particularly for nuclear pressure equipment manufacture.

The partial commissioning authorisation, which allows the introduction and storage of fresh fuel and source clusters in the pool (see Focus 20 in § 14.1.3.1 and Focus 34 in § 19.1.2) was issued by ASN in October 2020 following its examination. At present, all the fuel assemblies have been received and are stored in the fuel building pool.

This authorisation constitutes one of the steps prior to commissioning of the Flamanville EPR reactor. Commissioning of the installation, that is to say loading the fuel into the reactor vessel, is subject to ASN authorisation.

The commissioning authorisation application file comprising the safety analysis report, the general operating rules, the on-site emergency plan, the decommissioning plan, an update of the impact study and the risk study, is examined by ASN, assisted by IRSN and the Advisory Committees of Experts. A number of specific points relative to the design of certain equipment items (pressuriser valves, recirculation function filtration system) or the safety case (integration of operational experience feedback from the EPRs in service) are still being examined.

ASN also assesses regulatory compliance of the most safety-important NPE items. Some of the NPE components have anomalies which are detailed below:

***Anomaly in the composition of the steel in the centre of the EPR reactor pressure vessel closure head and bottom head***

On 7 April 2015, ASN released information concerning an anomaly in the composition of the steel in the centre of the Flamanville 3 EPR pressure vessel closure head and bottom head. This anomaly is linked to the presence of a high carbon concentration which results in mechanical properties that are not as good as expected.

Framatome, in collaboration with EDF, has launched a test programme to assess the mechanical properties. The results show that the mechanical properties of the material are sufficient to prevent the risk of fast fracture, given the loads applied and postulating the existence of the most unfavourable flaw. ASN therefore considered that this anomaly is not such as to compromise the serviceability of the EPR reactor pressure vessel bottom head and closure head, provided that specific inspections are carried out during operation of the installation to ensure that no flaws appear.

See Focus 32 in Chapter 18.

***Anomalies on the main steam lines***

At the beginning of 2017, EDF informed ASN of design deviations and anomalies in the production of the main steam lines (VVP system) of the Flamanville EPR reactor. These anomalies concerned firstly mechanical properties (impact strength) lower than those stipulated in the break preclusion approach[3] applicable to these pipes, and secondly the presence of defects detected late (during the non-destructive tests performed on the welds during the pre-service inspection of the equipment). ASN had considered as of 2018 that preference should be given to repairing all the welds.

EDF wanted to keep these welds, which are situated in the reactor containment penetrations, in their present condition by applying a test programme and reinforced in-service monitoring. ASN considered that the nature and the particularly large number of deviations that occurred at the design stage and during manufacture represented a major obstacle to maintaining these welds "as is", and in June 2019 ordered that the welds be repaired before commissioning the reactor.

Since then, the repair of the secondary system welds on the Flamanville EPR reactor has mobilised significant EDF resources. In effect, due to the observed anomalies, about one hundred welds on the secondary system needed repairs. EDF designed specific mock-ups and conducted tests to qualify the repair processes. ASN subjected this repair work to tightened oversight to check the quality of the new welds.

See Focus 33 in Chapter 18.

### 4.1.5. Environmental monitoring

France has implemented a unique instrument (RNM) for providing the public, via a dedicated website (*www.mesure-radioactivite.fr*), all the results of environmental radioactivity measurements taken by the various actors (state services, local authorities, non-governmental organisations, public institutions and nuclear licensees) who participate in the monitoring of environmental radioactivity.

The reviews of the radiological situation of the French environment, presenting IRSN's analysis and interpretation of all the environmental measurements taken via the RNM, for the periods 2015-2017 and 2018-2020 were published in 2019 and 2021 respectively. Using the results of measurements taken in the different compartments of the environment (air, water, soils, milk, agricultural production, etc.), IRSN evaluated the radiological exposure of the populations via the various possible exposure routes, showing that the doses received by the populations living near the sites are generally very low – about one microsievert per year (1 µSv/year), that is to say one thousandth of the regulatory limit (1 mSv/year).

Lastly, the 2018-2020 review shows the environmental radionuclide measurements further to various events that occurred over this period (accidental release of selenium 75 by a Belgian installation in May 2019, fire at the La Hague laundry in February 2020, forest fires in areas contaminated by the Chernobyl accident in spring 2020 and a fire in a nuclear submarine in the port of Toulon in June 2020). Although very small traces of these events were occasionally measured on the environmental radioactivity monitoring equipment operated by IRSN in France, no abnormal rise in ambient radioactivity was detected during these events, which had no health impact on the population.

See Focus 27 and 28 in Chapter 15.

[3] For information, the principle of application of a break preclusion approach consists in not examining the consequences of the break of a pipe in the nuclear safety case because such a break is rendered extremely improbable with a high level of confidence. Application of this approach must lead to a reinforcement of the first two levels of defence in depth: it is therefore underpinned by particularly stringent measures in terms of the design, manufacture and in-service monitoring of these pipes.

### 4.1.6. Developments in inspection practices

In 2017, ASN created the position of Chief Inspector, whose prime role is to lead the ASN inspection policy. Under the leadership of the Chief Inspector, ASN is introducing changes in its inspection practices.

***Irregularities***

The risk of irregularities among known manufacturers, suppliers or inspection organisations, evidenced since 2015, has given rise to changes in ASN's inspection practices.

In 2016, ASN began to consider the modification of BNI inspection practices in response to irregular situations. In so doing, it questioned other regulation and oversight administrations, its foreign counterparts and the licensees with regard to their practices, in order to learn pertinent lessons.

In 2019, ASN hired two people from administrations regularly faced with these problems: the gendarmerie and national police force. These new recruits brought the benefit of their experience, proposing new approaches, notably regarding possible enforcement measures and relations with the prosecution offices, and to develop the actions already under way, particular with regard to inspection.

These new inspections are conducted:

- in the EDF and Orano head office departments, with the aim of examining how these groups have incorporated prevention of the risk of fraud into their procurement policies and the state of progress in the handling of certain confirmed cases of fraud they have identified;
- on the nuclear sites, integrating an in-depth search for proof of performance of activities, for example by verifying the effective presence of a person who certified that they performed or checked a given activity on a given date;
- on the premises of suppliers to address the risk of fraud in the subcontracting chain with the aim of raising awareness to fraud risks.

Furthermore, the question of data integrity - linked to the risk of fraud given that shortcomings in traceability can facilitate irregularities - is increasingly addressed and forms the subject of requirements in certain inspection follow-up letters.

See Focus 23 in Chapter 14.

***Oversight of reactor outages***

ASN has made changes to its oversight of reactor outages. Until now, oversight was based primarily on the examination of the files presenting the work programme during the reactor outage and the results of that work.

As part of its 2018-2020 strategic plan, ASN experimented with a relaxation of its documentary checks and a reinforcement of its field inspections during the course of ten reactor outages in 2019, particularly concerning the inspection and maintenance activities. This approach led to more inspections being performed in connection with these outages. Given the positive feedback from this experiment, ASN decided to generalise this new oversight approach to all the refuelling outages scheduled by EDF. These new oversight methods enable ASN's resources to be focused on the activities with the highest risks, oversight to be made more efficient, and EDF to be repositioned as holder of prime responsibility for the safety of its installations.

***Tailored inspections during the health crisis***

During the crisis resulting from the Covid epidemic, the inspectors, like the licensees and persons in charge of nuclear activities, were subject to travel restrictions intended to prevent the epidemic from spreading and which affected their work. ASN immediately began to look at ways of continuing with its inspections. First of all, on-site inspections were suspended except in case of necessity, such as the occurrence of a significant event.

To compensate this, new desk-based inspection practices were rapidly put into place. These inspections more specifically involved examining documents relating to routine operations along with audio and video conferences with the licensee. ASN moreover used digital tools hitherto little employed, such as real-time and off-line remote-examination of the physical operating parameters of the reactors. Given the significant reduction in maintenance work on the facilities, this type of inspection, for the nuclear reactors, first of all targeted operating activities (reactor operation, periodic tests, etc.).

Initially considered a stop-gap solution until health protocols allowing access to the installations were put in place, these inspections have proved their worth as a complement to on-site inspections: possibility of remotely accessing some databases in virtually real time; possibility of devoting more time to examining documents than would be possible on site.

These new forms of inspection are not intended to substitute for presence in the field, which remains essential for understanding the issues relating to a nuclear facility or activity, examining the condition of premises and equipment, observing the performance of work and understanding the interactions between the persons involved. They do however enable the inspectors' presence in the field to be optimised, so that they can then focus on what cannot be inspected remotely.

This crisis has been a powerful accelerator of the transformations already under way, but also the starting point for new oversight practices.

***Exercise on simulator for operation in incident or accident situation***

ASN has developed specific inspections comprising firstly a situational exercise for the operating team on the scale-one reactor simulator, and secondly, field application of the actions required by the incident and accident instructions, but without actuating the devices.

The aim of these inspections is to verify the operating team's ability to manage an accident scenario, and in particular:

- over almost the entire duration of a shift, complying with the applicable best practices (operational communication, self-checking, responsibilities of the players, etc.),
- during the phases to reach the safe state,
- during changes of shift,
- the applicability in the field of the instruction sheets associated with the procedures.

To do this, ASN asked the training departments of several NPPs to design scenarios for examining these points. These scenarios were played in the presence of a team of inspectors, which enabled ASN to examine in situ the behaviour of an operating team in the simulator room and in the field, its know-how and the applicability of the incident and accident operating instructions and thereby assess the quality of the accident situation training of the operating teams.

See Focus 11 in Chapter 7.

### 4.1.7. Post-accident management

The purpose of the Codirpa (Steering committee for managing the post-accident phase of a nuclear accident) is to submit to the Government proposed developments in the national strategy for protecting the population and winning back regions following a nuclear accident.

In 2019, the Codirpa submitted to the Government proposed changes in the post-accident strategy for managing the consequences of a nuclear accident in order to integrate the lessons learned from the Fukushima Daiichi accident and the French national emergency exercises. These changes concern the simplification of the defined zones of population protection measures to protect the population against the risk of external exposure (perimeter of population distancing (uninhabitable zone)) and to limit population exposure to the risk of contamination by ingestion (perimeter for non-consumption of locally produced fresh foodstuffs, use of the maximum permissible levels of radioactive contamination defined at European level for the trading of foodstuffs). These changes in the post-accident doctrine in France were validated by the Government in 2020 and will be applied in the national major nuclear or radiological accident response plan and in the off-site emergency plans (PPIs) around the installations when they are updated in the future.

In 2020, the Prime Minister gave the Codirpa a new mandate for the 2020-2024 period with a significant focus on accompanying the population, and the development of a culture of radiation protection. New work has already been initiated under this new mandate and resulted in several tangible advances, based on listening to and actively involving the players concerned:

- a document presenting a "questions and answers" relative to the health consequences of a nuclear accident, intended specially for health professionals;
- a practical guide for the inhabitants of a region contaminated by a nuclear accident: it comprises 28 topical sheets containing good radiation protection practices, advice for everyday living and information on radioactivity, the environment and methods of measuring radioactivity;
- the preparation of instructions concerning the consumption of locally produced fresh foodstuffs in a post-accident situation: these instructions were debated with four panels of citizens living near nuclear power plants in order to assess the understanding and acceptability of the proposed protection measures, which is crucial for their application.

See Focus 29 and 31 in Chapter 16.

### 4.1.8. "Energy pathways 2050" study

In response to a request from the Government, the national power grid operator, RTE, has launched in 2019 a broad study on the evolution of the power system called *"Energy Pathways 2050"*. This study analyses consumption trends and compares six scenarios for the development of the power system that guarantee security of supply and the achievement of the objectives of the national low-carbon strategy.

This study is based on an unprecedented consultation process: some forty meetings were held, bringing together experts from around one hundred different organisations (energy companies, NGOs, associations, think-tanks and institutes, regulatory authorities, public administrations, etc.). This concertation led to evolution of the scenarios and integration of numerous variants.

RTE has defined two families of scenarios, depending on whether the new investments in the generation capacity are exclusively focused on renewable energies ("M" scenarios) or on a more technologically diversified mix, i.e. a combination of renewable energies and new nuclear reactors ("N" scenarios).

Five of the six scenarios presented are based on the continued operation of the fleet, including one scenario based on the continued operation of most of the current reactors up to 60 years of age and some beyond. Three of the six scenarios involve the construction of new EPR2-type reactors, which constitutes an industrial challenge.

This study highlights the technical, economic and societal implications of the different energy policy orientations. It identifies the need to have evidence by 2030 on the capability of nuclear reactors to operate for up to 60 years.

#### 4.1.9. A new strategic plan, a new ASN regulation and oversight policy

In order to exercise its responsibilities and to ensure progress in nuclear safety and radiation protection, ASN must implement consistent actions that are commensurate with the issues involved. In order to do this, ASN relies on its values (independence, competence, rigorousness, transparency), on the commitment of its personnel and on a policy of continuous improvement.

During the course of 2017, ASN worked on an in-depth overhaul of its strategy and on adapting its regulation and oversight methods to the present and future issues and challenges. All the ASN personnel contributed to the development of a new strategic plan and a new oversight policy which has been implemented since 2018. This policy placed the emphasis on:

- the reinforcement of a graded approach: the "noteworthy modifications" resolution adopted in November 2017 and its entry into effect limit the authorisation procedures to the modifications presenting the greatest risks. Furthermore, ASN has instituted a system of priorities in its inspection programme in order to focus more effort on the higher-stake inspections;
- increasing the effectiveness of ASN's actions in the field: ASN has changed its oversight practices to take better account of the contextual changes. Moreover, sheets baptised "the BNI highway code" have been produced to enhance the sharing of lessons learned from the situations encountered by the inspectors in the field.

Today ASN is confronted with a relatively unprecedented number of subjects and high-stake transformations which are at the centre of political and societal debates: nuclear energy is effectively becoming a political issue that constitutes an important factor in energy transition in a context of climate emergency. At the end of 2021, in the development of its new strategic plan, ASN began looking into the future challenges and the changes it must prepare for:

- ASN must oversee a fleet of nuclear installations that is in a " transition period" insofar as firstly, for many of them, the question of their continued operation and the time frame of their shutdown is on the table, and secondly an unprecedented number of new installations (at the design or construction stage) is envisaged;
- our fellow citizens' desire for their views to be better heard and to be more clearly informed by the State. In the area of risk management, it is found that better results are obtained when the various players embrace the risks and the protection measures. This implies a significant amount of explanatory work beforehand;
- on the international front, a predominant factor in the forthcoming period is geopolitical change: the centre of gravity of nuclear energy is moving towards Asia and there is an increasingly wide divergence in nuclear policy choices in Europe. ASN will therefore have to redouble its efforts, in collaboration with its European partners, to promote an ambitious vision of nuclear safety on the international scale;

- ASN must continue to adapt its modes of functioning to remain attractive and arm itself with the skills to face these new challenges.

These changes have been shared and discussed in order to gather the views of all the personnel on the challenges during seminars organised at the ASN head office and in the regional divisions. This "collaborative" approach is vital because these challenges are going to guide ASN's future actions and therefore the work of all its personnel. The new strategic plan will be finalised at a convention to be attended by all the personnel in October 2022.

### 4.2. Main safety events since the 7th review meeting

***Seismic resistance deficiency in the Donzère-Mondragon canal embankment which protects the Tricastin NPP***

In August 2017, EDF sent ASN notification of a significant safety event concerning a risk of failure of a part of the Donzère-Mondragon canal embankment under the most intense earthquake studied in the nuclear safety case.

In view of the analysis of the potential consequences for safety should this portion of the embankment fail in the event of an earthquake, ASN imposed the temporary shutdown of the four Tricastin NPP reactors. The assessments showed in effect that the flooding resulting from failure of the embankment could lead to an accident with melting of the nuclear fuel of the four reactors while rendering deployment of the on-site and off-site emergency management resources particularly difficult.

In 2017, EDF reinforced the part of the embankment in question to ensure it would withstand the safe shutdown earthquake. Further to these works, ASN authorised restarting of the reactors.

See Focus 1 in Chapter 6.

***Significant safety event relative to a risk of partial or total loss of the heat sink***

In spring 2017, further to an ASN request, EDF inspected the fire protection system pipes of the Belleville-sur-Loire NPP. These inspections found the pipes on two sections of the JPP system (fire-fighting water production system) to be deteriorated, with wall thicknesses that did not meet the requirements to guarantee their seismic resistance. EDF extended its investigations to the essential service water system (SEC) pipes, which are also located in the premises of the pumping station, and to all the reactors in service.

Rupture of these pipes in the event of an earthquake could lead to flooding of the SEC pumps and therefore loss of the heat sink.

EDF rapidly implemented repair solutions on the defective pipe sections along with compensatory measures to rapidly safeguard the two redundant channels of the SEC system, with the definitive repairs being completed at the end of 2018. ASN checks, particularly in the course of its inspections, that the repairs are carried out satisfactorily.

See Focus 4 in Chapter 6.

***Significant safety event relating to defective electrical components rendering the safety systems unserviceable***

On 18 December 2019, EDF reported a significant safety event relating to faults on electrical cubicle components which put systems of the Penly NPP reactor 2 out of service.

During the reactor refuelling shutdown in July 2019, EDF replaced contactor insertion contacts in these electrical panels. The work was carried out on channels A and B simultaneously because it could not be carried out on channel A during a previous outage. Twenty-eight replacement insertion contacts installed on these electrical panels and coming from the same production batch were found to be defective, which led EDF to consider the reactor safeguard and cooling system pumps concerned by the anomaly and supplied by these electrical panels as being out of service.

EDF replaced the 28 defective insertion contacts of the Penly NPP reactor 2 with compliant parts before restarting the reactor. EDF also checked that the other reactors in the fleet were not affected.

See Focus 5 in Chapter 6.

***Nonconformities detected on electrical power sources***

Since 2020, during the conformity verifications of the reactor electrical power sources, and the emergency diesel generator sets in particular, as required by ASN, EDF detected anomalies on several reactors concerning seismic resistance deficiencies. These deficiencies concern the incorrect installation of the elastomer couplings on piping, the corrosion of certain portions of pipes or their supports, connection errors in certain electrical cabinets and electrical cabinet or cooling tower anchoring defects.

All of the observed deficiencies were repaired by EDF or, with regard to the incorrect installation of certain elastomer couplings, were subject to reinforced monitoring until their replacement at the next reactor outage.

See Focus 6 in Chapter 6.

***Fault in the application of a post-weld heat treatment process during the manufacture of steam generators***

In 2019, the manufacturer Framatome discovered that certain processes implemented for the assembly of steam generator (SG) components during the post-weld heat treatment[4] had led to insufficient control of the temperatures applied to the treated welds.

EDF justified the continued integrity of the equipment concerned by drawing on the results of tests performed on representative mock-ups, on material test coupons and by applying numerical temperature prediction models. Furthermore, during each reactor outage and prior to restarting, additional checks (thickness measurements and non-destructive examinations to detect faults) were carried out on the welds concerned.

ASN questioned the other manufacturers of large equipment items (Westinghouse and MHI) in order to check the appropriateness of the post-weld heat treatment processes they use. Tests and digital simulations are currently being carried out, notably to ascertain that the manufacturing conditions at the two manufacturers guarantee the conformity of the heat treatment operations with respect to the temperature ranges stipulated in the RCC-M code.

See Focus 7 in Chapter 6.

[4] To reduce the residual mechanical stresses that appear in the materials when components are welded, the manufacturer applies a stress relieving heat treatment (SRHT) which consists in heating the material for several hours to temperatures of a few hundred degrees. The treatment temperature and duration must be controlled in order to remove the stresses resulting from the welding, without altering the mechanical properties of the material while doing so.

***Detection of stress corrosion***

In November 2021, during the second ten-yearly outage of reactor No. 1 of the Civaux NPP (N4 plant series) ultrasound inspections performed on the four “cold” legs of the safety injection system (ECCS) revealed indications on each of the four legs.

As the signature of the inspection results was atypical, in-depth examinations were carried out. The four elbows were cut up and subjected to laboratory assessment. The expert assessments reveal the presence of cracks initiated on the internal skin of the pipe, with intergranular propagation which is typical of stress corrosion (SC), an unexpected phenomenon given the design, manufacturing and operating provisions.

In view of the unexpected origin of these cracks measuring a few millimetres, EDF decided:

- to shut down the 4 reactors of the N4 plant series,
- to inspect the pipes of the 900 and 1300 MWe series reactors in maintenance outage,
- to shut down the 6 reactors identified as being potentially the most affected after re-reading the inspections reports from their last ten-yearly outage, in order to inspect them.

At this stage, EDF has shut down or prolonged the scheduled outage of 12 reactors to allow in-depth expert assessments and, if necessary, repair. The reactors of the N4 series are more affected than those of the 1300 MWe series, while the oldest reactors of the 900 MWe series seem little affected by the phenomenon. The analyses conclude that the main cause is most probably linked to the geometry of the lines of pipes.

The mechanical calculations performed by EDF in line with the maximum detected defect sizes provide proof of the mechanical integrity of the ECCS lines in an accident situation. Furthermore, EDF has produced substantiation of the acceptability of the consequences of a break in two ECCS lines.

EDF has also put in place, on all the reactors, specific control and leak detection provisions so as to be able to bring the reactors to a safe state if a leak is detected.

ASN has asked EDF to provide a set of complementary substantiations and to propose a prioritised inspection strategy for the potentially affected systems of the reactor fleet as a whole. This strategy is currently undergoing expert assessment.

See Focus 8 in Chapter 6.

## 4.3. International peer reviews

France regularly hosts and participates in international peer reviews, particularly under the auspices of the IAEA or the European Commission (EC).

### 4.3.1. Reviews coordinated by the IAEA

***Integrated Regulatory Review Service (IRRS)***

ASN supports the peer review missions by participating in IRRS missions in foreign countries and by encouraging their hosting in France.

Thus, after an initial plenary mission and a follow-up mission that took place in 2006 and 2009 respectively, ASN hosted another "full scope" IRRS mission in 2014, further to which the auditors issued 46 recommendations and suggestions.

ASN developed an action plan to take appropriate measures in response to these recommendations and suggestions. The follow-up mission took place from 1 to 9 October 2017. The team of auditors concluded that France had significantly reinforced the framework of its regulation and oversight of nuclear safety and radiation protection, while nevertheless pointing out that ASN needed to remain vigilant with regard to human resources in view of the safety issues facing nuclear facilities in France. A total of 40 recommendations have been closed or are considered to be closed "subject to implementation of the ongoing measures". The concluding report of this mission - like the previous reports - was put on line on the ASN website in March 2017.

The next IRRS mission is planned for March 2024.

***Operational Safety Review Team (OSART)***

For many years now, France has also asked the IAEA to conduct OSART (Operational Safety Review Team) missions to perform operational safety review. On average, one OSART mission is organised in France each year. The entire French nuclear fleet has already undergone at least one OSART mission.

The following OSART missions have been carried out since the 7th review meeting:

- in 2017 on the Bugey site;
- in 2019 on the Civaux, Golfech and Bugey sites (follow-up), and at Flamanville 3 (pre- OSART);
- in 2021 on the Paluel, Belleville sites and Flamanville 3 (follow-up);
- in 2022 on the Civaux site (follow-up).

The recommendations are taken into account in the EDF action plans.

### 4.3.2. Reviews coordinated by EC

***European stress tests***

In December 2012, ASN published a national action plan in response to the recommendations resulting from the European stress tests peer review of 2012 and the 2nd extraordinary meeting of the Convention on Nuclear Safety (CNS) held in 2012. This action plan includes the requirements of the ASN resolutions of 26 June 2012 aimed at increasing NPP robustness to extreme situations.

ASN updated this action plan in 2014 and 2017. At the end of 2020, the measures defined by EDF allowed the closing out of the action plan actions and the addressing of the recommendations resulting from the European stress tests peer review. These measures help to improve:

- the protection against internal and external hazards,
- the electrical power resources,
- the prevention of accidents with core melt,
- the prevention of uncovering of fuel assemblies in the pool,
- the management of accidents with core melt,
- the emergency management,
- the on-site response means by deploying the nuclear rapid intervention force (FARN).

See Focus 18 in Chapter 14.

***Topical peer review (TPR)***

Council Directive 2014/87/Euratom of 8 July 2014 amending Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations, institutes a six-yearly peer review of a technical aspect relating to the safety of nuclear facilities.

The first review focused on the ageing management. The conditions of this review, which focused on power reactors and research reactors with a power level above 1 MWth, were defined by ENSREG (European Nuclear Safety Regulators Group) with the support of WENRA. The objectives of this topical review were to:

- enable the participating countries to review their provisions with regard to ageing management in order to identify the best practices and possibilities for improvement;
- have European sharing of the individual experiences of the participating countries and identify problems in common which they all have to address;
- provide the participating States with an open and transparent framework to develop improvement measures in the light of the review conclusions.

As part of this review, ASN drew up a self-assessment report in 2017, with contributions from EDF, the CEA and the ILL, giving the following conclusions:

- EDF's nuclear reactor ageing management approach is appropriate, particularly with regard to requirements of international standards and is backed up by a substantial research and development programme,
- the research reactor ageing management programmes need to be better formalised.

Following the peer review and its conclusions, France has defined improvement actions concerning:

- the taking into account of ageing phenomena specific to long construction phases or extended reactor outages in the ageing management programmes;
- the performance of "opportunity" inspections of underground pipes when they are rendered accessible by other works;
- the development of ageing management programmes for the research reactors.

These improvement actions have been integrated in the national action plan developed in 2018. By the end of 2020 the actions had been carried out, enabling this plan to be closed.

See Focus 25 in Chapter 14.

### 4.3.3. Other reviews

***WANO review***

The safety performance of the NPPs in the French fleet is assessed by the World Association of Nuclear Operators (WANO) by means of peer reviews. Since 2013, each NPP undergoes a review every four years jointly with an audit by the EDF nuclear inspectorate.

## 4.4. Outcome from the 7th review meeting

At the end of the 7th Convention review meeting, a number of challenges were identified, firstly those specific to each contracting party and secondly those common to all the contracting parties.

### 4.4.1. Challenges identified for France

The rapporteurs' reports indicate the challenges and suggestions for each contracting party, on which each country must report at the next review meeting.

At the end of the 7th Convention review meeting, five challenges were identified for France. The actions implemented to meet these challenge are summarised below and detailed in the report:

***Addressing the human resourcing needs for successful execution of demanding concurrent projects***– FR-2017-01

Between 2008 and 2018, EDF was faced with the need for a massive renewal of skills, which led to an unprecedented drive in terms of training and accompanying new employees, and the deployment of professional trade academies for on-site training of newcomers.

At the end of 2018, ASN underlined the need for the nuclear industry to refocus its attentions in order to maintain the key industrial skills vital to the quality of the work done and the safety of the facilities. Moreover, following the 2019 resolution concerning the repair of the EPR welds, the Jean-Martin Folz report in response to the government's demand underlines the question of the "*widespread loss of skills*", explained in part by the fact that no nuclear reactors were built in France over a long period of time, and concludes with "*the effort to be undertaken to reconstitute and maintain skills in the nuclear sector*".

Since then, a number of initiatives have been taken to remedy this loss of skills and restore the culture of quality:

- the creation in 2018 of the GIFEN (French nuclear energy industrial grouping), bringing together the entire French nuclear sector in a single professional union and covering all types of industrial activities (design, manufacture, construction, maintenance, etc.) and the areas of nuclear electricity production (fuel cycle, research, electricity production, equipment manufacture, decommissioning, etc.). This makes it possible to identify the needs and facilitates dialogue with the public authorities;
- EDF's Excell action plan "to restore the level of quality, rigour and excellence that reigned during the construction of the French nuclear fleet", presented in December 2019 after the abovementioned Folz audit. This plan is based on the reinforcement of industrial quality, of skills and of the governance of the major nuclear projects. Several of its actions, such as "the in-depth review of customer-supplier relations", "regular project tracking by the board of directors", or "the reinforcement of the qualification of manufacturing processes and traceability tools for the most sensitive operations" have been started;
- the creation of a University of Professional Activities in the Nuclear Sector (UMN), which aims to give impetus to the nuclear sector's training resources, especially the critical skills, in order to speed up recruitments in the activities suffering most from skills shortages.

In addition, the new energy policy perspectives in the nuclear sector imply a considerable industrial effort to meet the industrial and safety challenges. The nuclear sector needs to put in place a real recovery and general mobilisation plan to render this perspective industrially sustainable and to have the skills enabling it to take on projects of such scale and duration.

***Collaborating with international counterparts to evaluate and (as needed) supplement codes and standards for large equipment manufacturing to address carbon segregation issue and other relevant subjects*** – FR-2017-02

Further to the detection of anomalies in the chemical composition of the steel of the Flamanville EPR reactor pressure vessel closure head and bottom head, EDF informed ASN that SG channel heads manufactured by

Creusot Forge and Japan Casting and Forging Corporation (JCFC,) equipping 18 reactors in service, were also affected by the carbon segregation problem.

In the light of the anomalies observed on the French NPP fleet, ASN suggested to the WENRA members in 2018 that a recommendation be prepared: the working group coordinated by ASN agreed on a text that was adopted at the plenary session of 24-26 April 2018. The adopted recommendation stipulates that WENRA members must undertake to have the licensees take measurements of the carbon concentration in large-sized forged components and analyse the results. It is also recalled that the licensees are responsible for conserving manufacturing records. In addition, for new constructions it is requested that the safety important manufacturing parameters be identified and verified in order to guarantee the quality of the component (areas with a risk of heterogeneity, heat treatments, location of control test coupons). Generally speaking, the interaction between the licensee, the designer and the manufacturer must be reinforced on these subjects.

Further to this anomaly, work to revise the RCC-M code published by AFCEN[5] has begun This code now includes a method for controlling the risk of heterogeneity: the manufacturer must identify the parameters that can influence the risk of heterogeneity resulting from the operation in question, check their effects through a test programme on a dedicated part, then check these parameters on the production parts through an acceptance test programme.

Alongside this, within the WGCS group of the CNRA, ASN is working with its counterparts on establishing a consensus position relative to the qualification of the materials manufacturing techniques. The aim is to consider the subject from the overall viewpoint of manufacturing processes, and their impact on component quality: conformity deviations, non-uniformity (heterogeneity) of the final characteristics of materials, such as carbon segregation, etc.

***Completing evaluation and regulatory response to manufacturing practice irregularities*** – FR-2017-03

Following the irregularities discovered in the manufacturing files of Creusot Forge, ASN initiated a review of its regulation and oversight activities so that cases of fraud could be prevented, detected and dealt with.

In 2018, ASN defined an action plan to optimise the prevention, detection and handling of suspected cases of fraud. Within this framework, ASN has more specifically enhanced its own oversight process with the addition of a search for fraud during the course of inspections. More specifically, the question of data integrity - linked to the risk of fraud given that shortcomings in traceability can facilitate irregularities - is increasingly addressed and forms the subject of requirements in certain inspection follow-up letters. ASN has also implemented a system for reporting of fraud or falsification on its website, as well as an in-house process for responding to these reports. ASN follows up all potential cases of fraud reported to it by the licensees or whistle-blowers.

ASN has also asked the industry players to step up their actions in this respect. Since 2017, EDF has put in place specific provisions with the aim of preventing and detecting these risks. More specifically, EDF has adapted its monitoring practices, notably through increased use of unannounced inspections or checks in the presence of all parties. EDF has also refocused its manufacturing inspections in suppliers' factories or for on-site repairs and modifications, with manufacturing inspection measures on suppliers' premises focusing more on the detection of counterfeit, fraudulent or suspect item (CFSI) issues. Since the beginning of 2021, all the

[5] AFCEN, the French association for rules on design, construction and in-service monitoring of nuclear steam supply systems, comprises 60 French and international industry players, including EDF, Framatome and the CEA.

EDF group entities have initiated the ISO 19443 certification procedure. By early 2022, a large number of EDF entities had already obtained ISO 19443 certification (for the others, the procedure is in progress). This procedure reinforces integration of the CFSI risk.

Lastly, under the impetus given by the GIFEN (French Nuclear Energy Industry Players Group), many suppliers have engaged in the ISO 19443 certification procedure, the provisions of which include specific requirements regarding training, detection, supplier monitoring and information on CFSI aspects: this provides additional structural guarantees for taking the CFSI risk into account.

For more details, see § 7.4, § 13.2 and Focus 23 in § 14.2.2.

***Ensuring adequate maintenance of power plants, including through efforts being developed such as in-field technical training and supervision*** – FR-2017-04

EDF has a maintenance policy for the nuclear fleet in operation that is structured to enhance the reliability of the equipment and systems, to guarantee throughout the installation's life cycle that they are capable of fulfilling their assigned functions with respect to the stresses and ambient conditions that can prevail in the situations for which they are required. The maintenance programmes specify the nature and frequency of the preventive maintenance activities. They are subject to a continuous improvement process based on operational experience feedback from the structures, systems and components (SSCs).

EDF has Training Committees in the units who define "just-in-time" training courses with the aim of safeguarding the accomplishing of certain sensitive activities, particularly through "mock-up spaces" for maintenance.

EDF has also put in place a system of prior qualification of outside contractors who perform a large proportion of the maintenance operations on the French nuclear power reactor fleet. It is based on an assessment of the technical know-how and quality organisation of the subcontractor companies and is formally written up in the Social Requirements document, a constituent of the contracts, created under the work of the CSFN (Nuclear Sector Strategic Committee) with EDF and its main contractors.

For more details, see § 11.2, § 13 and § 19.3.2.

***Coming to a technical/regulatory position by 2019 regarding the reasonable application, as part of the PSR process, of EPR (Generation III) safety objectives and lessons learned from previous PSRs and regulatory ten-year inspections to existing reactors*** – FR-2017-05

Within the framework of the 4th PSR of the 900 MWe reactors (see Focus 16), ASN issued a position statement on the level of safety to achieve for continued operation of the reactors: the safety objectives adopted for this PSR have been defined with regard to the objectives applicable to the new generation reactors, particularly the reduction of the radiological consequences in the event of an accident (with or without core melt).

In 2020, with the assistance of IRSN, ASN finalised its examination of the generic studies linked to the 4th PSR. On completion of this examination, ASN issued a resolution in February 2021 on the conditions for continued operation of the reactors.

For more details, see § 6.3, § 14.1.2.2 and Focus 17.

Alongside this, one issue stemming from the 6th review meeting was still open: ***Finalize implementation of Fukushima lessons learned*** (FR-2014-01)

In December 2012, ASN published the national action plan in response to the recommendations resulting from the European stress tests peer review of 2012 and the 2nd extraordinary meeting of the Convention on Nuclear Safety (CNS) held in 2012. This action plan includes the actions aiming to increase NPP robustness to extreme situations.

ASN issued progress statements on these actions in 2014 and 2017 (updating the action plan). At the end of 2020, the measures defined by EDF enabled the actions plan actions to be closed out and the recommendations from the European stress tests peer review to be addressed.

See Focus 18 in § 14.1.2.2.

### 4.4.2. Challenges common to all the contracting parties

Nine subjects have been identified as challenges for all the Contracting Parties to the Convention. The two challenges addressed by topical sessions during the review meeting are detailed below:

***Safety culture***

The safety policy signed by the EDF Chairman & CEO set the requirements and principles for ensuring, in all the decisions taken at all levels of the company, the priority given to the protection of interests, first and foremost by preventing accidents and mitigating their consequences on account of nuclear safety.

Responsibility for implementing this policy lies with the corresponding managerial line. It reaffirms the priority given to safety, with strong commitments in terms of behaviour and safety culture, the search for constant progress, and openness to international best practices. This policy is disseminated to each member of staff and to each contractor and subcontractor.

Each NPP director is committed to developing continuous improvement and integrating the best practices resulting from the peer reviews (OSART and WANO). The safety culture is reinforced in each NPP through the development of safety leadership and the "Safety Culture" road map. This road map contains different types of improvement actions which relate to training, the use of safety management levers and practices (risk analyses, work reliability-enhancement practices, inspection, etc.) but also time for sharing ideas and discussion within the teams.

EDF also has independent safety assessment systems, like the independent safety organisation and the CSNE (Nuclear Safety and Operations Committee), which allows a cross-cutting safety analysis of operating events with the participation of senior management of all the units.

See Chapter 10 and Focus 14.

***Managing the safety of ageing nuclear facilities and plant life extension***

EDF has implemented an ageing management strategy for its nuclear power reactors which is based on three lines of defence: anticipation of ageing in the design, monitoring of the actual condition of the facilities and the repair, renovation or replacement of equipment actually or potentially affected.

Ageing management is based in particular on design, operating, in-service monitoring and routine maintenance measures, supplemented by exceptional maintenance steps. It contributes in particular to maintaining the qualification of protection important components (PICs). In this respect it comprises:

- analyses of the ageing mechanisms and of the capability for continued operation of the components for all the reactors with regard to the behaviour of the equipment items and demonstrating management of their ageing,

- an analysis specific to each reactor to confirm that the generic analyses do effectively cover its particularities, with this analysis providing proof of the reactor's fitness for continued operation,
- maintenance, periodic testing and renovation programmes,
- the obsolescence management programmes decided nationally or locally.

Within the framework of the 4th periodic safety review, EDF implemented a major programme of work relating to equipment ageing in view of the continued operation of the facilities beyond 40 years.

The question of nuclear reactor ageing management was also the subject of the first Topical Peer Review stipulated by Council Directive 2014/87/Euratom of 8 July 2014 establishing a six-yearly peer assessment of a technical subject linked to the nuclear safety of their nuclear installations.

See § 14.2.2.2, Focus 24 and Focus 25.

***International peer reviews***

The international peer reviews are detailed in paragraph 4.3.

***Legal framework and independence of regulator body***

The regulatory framework governing the BNIs is detailed in the chapter dedicated to Article 7.

The independence of the regulator is addressed in the chapter dedicated to Article 8.

***Financial and human resources***

The human and budgetary resources are addressed in the chapter dedicated to Article 8 for the safety authority (nuclear regulator) and in the chapter dedicated to Article 11 for the licensees.

***Knowledge management***

Knowledge management is addressed in the chapter dedicated to Article 11.

***Supply chain***

The supply chain is addressed in the chapter dedicated to Article 13. ASN's role in supplier oversight is addressed in paragraphs § 13.4, § 18.2.3.

***Emergency preparedness***

Emergency preparedness is detailed in the chapter dedicated to Article 16.

***Stakeholder consultation and communication***

Consultation of the stakeholders and communication are detailed in paragraphs § 7.2.5, § 8.1.3, § 9.2 and Focus 13.

## 4.5. Future main activities until the next review meeting in three years

The ASN oversight challenges for the next 3 years, with regard to nuclear reactors, concern:

***Commissioning of the EPR reactor***

EDF plans fuel loading and reactor startup by mid-2023.

The commissioning authorisation application file comprising the safety analysis report, the general operating rules, the on-site emergency plan, the decommissioning plan, an update of the impact assessment and the risk assessment, is examined by ASN, assisted by IRSN and the Advisory Committees of Experts. A number of specific points relative to the design of certain equipment items (pressuriser valves, recirculation function filtration system) or the safety case (integration of operational experience feedback from the EPRs in service) are still being examined. ASN must also finalise the examination of the startup test results in order to check that the as-built facility complies with the assumptions used in the safety case.

ASN is continuing its tightened oversight of the weld repair work on the Flamanville EPR secondary systems to check the quality of the new welds. ASN is also finalising the conformity assessments of the nuclear pressure equipment most important for safety.

ASN will issue a resolution on the commissioning authorisation application in 2023.

***The fourth generic periodic safety review of the 1300 MWe reactors***

In July 2017, EDF presented a file giving the approaches envisaged for the generic phase of the fourth periodic safety review of the 1300 MWe reactors. The aims of the fourth periodic safety review of the 1,300 MWe reactors are similar to those for the 900 MWe reactors

ASN has started examining the generic safety review file, which contains the installation conformity verification procedure, the management of ageing and obsolescence, reactor pressure vessel integrity studies, spent fuel pool safety studies, the mitigation of the consequences of accidents, the improvement in the management of accidents with core melt and the installation's ability to withstand internal and external hazards. Its examinations have focused in particular on the methods that will be used in this review to analyse certain accidents and to assess the hazard robustness of the installations. EDF has started the studies necessary for updating of the regulatory reference files of the main primary and secondary systems.

ASN plans to issue a resolution on the generic studies for this safety review in 2025.

***The EPR2 project***

EDF is developing a new reactor called EPR 2, with the aim of integrating the lessons learned from the design, construction and commissioning of the EPR reactors and the operational experience feedback from the reactors in service. As with the EPR reactors, this project aims to meet the general safety objectives of third-generation reactors. Furthermore, this reactor will integrate, from the design stage, all the lessons learned from the Fukushima Daiichi NPP accident. This more specifically entails reinforcing the design against natural hazards and consolidating the autonomy of the installation and the site in an accident situation (with or without core melt) until such time as the off-site resources can intervene.

EDF submitted its safety options dossier (DOS) in 2016. After examining this dossier, ASN made a position statement on the safety options in July 2019. ASN considers that the general safety objectives, the baseline safety requirements and the main design options are on the whole satisfactory. ASN’s opinion identifies the subjects to be considered in greater depth prior to submitting a reactor creation authorisation application. The additional technical information provided by EDF further to this opinion led to the conclusion that the adoption of a break preclusion approach for the primary and secondary system pipes was acceptable.

EDF has planned submitting its creation authorisation application for a first pair of EPR2 reactors at the Penly site in March 2023, following on a public debate to take place in the autumn 2022.

***The Nuward SMR project***

EDF plans submitting its safety options dossier for the NUWARD™[6] small modular reactor (SMR) project developed by a consortium comprising EDF, Technicatome, the CEA and Naval Group, at the end of 2022.

ASN, assisted by IRSN, will start examining the safety options dossier as of 2023.

For information, ASN has already begun technical discussions with the Nuward project prior to submission of the DOS. These discussions, which concern the main safety options of the NUWARD™ SMR project sponsored by EDF, are under way with the Finnish nuclear regulator (STUK) and the Czech nuclear regulator (SUJB). This tripartite initiative, launched by ASN in the 1st quarter 2022, is a first in Europe. It aims to achieve a joint assessment of the main safety options considered by EDF, and notably the targeted safety objectives, the safety approach used in the design, the use of passive systems and the integration of two reactor modules within a single installation.

The experience and the conclusions of this multilateral review of an advanced-design SMR project will bring tangible progress in the harmonisation and convergence of the authorisation processes applicable to such reactors, particularly under the initiative for the development of SMRs launched by the European Union in 2021 and the IAEA's Nuclear Harmonisation and Standardisation Initiative (NHSI).

## 4.6. Implementation of the principles of the Vienna Declaration

The Vienna Declaration, adopted in February 2015, sets out the principles relative to implementation of the objective of the Convention on Nuclear Safety, which is to prevent accidents that could have radiological consequences and to mitigate these consequences should they occur.

1. *New nuclear power plants are to be designed, sited, and constructed, consistent with the objective of preventing accidents in the commissioning and operation and, should an accident occur, mitigating possible releases of radionuclides causing long-term off site contamination and avoiding early radioactive releases or radioactive releases large enough to require long-term protective measures and actions.*

For the design of the EPR reactor, three main improvement objectives with respect to the preceding reactors have been adopted, which figure in the "*technical directives for the design and construction of the next generation of pressurised water nuclear reactors*":

- reduce the number of incidents with the aim of reducing the possibilities of accident situations arising further to such events;
- significantly reduce the probability of core melt;
- significantly reduce the radioactive releases that could result from all conceivable accident situations, including core melt accidents. The technical directives stipulate in this respect that:
  - *" for accident situations without core melt, there shall be no necessity of protective measures for people living in the vicinity of the damaged plant (no evacuation, no sheltering)";*
  - *"Low pressure core melt sequences have to be dealt with so that the associated maximum conceivable releases would necessitate only very limited protective measures in area and in time for the public. This would be*

[6] The NUWARD™ project is an electricity production unit concept consisting of two pressurised water nuclear reactors of 170 MWe each. This project lies within the reactor category referred to internationally as Small Modular Reactors (SMRs).

*expressed by no permanent relocation, no need for emergency evacuation outside the immediate vicinity of the plant, limited sheltering, no long term restrictions in consumption of food";*

- *"Accident situations with core melt which would lead to large early releases have to be "practically eliminated": if they cannot be considered as physically impossible, design provisions have to be taken to design them out. This objective applies notably to high pressure core melt sequences".*

These EPR safety objectives are those of Principle No.1 of the Vienna Declaration on Nuclear Safety.

Produced jointly with IRSN, the ASN Guide No. 22 contains recommendations with regard to safety for the design of pressurised water reactors. The guide focuses essentially on the prevention of radiological incidents and accidents and the mitigation of their consequences. It details the general design objectives and principles and makes recommendations to help meet regulatory requirements. It updates the technical directives adopted by ASN in 2000. The safety objectives are similar to those set out in the technical directives and correspond to those of principle No.1 of the Vienna Declaration on Nuclear Safety.

The Flamanville 3 creation authorisation decree issued in 2007 specifies that "*accidents with core melt which could lead to early large-scale releases are the subject of designed-in preventive measures, supplemented if necessary by operational provisions, the performance and reliability of which should consider this type of situation to be precluded*" and *"that in the event of an accident situation with low-pressure core melt, it would only be necessary to resort to population protection measures that are extremely limited in terms of scope and duration*". Furthermore, for accidents without fuel meltdown (in the reactor core or pool), the objective is that the radiological consequences should be as low as reasonably achievable and, whatever the case, they must not lead to the need to implement population protection measures (no sheltering, no taking of stable iodine tablets, no evacuation).

In its commissioning authorisation application for Flamanville 3, EDF provided elements demonstrating achievement of these objectives, elements which have been examined and have been reviewed by the Advisory Committee for Nuclear Reactors. ASN deemed this demonstration satisfactory.

2. *Comprehensive and systematic safety assessments are to be carried out periodically and regularly for existing installations throughout their lifetime in order to identify safety improvements that are oriented to meet the above objective. Reasonably practicable or achievable safety improvements are to be implemented in a timely manner.*

The Environment Code stipulates that BNI licensees must perform periodic safety reviews of their facility, taking international best practices into account (Article L. 593-18). "*This review must allow […] updating of the assessment of the risks or drawbacks presented by the installation […], taking into account more specifically the state of the installation, the experience acquired during operation, the development of knowledge and of the rules applicable to similar installations".*

The periodic safety reviews thus provide the opportunity to conduct large-scale inspections and modifications to installations, intended to improve safety taking account of changes in requirements, practices and knowledge, as well as operational experience feedback. In addition to a verification of installation conformity, they include a safety reassessment aiming to determine the level of safety and to improve it in the light of:

- the French regulations and the most recent safety objectives and practices in France and abroad;
- the operational experience feedback for the installation;
- the operational experience feedback from other nuclear installations in France and abroad;
- the lessons learned from other installations or facilities involving risks.

More specifically, the safety objectives considered for the 4th periodic safety review of the 900 and 1300 MWe plant series were defined in the light of the safety objectives set for the third-generation reactors, and notably the EPR. In this respect, EDF has extended its safety case to the prevention and mitigation of severe accidents, including in extreme beyond-design-basis situations and is implementing major modifications.

In 2011, France began conducting complementary safety assessments further to the Fukushima Daiichi NPP accident: they fitted into a dual context: firstly, the conduct of a nuclear safety audit of the French civil nuclear facilities with regard to the Fukushima Daiichi events, and secondly, the organisation of the nuclear power plant stress tests required by the European Council at its meeting of 24 and 25 March 2011.

The complementary safety assessments were thus carried out following the European specifications for all nuclear installations, that is to say NPPs, research facilities, fuel cycle facilities and installations under construction (EPR, JHR and ITER).

Further to this review, ASN issued resolutions for the BNI licensees so that their material and organisational provisions can:

- prevent a severe accident or limit its progression;
- limit large-scale releases of radionuclides into the environment in the event of an accident;
- enable the licensee to fulfil its duties in an emergency situation.

EDF has introduced significant changes in its installations, with the aim of better preventing/mitigating situations involving total loss of electrical power and loss of the heat sink (reinforcement of the emergency organisation, creation of the FARN rapid intervention force, addition of one diesel generator set and one water source per reactor).

Lastly, Council Directive 2014/87/Euratom of 8 July 2014 introduced the holding of a peer review of a technical aspect relating to the nuclear safety of their nuclear facilities, at least every six years. The first of these Topical Peer Reviews held in 2017 addressed the subject of ageing management. Further to the peer review and its conclusions, France defined improvement measures which were integrated in the national action plan produced in 2018. By the end of 2020 the actions had been carried out, enabling this plan to be closed.

3. *National requirements and regulations for addressing this objective throughout the lifetime of nuclear power plants are to take into account the relevant IAEA Safety Standards and, as appropriate, other good practices as identified inter alia in the Review Meetings of the CNS.*

France has established and maintains in effect a national legislative and regulatory framework relative to the nuclear safety of BNIs. French legislation and the regulations applicable to BNIs are based on the fundamental principle of the prevention of accidents with radiological consequences and the mitigation of the consequences should an accident occur.

The periodic safety reviews described above integrate the developments in safety standards, particularly those of the IAEA. With regard to the nuclear power reactors, the OSART missions conducted on the sites or at the licensee's head offices are also based on the IAEA standards and current best practices.

The regulatory requirements are subject to regular reviews, which take into account developments in international standards and documents (ICPR, AIEA, WENRA). The BNI Order and ASN regulations (see Appendix B) broadly integrate the WENRA safety reference levels into French legislation.

More specifically, the preparation of any new technical regulation at ASN involves the production of a "Document d'Orientation et de Justification" (Guidance and Justification Document) which presents more specifically the objectives of the text with the reasons for drafting or amending it, the regulatory texts and associated or related guides (upstream, to be adapted, created, modified or repealed, etc.). The international standards such as those issued by the IAEA and the recommendations and reference levels issued by the ICRP or WENRA are taken into account in this document.

Furthermore, the significant involvement of France in the work of the IAEA, as much on the CSS as in the five committees (NUSSC, RASSC, TRANSSC, WASSC, EPReSC) and in WENRA fosters the harmonisation of French regulatory requirements with international standards.

# C. REPORTING ARTICLE BY ARTICLE

## Article 6 Existing nuclear installations

**ARTICLE 6 EXISTING NUCLEAR INSTALLATIONS**

***Each Contracting Party shall take the appropriate steps to ensure that the safety of nuclear installations existing at the time the Convention enters into force for that Contracting Party is reviewed as soon as possible. When necessary in the context of this Convention, the Contracting Party shall ensure that all reasonably practicable improvements are made as a matter of urgency to upgrade the safety of the nuclear installation. If such upgrading cannot be achieved, plans should be implemented to shut down the nuclear installation as soon as practically possible. The timing of the shut-down may take into account the whole energy context and possible alternatives as well as the social, environmental and economic impact.***

### 6.1. Nuclear installations in France

#### 6.1.1. Nuclear power reactors

The fleet of nuclear power reactors currently in operation covered by the scope of this Convention comprises 56 pressurised water reactors (PWR) built in successive standardised series. They are grouped in 18 nuclear power plants (NPPs), each comprising between two and six reactors of the same plant series (see the geographical location map in figure A-1 in Appendix A). All these reactors were designed by the same supplier, Framatome. They were commissioned between 1978 and 1999 (see figure A-2 in Appendix A). They include:

- the 32 reactors of 900 MWe situated on the Bugey, Dampierre, Gravelines, Blayais, Tricastin, Chinon, Cruas and Saint-Laurent-des-Eaux sites,
- the 20 reactors of 1300 MWe situated on the Paluel, Flamanville, Saint-Alban, Belleville-sur-Loire, Cattenom, Golfech, Nogent-sur-Seine and Penly sites,
- the 4 reactors of 1450 MWe situated on the Chooz and Civaux sites.

In December 2022, the average age of the reactors in service, based on the dates of the first divergence of the reactors, stood as follows:

- 40 years for the thirty-two 900 MWe reactors,
- 35 years for the twenty 1300 MWe reactors,
- 25 years for the four 1450 MWe reactors.

The 1650 MWe EPR reactor situated at Flamanville is under construction. EDF has announced it will be commissioned in mid-2023.

#### 6.1.2. Research reactors

Two research reactors are in service in France:

- the High-Flux Reactor (HFR), situated near the CEA's Grenoble site and operated by the Laue-Langevin Institute (ILL), a research institute comprising several European partners,
- the Cabri reactor, situated at the Cadarache centre and operated by the CEA, and intended for experimental programmes that aim to achieve a better understanding of the behaviour of the nuclear fuel of pressurised water reactors in the event of a reactivity accident.

The CEA, in partnership with EDF and Framatome, along with other foreign organisations, is building the Jules Horowitz research reactor (JHR) on the Cadarache site: it will constitute a European experimental irradiation tool, at the disposal of the nuclear industry, research organisations and nuclear safety authorities and their technical support organisations. It will also produce radionuclides for nuclear medicine and the non-nuclear industry. Commissioning of reactor is currently scheduled for 2028.

The list of French research reactors in service and under construction is given in § A.3 of Appendix A.

## 6.2. Overview of safety-related events since the 7th review meeting

ASN endeavours to circulate information to its counterparts on noteworthy events that have affected French nuclear facilities. The aim of this paragraph is to recapitulate a number of notable events that have occurred on the nuclear fleet since the last review meeting:

***Seismic resistance deficiency in the Donzère-Mondragon canal embankment which protects the Tricastin NPP***

### Focus 1 : The Tricastin NPP embankment

At the request of ASN, EDF studied the seismic behaviour of the embankments of the Donzère Mondragon canal situated upstream of the Tricastin NPP. In this light of the conclusions of its geotechnical investigations and its studies, EDF reported a significant safety event (ESS) to ASN on 18 August 2017 concerning a deficiency in stability of a section of the embankment to the safe shutdown earthquake (SSE). ASN rated this event level 2 on the INES scale.

On 27 September 2017, in view of the analysis of the potential consequences for safety should this 400 m section of embankment fail, ASN imposed the temporary shutdown of the four Tricastin NPP reactors. The assessments showed in effect that the flooding resulting from failure of the embankment could lead to an accident with melting of the nuclear fuel of the four reactors while rendering deployment of the on-site and off-site emergency management resources particularly difficult.

In December 2017, ASN approved restarting of the reactors after completion of the initial embankment reinforcement work and putting in place human and material resources (backfill, construction equipment, etc.) necessary to rapidly carry out the work necessary to repair any damage to the embankment that could be caused by an earthquake.

Through a resolution of 25 June 2019, ASN then required EDF to carry out additional embankment reinforcement to ensure its robustness beyond the SSE up to the extreme earthquake defined following the Fukushima Daiichi accident. This resolution requires this reinforcement work to be completed by the end of 2022 at the latest.

Pending this reinforcement work, the ASN resolution obliges EDF to:

- ensure tightened monitoring of the embankment;
- carry out specific actions should the piezometric level rise, including reactor shutdown as of a given alert threshold;
- maintain human and material rapid response resources at the embankment.

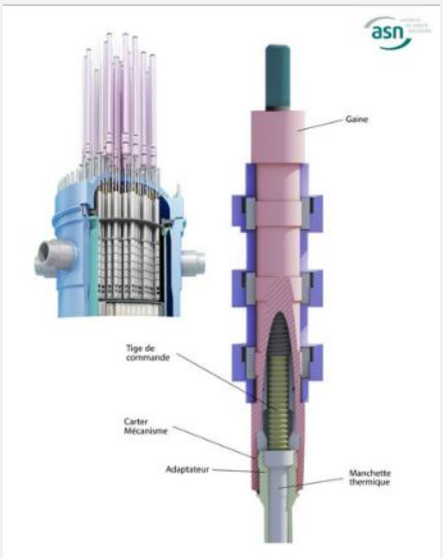
***Wear of the thermal sleeves of the rod cluster control assemblies having led to a risk of blockage of the RCCAs on the 1,300 MWe reactors***

## Focus 2 : Wear of the thermal sleeves

Further to a blockage during rod drop tests on the Belleville 1 reactor in 2017, wear of the upper flange of the thermal sleeves was detected. This wear led to rupture of the upper part of the sleeves creating metallic debris which blocked the travel of one RCCA. EDF has observed this RCCA blockage phenomenon on several 1,300 MWe reactors:

- on reactor 2 of the Saint-Alban NPP on 3 November 2017,
- on reactor 2 of the Belleville-sur-Loire NPP on 5 and 13 December 2017,
- on reactor 1 of the Nogent-sur-Seine NPP on 17 August 2018.

Further to the detection of this wear phenomenon, EDF initiated a plan to inspect the thermal sleeves of all its reactors. The investigations showed that the twenty 1,300 MWe reactors are particularly likely to be affected by this significant wear. Pending inspections of all the 1,300 MWe reactors at their refuelling outage, ASN asked EDF to conduct monthly rod drop tests (test normally carried out once when restarting a reactor after refuelling and once at the end of the cycle before the next refuelling) and, as a compensation measure, to put in place operating measures to ascertain that reactor trip remains effective even in the event of several RCCAs blockage.




On the basis of these inspections, EDF set up a maintenance strategy which consists in, depending on defined criteria, either replacing the thermal sleeves, or installing compensators on the top of the rod cluster guides to prevent lowering of the sleeve which is the cause of its wear, or removing the sleeves located on the unused rod clusters. Since this strategy was put in place, 34 thermal sleeves have been replaced, 5 have been removed, and 37 compensators have been installed.

***The earthquake at Le Teil near the Cruas and Tricastin NPPs***

## Focus 3 : The Le Teil earthquake

An earthquake occurred in the municipality of Le Teil on 11 November 2019. During this earthquake, one of the five sensors of the seismic monitoring system, required by basic safety rule RFS 1.3.b, in the Cruas NPP exceeded the threshold beyond which the reactors must be shut down in order to carry out in-depth verifications. The ground movements recorded were about five times lower than the level taken into consideration in the reactor safety case.

EDF carried out an in-depth diagnosis of its Cruas installations, the content of which was submitted to ASN. It inspected more particularly the civil engineering structures and the condition of the safety important equipment. The Cruas NPP nuclear island is built on aseismic bearing pads which attenuate the seismic movements. EDF inspected the condition of these pads further to this earthquake. At the request of ASN, EDF carried out tests to check the correct functioning of the reactor safeguard systems.

ASN approved restart of reactors 2 and 4 on 6 December 2019, reactor 3 on 11 December 2019 and reactor 1 on 16 January 2020.

A reassessment of the seismic hazard for the Cruas site was carried out, postulating extension of the network of faults which caused the Le Teil earthquake under the site and assuming the occurrence of an identical earthquake with a magnitude increased by 0.5. As this reassessed earthquake exceeds the seismic motion spectrum of the SSE adopted for the site's third periodic safety review, within a limited frequency range, studies to verify the seismic behaviour of the installation and any needs for seismic reinforcement are in progress as part of the fourth periodic safety review.

***Maintenance deficiency in a circuit leading, in the event of an earthquake, to a risk of flooding and loss of the heat sink***

### Focus 4 : Fire-fighting circuit of water pipe degradation

The preventive maintenance programme for the equipment making up the fire-fighting water production system (JPP) of the 1,300 MWe reactors provides for monitoring of the fire protection pipes by external visual inspections, the aim of which is more specifically to detect corrosion, leaks, sweating or perforation of the pipes and their connection seals.

Following an inspection, ASN requested in March 2017 that EDF inspects the condition of fire-fighting water production system (JPP) pipes of the Belleville NPP. The first results revealed faster deterioration than expected on some sections. EDF therefore decided to extend its inspections to other sections, which revealed pipes in deteriorated conditions in the pumping station premises, with a level of corrosion that do not meet anymore the requirements guaranteeing their seismic resistance.

The JPP pipes in question are situated in the pumping station premises of the essential service water systems (SEC) of each reactor. The SEC system is used for cooling, via the intermediate cooling system, all the safety important systems and equipment of the installation. In the event of an earthquake, rupture of the JPP pipes would cause flooding of these premises resulting, in the absence of an effective means of evacuating the water, failure of the SEC system pumps. In such a situation, the residual heat would no longer be removed from the reactor. The licensee therefore deployed mobile water extraction devices to prevent the risk of flooding the SEC pumps. These devices were kept in place throughout the damaged pipe repair phase. ASN conducted an inspection to check implementation of the compensatory devices.

EDF also extended its investigations to the SEC pipes, which are also located in the premises of the pumping station, and to all the reactors in service. Rupture of these pipes in the event of an earthquake could also lead to flooding of the SEC pumps and therefore loss of the heat sink.

These investigations revealed significant deterioration of the pipes of the fire-fighting water production and SEC systems on many of the nuclear fleet reactors, meaning that the risk of the SEC system motors being flooded in the event of rupture of these systems further to the maximum historically probable earthquake could not be ruled out.

EDF rapidly implemented repair solutions on the defective pipe sections along with compensatory measures to safeguard the two redundant channels of the SEC system, and completed the definitive repairs at the end of 2018. ASN checks, particularly in the course of its inspections, that the repairs are carried out satisfactorily.

***Defective electrical components rendering the safety systems unavailable***

### Focus 5 : Defective insertion contacts on electrical panels

On 18 December 2019, EDF reported a significant safety event relating to faults on electrical cubicle components which rendered unavailable systems of the Penly NPP reactor 2.

During restarting of the emergency and cooling pumps for post-work requalification, anomalies led EDF to detect malfunctioning of components.

EDF carried out investigations: 28 components replaced on the electrical panels were defective. The components in question were twenty-eight contactor insertion contacts, all from the same manufacturing batch. The contactors are an integral part of the 6.6 kV electrical panels. They serve to switch electrical equipment on or off on the basis of automatic command signals from the control and instrumentation system, the reactor protection system or manual commands sent from the control room or applied locally. A contactor contains a moving and replaceable component called an insertion contact which, by means of two coils, closes the contactor and holds it in the closed position. The insertion contacts of the contactors in question have a defect that makes it possible for them to jam in the open position, preventing them from correctly fulfilling their function.

The defect concerned all the more equipment given that, further to postponement of maintenance on one of the two electrical trains at a previous reactor outage due to unavailability of spare parts, the licensee replaced insertion contacts on the two trains simultaneously, resulting in a common mode. The maintenance strategy is nevertheless normally defined so as to ensure the maintenance of each redundant electrical train during separate reactor outages.

In the event of an accident situation, the simultaneous presence of several defects could have led to the inability to operate safeguard equipment or redundant auxiliaries of the reactor, used to bring the reactor to and maintain it in a safe state.

EDF replaced the 28 defective insertion contacts of the Penly NPP reactor 2 with compliant parts before restarting the reactor. EDF also checked that the other reactors in the fleet were not affected.

***Deficiencies in the seismic resistance on components of emergency diesel generators***

### Focus 6 : Verifications of the conformity on components of the emergency diesel generator sets

In the course of the verifications of the conformity of the electrical power sources of its reactors, EDF detected deficiencies in the seismic resistance of certain components necessary to the functioning of the diesel-engine emergency power generator sets of several of its reactors. These deficiencies concern the incorrect installation of the elastomer couplings on piping, the corrosion of certain portions of pipes or their supports, connection errors in certain electrical cabinets and electrical cabinet or cooling tower anchoring defects.

These emergency diesel generator sets provide a redundant electrical power supply to certain safety systems in the event of loss of off-site electrical power. If off-site electrical power is lost as a result of an earthquake, operation of the emergency diesel generator sets could no longer be guaranteed owing to these defects.

All of the observed deficiencies were repaired by EDF.

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***Fault in the application of a post-weld heat treatment process in a manufacturing plant***

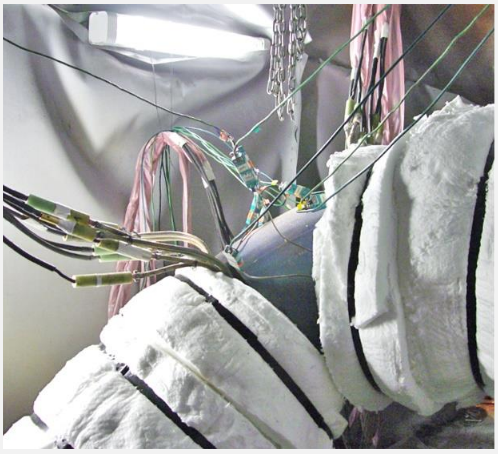
### Focus 7 : Post-weld heat treatment process

In 2019, the manufacturer Framatome brought to light the fact that certain processes used in its Saint-Marcel plant or in the NPPs to assemble components or install the steam generators, had led to insufficient control of the temperatures applied to the treated welds.

To reduce the mechanical stresses created in welded areas, the manufacturer applies a post-weld heat treatment (PWHT), which consists in heating the material for several hours to a temperature of several hundred degrees. This heating can be carried out on the complete part in a furnace if the size of the part so permits, or locally by using heating devices such as electrical heating elements. The treatment temperature and duration must be controlled in order to remove the stresses resulting from welding and to avoid altering the mechanical properties of the material, which could happen if, for example, the material was subjected to excessively high temperatures.

EDF justified the continued integrity of the equipment concerned by drawing on the results of tests performed on representative mock-ups, on material test coupons and by applying numerical temperature prediction models. Furthermore, additional checks (thickness measurements and non-destructive examinations to detect faults) were carried out on the welds concerned during each reactor outage and prior to restarting. No blocking point has been identified to date, but further non-destructive examinations are scheduled over the 2023-2026 period.

Moreover, equipment items currently being manufactured are also concerned: appropriate treatment strategies have been defined for each item of equipment concerned. This includes repair studies, test mock-ups and digital simulation studies to assess the impact of the deviations on the required mechanical properties.



ASN questioned the other manufacturers of large equipment items (Westinghouse and MHI) in order to check the appropriateness of the post-weld heat treatment processes they use. The first elements provided by the two manufacturers are currently being examined. Tests and digital simulations are also currently being carried out, notably to ascertain that the manufacturing conditions applied by these two manufacturers guarantee the conformity of the heat treatment operations with respect to the temperature ranges stipulated in the RCC-M code.

*Copyright : ASN*

***Stress corrosion phenomenon affecting the lines of pipes connected to the primary system***

### Focus 8 : Detection of stress corrosion on the safety injection system (ECCS)

In order to protect against the risk of having an evolving flaw that could lead to fast fracture of an equipment item, the maintenance programmes require the performance of periodic checks. Thus, for each reactor in the nuclear fleet, manual non-destructive examinations (NDEs) are carried out by ultrasounds or radiography at each ten-yearly outage on pre-identified welds. The damage mode looked for corresponds to thermal fatigue damage.

In November 2021, during the second ten-yearly outage of reactor No. 1 of the Civaux NPP (N4 plant series) ultrasound inspections performed on the four cold legs of the safety injection system (ECCS) revealed indications on each of the 4 legs, close to two welds situated upstream and downstream of an elbow in the pipe. No indication had been identified during the inspections carried out during the first ten-yearly outage in 2011. These NDEs were carried out to ensure there was no thermal fatigue damage.

As the signature of the inspection results was atypical, in-depth examinations were carried out. The four elbows were cut up and subjected to laboratory assessment. The expert assessments reveal the presence of cracks initiated on the internal skin of the pipe, mainly near the weld bead root, with intergranular propagation. The mechanism behind the cracking is stress corrosion (SC), a damage mechanism that is not looked for during the periodic checks because the design, manufacturing and operating provisions were such as to exclude - in principle - stress corrosion on these pipes fabricated from austenitic stainless steel.

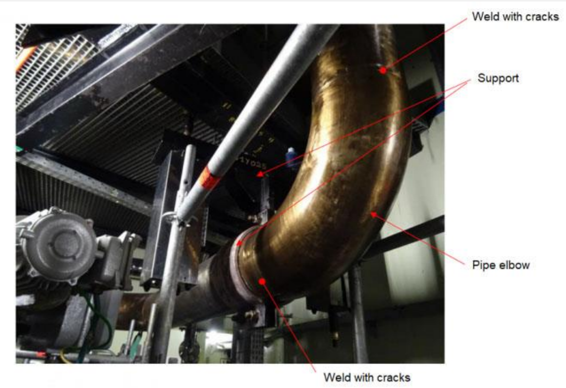
In the light of the unexpected origin of the cracks of a few millimetres discovered in the weld heat-affected zones, EDF decided:

- to shut down the 4 reactors of the N4 plant series;
- to inspect the pipes of the 900 and 1300 MWe series reactors in maintenance outage;
- to shut down the 6 reactors identified as being potentially the most affected after re-reading the reports of the ultrasound inspections performed on the pipes at their last ten-yearly outage, in order to inspect them.

At this stage, in view of the first results, EDF has shut down or prolonged the scheduled outage of 12 reactors to allow in-depth expert assessments and, if necessary, repair.

At this stage, the reactors of the N4 series are more affected than those of the 1300 MWe series, while the oldest reactors of the 900 MWe series seem little affected by the phenomenon. This would seem to confirm that this phenomenon is not related to the ageing of the installations. The analyses of the affected welds conclude that the main cause is most probably linked to the geometry of the lines of pipes: the geometry of the 1,300 MWe and N4 reactor lines favours thermal stratification of the fluid in the horizontal sections of the auxiliary pipes, which creates additional thermomechanical stresses in the heat affected zones of the welds.

The mechanical calculations performed by EDF in view of the maximum detected defect sizes provide proof of the mechanical integrity of the ECCS lines in an accident situation. Furthermore, EDF has produced substantiation of the acceptability of the consequences of a break in 2 ECCS lines, with a compounding (aggravating) factor included.




EDF has also put in place, on all the reactors, specific management and leak detection provisions so as to be able to bring the reactors to a safe state if a leak is detected.

ASN has asked EDF to provide a set of complementary substantiations and to propose a prioritised inspection strategy for the potentially affected systems of the reactor fleet as a whole. This strategy is currently undergoing expert assessment.

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### 6.3. Review of nuclear installation safety and associated safety improvements

In accordance with the provisions of Article L. 593-18 of the Environment Code, the licensee is obliged to conduct a periodic safety review of its installations every ten years. The periodic safety reviews are an ideal opportunity to conduct large-scale inspections and modifications to installations, intended to improve their safety taking account of changes in requirements, practices and knowledge, as well as operational experience feedback. The mechanism of the safety reviews is presented in § 14.1. On completion of the periodic safety reviews, ASN may issue technical requirements governing the continued operation of the installations (L. 593 - 19 of the Environment Code).

### 6.3.1. Nuclear reactor improvements

In view of the similarities between the reactors of a plant series, the periodic safety review of the reactors is in practice carried out in two complementary phases: a first "generic" phase common to all the reactors of a given series, as they were all designed to a similar model, and a second "specific" phase which takes into account the characteristics specific to each installation, notably the geographical location.

***900 MWe reactors***

At the end of 2022, 12 reactors of the 900 MWe series will have undergone their fourth ten-yearly outage. Between 2023 and 2025, 13 additional reactors of the 900 MWe series will undergo their fourth ten-yearly outage and will too integrate the modifications decided during the fourth periodic safety review.

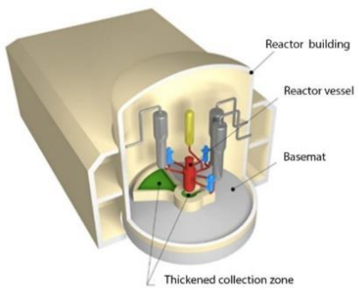
As detailed in Article 14, the safety review of these reactors and the resulting improvements are carried out in the light of the new-generation reactors, such as the EPR, the design of which meets significantly reinforced safety requirements, particular regarding mitigation of the radiological consequences of accidents without core melt (see Focus 9 below) in order to significantly reduce the occurrence of situations requiring the implementation of population protection measures and the reduction of the risk of an accident with core melt and the mitigation of its consequences. In this respect, EDF extended its safety case to include the prevention and mitigation of severe accidents, including in extreme situations beyond the design basis, and has defined major modifications.

The modifications implemented, which are detailed below, have the following aims:

1. Mitigation of the radiological consequences of accidents without core melt: implementation of the resupply of the steam generator emergency supply tank by the fire-fighting water production system, increasing the atmospheric discharge capacity of the turbine bypass unit, interconnection of the ultimate backup diesel generator sets of the even and odd reactor numbers, lowering of the equivalent iodine limit of the radiochemical specifications of the primary system water, etc.;
2. Avoid massive releases and the long-term environmental effects of accidents with core melt: stabilisation of the corium under water by passive reflooding after dry spreading in the reactor pit and the adjacent RIC room and removal of residual power to the exterior of the containment without opening the venting device (see Focus 9 below);
3. Reduce the risk of spent fuel assemblies melting in the storage pool: putting in place of a diversified system for cooling the spent fuel pool in the fuel building;
4. Improving the hazard resistance of the installation: reinforcement of the polar crane to withstand the extreme earthquake, modifications (unit heaters, ventilation systems, etc.) to reduce the temperature in the premises in heatwave situations, lightning protection measures, etc.

## Focus 9 : Modification to limit the consequences of an accident with reactor vessel melt-through

***Installation of a "corium stabilisation" system in the reactor pit***




The purpose of this modification is to limit the consequences for the public and the environment in the event of a severe accident with reactor vessel melt-through by installing a corium stabilisation system on the basemat for accident situations with core melt (system equivalent to the Core Catcher of the EPR).

In an accident situation with core melt, melting of the fuel assemblies can lead to the formation of a pool of corium[7] which can ultimately melt through the reactor vessel and cause erosion of the basemat[8], thereby compromising containment.

The modification allows:

- spreading of the corium after melting through the reactor vessel, which takes place in the reactor pit and the core instrumentation room. Dry spreading of the corium is guaranteed by prior sealing of the reactor vessel pit and the adjacent instrumentation room;
- gravity reflooding of the corium using the water present in the sumps and in the bottom of the reactor building, which have been filled beforehand by the Safety Injection System (RIS), the Containment Spray System (EAS) or by the "hardened safety core" (ND) Spray.

***Installation of a corium cooling system "EAS-ND system"***

The purpose of this modification is to add a means of evacuating the residual power outside the containment in extreme situations without opening the containment venting system.

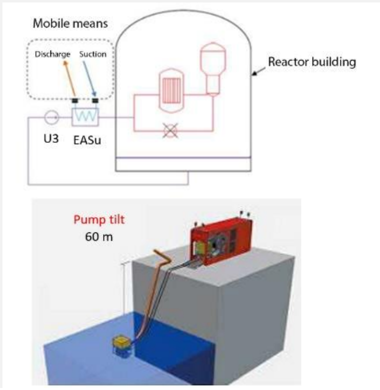
This modification allows the reactor buildings sumps to be filled with water necessary to stabilise the corium.

This system comprises:

- a pump that can function by direct injection from the PTR (Reactor Cavity and Spend Fuel Pit Cooling and Treatment Station) reservoir or by recirculation from the sumps of the reactor building supplied by the ultimate backup diesel generator set (DUS),
- a heat exchanger which evacuates the heat of the primary fluid carried by the pump (EAS-ND) to the mobile ultimate heat sink (SF-u),

[7] Corium is a metallic and mineral magma consisting of molten elements of the nuclear reactor core

[8] The basemat is a concrete slab of several metres thickness which is the foundation of the reactor building




- an ultimate heat sink (SF-u) consisting of mobile pumping equipment brought in and deployed by the FARN rapid response unit (diesel generator sets supplying submersible pumps). This ultimate heat sink is connected to the fixed part of the cooling system by hoses connected to tappings situated at the edge of the nuclear island.

***1300 MWe reactors***

At the end of 2022, 17 reactors of the 1,300 MWe series will have undergone their third ten-yearly outage Between 2023 and 2025, 3 additional reactors of the 1,300 MWe series will undergo their third ten-yearly outage and will integrate too the modifications decided during the third periodic safety review.

The studies carried out in this context lead to modifications that significantly improve the safety of the 1,300 MWe reactors, particularly with regard to the objectives of:

- reducing the radiological consequences of design-basis accidents, in particular with implementing a modification to avoid that the affected steam generator pours water in the event of a steam generator tube rupture, in order to limit releases;
- better take into account certain external hazards, especially:
    - protection of equipment important to safety from projectiles generated by high winds;
    - increasing the capacity of air-conditioning systems in order to maintain, in a heat wave, a temperature in the premises compatible with the operation of equipment important to safety;
    - prevention of the risks of explosion induced in the event of an earthquake by reinforcing the resistance of the hydrogen circuits in the nuclear island and by ensuring automatic shutdown of the electrochlorination installations in an earthquake situation.
- reducing the risk of uncovering the fuel assemblies stored in the pool, in particular by installing a device for automatic isolation of the inlet line of the cooling circuit of the pool in case of detection of a very low water level in the pool;
- reducing the risk of early releases in the event of a severe accident, by limiting gaseous radioactive iodine releases with the implementation of sodium tetraborate baskets.

The aims of the fourth periodic safety review of the 1,300 MWe reactors, with the first reactor planned to undergo its fourth ten-yearly outage in 2026, are similar to those for the 900 MWe reactors.

***1450 MWe reactors***

The four 1,450 MWe reactors will have undergone their second ten-yearly outage at the end of 2022, during which the modifications resulting from the second periodic safety review are implemented.

The studies carried out in this context lead to modifications that significantly improve the safety of these reactors, particularly with regard to the objectives of:

- reducing the radiological consequences of design-basis accidents, notably by improving the leak tightness of the reactor containment (reduction of leaks associated with the sensitive penetrations, leaks at the PTR reservoir and installation of resin sealing coating on the internal containment wall) and improvement in the management of accidents involving steam generator tube rupture;
- reducing the radiological consequences with core melt and the risks of early and significant releases, notably by the installation of sodium tetraborate baskets to limit releases of iodine and the reinforcement of certain equipment items that contribute to containment but were not initially designed to function in the event of core melt (Containment space filtration system and RIS/EAS Leak reinjection system in the reactor building);
- reducing to a residual level the risks of uncovering a fuel assembly in the spent fuel pool by draining, particularly by installing automatic low-level closing systems for the drain valves and the suction valves;
- reinforcing of the protection of the installations against explosion risks (gas yards, protection of H2 pipes, installation of H2 detectors, control systems, ATEX equipment, etc.), against very hot weather (installation and replacement of the cooling units, replacement of sensitive electrical equipment, etc.), against seismic risks ("seismic interaction approach", reinforcement of the bridge between the turbine halls at Civaux, etc.)

### 6.3.2. Improvements to the high flux reactor (HFR) in the Laue-Langevin Institute (ILL)

The safety improvements resulting from the last periodic safety review aim to increase the facility's ability to withstand internal and external hazards and to implement an operational hardened safety core (see Focus 19 in § 14.1.2.2).

The main improvements carried out or planned concern:

- increased reliability of the polar crane lifting system;
- safeguarding the tritium inventory by transforming tritium gas into tritiated water;
- the addition of fire risk control provisions: automatic sprinkler extinguisher system in the reactor building's experimentation areas;
- seismic reinforcement of the reactor building and its protection important equipment, in order to take account of changes to seismic standards, and the reinforcement of the adjacent buildings to guarantee their stability or at least ensure that they do not represent a hazard for the reactor building;
- the installation of an ultimate flooding system supplementing the measures to prevent the risk of draining of the pile block in the event of a break on the reactor primary coolant system;
- installation of the (redundant) groundwater system to guarantee that the fuel remains flooded and cooled. This system may also be used for fire-fighting;
- the installation of the (redundant) seismic depressurisation system enabling the reactor containment to be kept at negative pressure with extraction filtration;
- the installation of automatic cut-out of all non-seismic electrical power supplies when a seismic threshold is reached, to avoid any post-earthquake electrical fire;
- the creation of a new operational emergency management centre to deal with an extreme natural hazard situation.

## 6.4. Final shutdown of reactors

In 2020, the two 900 MWe reactors at the Fessenheim NPP were shut down.

### Focus 10 : Final shutdown of the two reactors of the Fessenheim nuclear power plant

EDF sent the Minister responsible for the ecological transition and solidarity and ASN the demand for the abrogation of operation and the final shutdown notification for the two reactors of the Fessenheim NPP, reactor No. 1 on 22 February 2020 and reactor No. 2 on 30 June 2020.

This followed on from the State's signing on 27 September 2019 of the decision for early closure of the Fessenheim NPP resulting from the capping of nuclear electricity production laid down by the Act of 17 August 2015 relative to energy transition for green growth.

Moreover, since the 7th Convention Review Meeting, CEA research reactors have been definitively shut down:

- the Orphée reactor situated on the Saclay centre, which used neutron beams for research and has been in final shutdown status since late 2019;
- the Masurca reactor, situated on the Cadarache centre, which was a critical mock-up reactor and has been in final shutdown status since December 2018;
- the Éole and Minerve reactors situated on the Cadarache centre, which were also critical mock-ups, have been in final shutdown status since 2017;
- the critical mock-up Isis, situated at the Saclay centre, has been in final shutdown status since March 2019.

The final shutdown of these reactors results from a significant reduction in research programme needs and the cost of maintaining all these facilities in operational condition:

- the experimental and research needs no longer justified the need to keep the Orphée and Eole-Minerve reactors in operation;
- the Masurca reactor was shut down as a consequence of abandoning the ASTRID project;
- shutting down the Isis critical mock-up follows on from the shutdown of the Osiris reactor, located in the same building of the BNI.

# Article 7 Legislative and regulatory framework

**ARTICLE 7 LEGISLATIVE AND REGULATORY FRAMEWORK**

*Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of nuclear installations.*

*The legislative and regulatory framework shall provide for:*

*i) the establishment of applicable national safety requirements and regulations;*

*ii) a system of licensing with regard to nuclear installations and the prohibition of the operation of a nuclear installation without a licence;*

*iii) a system of regulatory inspection and assessment of nuclear installations to ascertain compliance with applicable regulations and the terms of licences;*

*iv) the enforcement of applicable regulations and of the terms of licences, including suspension, modification or revocation.*

## 7.1. Legislative and regulatory framework

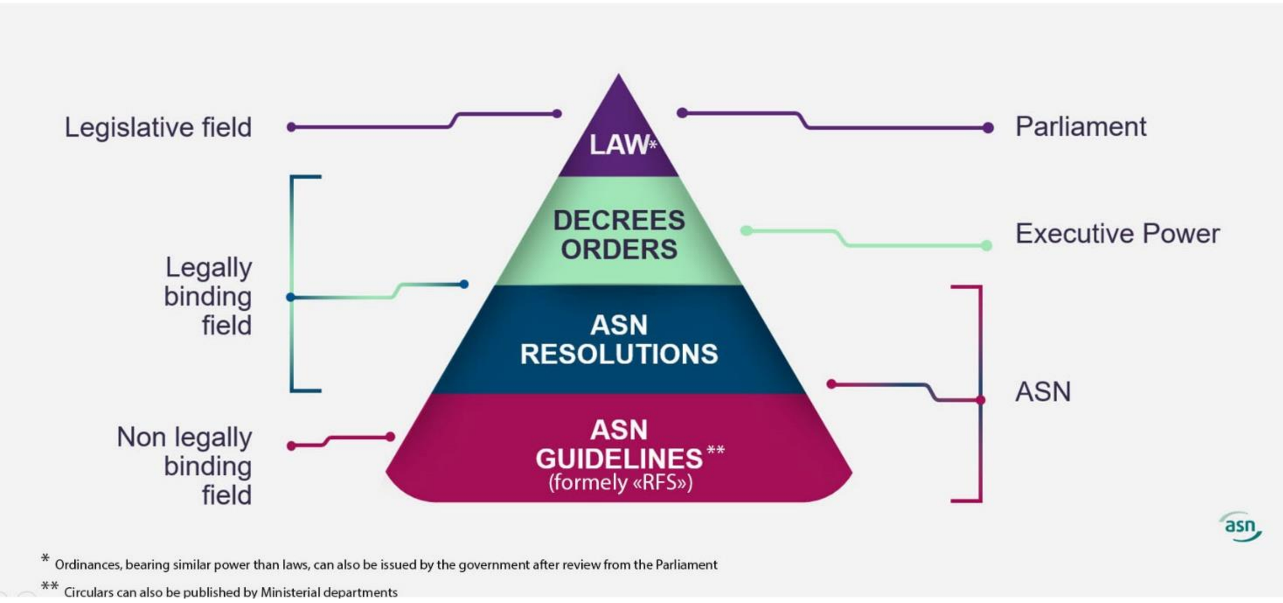



*Figure 7-1: Different levels of regulation*

### 7.1.1. Overview of the legislative framework

The Environment Code sets out a specific system for certain installations using radioactive or fissile materials or particle beams *"owing to the risks or adverse effects they can present for public health and safety or protection of nature and the environment."* (Article L591-1). These installations are called "Basic Nuclear Installations" or BNIs. Nuclear reactors are among these. Public health and safety, protection of nature and the environment mentioned above, are called "protected interests".

The legislative and regulatory parts of the Environment Code contain most of the BNI creation authorisation provisions, their control and sanctions in this field. The provisions specific to BNIs are, with respect to the legislative part, contained in Articles L. 593-1 et seq. of this Code and, with respect to the regulatory part, in Articles R. 593-1 et seq. of the same Code.

The legislative and regulatory provisions of the Environment Code (Articles L.591-1 to L.597-46) and the Order of 7 February 2012 setting the general rules relating to basic nuclear installations transpose Directive 2009/71/Euratom of 25 June 2009 establishing a community framework for the nuclear safety of nuclear installations. This Directive was modified by Directive 2014/87/Euratom of 8 July 2014. Ordinance 2016-128 of 10 February 2016 transposed the legislative part of the Directive of 8 July 2014.

Important legislative provisions were introduced into the Environment Code subsequent to 2015. They concern:

- reinforcement of transparency and information of the citizens, in particular by reinforcing and extending the remit of the local information committees (CLI) and by reinforcing certain procedures for informing the local populations;
- consolidation of the BNI system with regulation of the use of subcontracting, changes to the BNI modification system and overhaul of the system for BNI final shutdown and decommissioning;
- clarification of the organisation of the oversight of nuclear safety and radiation protection by ASN and IRSN.

2019 represented an important milestone in the work to codify nuclear law in the Environment Code. Decree 2019-190 of 14 March 2019 codifying the provisions applicable to basic nuclear installations, the transport of radioactive substances and transparency in the nuclear field codified and updated the provisions of eight Decrees covering BNIs and transparency in nuclear matters applicable to BNIs.

The Environment Code also contains:

- the provisions specific to the roles and attributions of ASN, in Articles L. 592-1 et seq. and R. 592-1 et seq. of the Environment code,
- the provisions regarding information, participation by the public (L. 121-1 and R. 121-1 and L. 123-1 et seq. of the Environment Code), the local information committees, transparency in nuclear matters and the right to information (L. 125-10 et seq. of the same Code),
- financial provisions, such as those concerning the creation of decommissioning assets (L. 594-1 and D. 594-1 of the same Code) but also those on the sustainable management of radioactive materials and waste (L.542-1 et seq. and R. 542-1 of the same Code),
- the provisions concerning nuclear pressure equipment (L. 557-1 et seq., L. 595-2 et seq. and R. 557-1-1 et seq. of the same Code).

Orders and ASN Regulations also govern this field. These are specified in sections 7.2 and 7.3.

### 7.1.2. Ratification of international conventions and legal instruments

Article 52 of the French Constitution stipulates that the President of the Republic negotiates and ratifies treaties, including international conventions. The ratified conventions are published in the Official Journal of the French Republic (JORF).

The conventions linked to nuclear safety ratified and published by France notably include:

- the Convention on Nuclear Safety, published in the JORF by Decree 96-972 of 31 October 1996. In 2015, the contracting parties to the convention, taking account of the lessons learned from the Fukushima-Daiichi NPP accident, adopted the Vienna Declaration on Nuclear Safety;
- the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management, published in the JORF by Decree 2001-1053 of 5 November 2001;

- the Convention on Third-Party Liability in the Field of Nuclear Energy (1960 Paris Convention). France also ratified the protocols signed on 12 February 2004, reinforcing the Paris convention of 29 July 1960 and the Brussels convention of 31 January 1963 concerning third-party liability in the field of nuclear energy;
- the Convention on Early Notification of a Nuclear Accident, published by Decree 89-361 of 2 June 1989;
- the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, published by Decree 89-360 of 2 June 1989;
- the Espoo[9] Convention on Environmental Impact Assessment in a Transboundary Context, published by Decree 2001-1176 of 5 December 2001;
- the Convention on Access to Information, Public Participation in the decision-making process and Access to Environmental Justice[10], published by Decree 2002-1187 of 12 September 2002;
- the Euratom[11] Treaty, signed by France in Rome on 25 March 1957. It entered into force in 1958.

## 7.2. The general technical regulations

The overhaul of the general technical regulations relative to BNIs began in 2006: it incorporates the "reference levels" of the common baseline requirements developed by WENRA, the Western European Nuclear Regulators' Association.

### 7.2.1. The Orders

#### *7.2.1.1. The "BNI Order" of 7 February 2012*

Issued pursuant to Article L. 593-4 of the Environment Code, the Order of 7 February 2012 setting the general rules relative to BNIs, called the "BNI Order", defines the general rules for the design, construction, operation, closure and decommissioning of basic nuclear installations, as well as the final shutdown, upkeep and surveillance of radioactive waste disposal facilities for the protection of the interests protected by Article L. 593-1 of the same Code (see § 7.1.1). It notably incorporates rules corresponding to the best international practices into French law. It takes up and reinforces prior regulations, more specifically giving a legal foundation for ASN's requests.

This Order contains:

- provisions on the licensee's organisation and its responsibilities, detailed in the sections specifying the regulatory framework in chapters 10, 11, 12, 13, 14 and 19;
- provisions on the integrated safety management system, detailed in the sections concerning the regulatory framework in chapters 10,13, 14 and 19;
- provisions concerning SSCs, so that they can perform the functions assigned to them, detailed in the sections specifying the regulatory framework in chapters 13, 14 ,18 and 19; in particular, provisions of this

[9] The Espoo convention requires the State in which a project is planned to examine its environmental consequences for the neighbouring States and stipulates that the State in which the project is planned must notify the affected part of the neighbouring State of any project liable to have a significant prejudicial transboundary impact on the environment. It enables the neighbouring State to take part in the environmental impact assessment procedure.

[10] The Aarhus convention comprises three objectives: to improve access by citizens and associations to environmental information, to enable extensive participation by them in the decision-making process and facilitate their access to justice with respect to damage caused to the environment.

[11] The purpose of the EURATOM Treaty is the development of nuclear energy while protecting the population and workers against the harmful effects of ionising radiation.

Order require that the licensee identify the protection important components (PIC)[12] of the protected interests. These PICs undergo qualification, proportionate to the issues, with the aim in particular of guaranteeing the ability of said components to fulfil their assigned functions with respect to the stresses and environmental conditions associated with the situations for which they are required;

- provisions concerning activities said to be important for the protection of protected interests, detailed in the sections specifying the regulatory framework in chapters 12 and 13; in particular, provisions of this Order require the licensee to identify the activities said to be important for the protection of protected interests (PIA)[13]. The activities, their technical control and the verifications and assessments are documented and traced such that compliance with the specified requirements can be demonstrated in theory and subsequently verified;
- provisions concerning water intake, effluent discharge and monitoring, detailed in the section specifying the regulatory framework in chapter 15;
- provisions concerning design, detailed in the sections specifying the regulatory framework in chapters 17 and 18;
- provisions concerning the management of emergency situations, detailed in the sections specifying the regulatory framework in chapter 16;
- provisions concerning the analysis and reporting of significant events, detailed in the sections specifying the regulatory framework in chapter § 19.6.

This Order also contains provisions regarding information of the public.

After ten years of application of this Order and feedback from its implementation, its revision is in progress. The stakeholders will be consulted with respect to this revision.

#### *7.2.1.2. Orders relative to pressure equipment*

BNIs comprise two types of pressure equipment: on the one hand, nuclear pressure equipment (NPE), in other words that making up the main primary and secondary systems (MPS and MSS) and that confining radioactive products and, on the other hand, that which is not specific to nuclear facilities but which is installed in them. The regulations applicable to pressure equipement are detailed in table 7-1.

[12] PICs are defined as performing functions that demonstrate that interests are sufficiently protected.

[13] PIAs are defined as participating in provisions that demonstrate that interests are sufficiently protected.

| | Nuclear pressure equipment | | Pressure equipment and simple pressure vessels installed within the perimeter of BNIs (In-service monitoring) |
|---|---|---|---|
| | Pressurised water reactor main primary and secondary systems | Other nuclear pressure equipment | |
| **General provisions** | Legislative and regulatory parts of the Environment Code (Chapter VII of Part V of Book V) | | |
| **Provisions concerning equipment manufacture** | Section 12 of Chapter VII of Part V of Book V of the Environment Code (regulatory part)<br><br>Order of 30 December 2015 | Section 12 of Chapter VII of Part V of Book V of the Environment Code (regulatory part)<br><br>Order of 30 December 2015 | Sections 9 and 10 of Chapter VII of Part V of Book V of the Environment Code |
| **Operational provisions** | Section 14 of Chapter VII of Part V of Book V of the Environment Code<br><br>Order of 10 November 1999 | Section 14 of Chapter VII of Part V of Book V of the Environment Code<br><br>Order of 30 December 2015 | Section 14 of Chapter VII of Part V of Book V of the Environment Code<br><br>Order of 20 November 2017 |

*Table 7-1: Regulation of pressure equipment installed within the perimeter of BNIs*

The regulation provisions for all pressure equipment are based on the same principles:

- The design and manufacture of the equipment must be compatible with compliance with the essential safety requirements, which are defined by national regulations on the basis of the annexes to European Directive 2014/68/EU of the European Parliament and Council of 15 May 2014 on the harmonisation of the legislations of the Member States relative to the making available on the market of pressure equipment. These requirements concern both the analysis of the risks relating to the equipment, the appropriateness of the materials and manufacturing processes with respect to the intended uses, non-destructive inspections, etc. The sizing of these requirements is tailored to the nature of and the risks presented by the equipment, taking account of certain specific factors for NPE, including the radioactivity of the fluid;
- Compliance with these essential requirements must be ensured throughout the lifetime of the equipment, which is guaranteed via in-service monitoring requirements. Depending on the associated risk level, these requirements may include periodic inspections, or periodic requalification operations.

The main primary system and the main secondary system of PWRs are subject to specific in-service monitoring requirements, given the essential role of these systems and the potential implications if they break. The Order of 10 November 1999, mentioned in table 7-1 above, thus requires the creation of a regulatory reference files specifying the appropriate non-destructive checks and examinations for all loads, situations and ageing modes which these systems are liable to encounter. They are subject to periodic requalification checks every ten years, with a hydraulic pressure test, under the direct supervision of ASN. The performance of these checks coincides with the performance of the reactor periodic safety reviews.

### 7.2.2. Technical regulations issued by ASN

Pursuant to the Environment Code, ASN can issue regulations to clarify the Decrees and Orders issued relating to nuclear safety and radiation protection. They are subject to approval by the Minister in charge of nuclear safety or radiation protection (Articles L. 593-19 and L. 592-20 and Article R. 592-17 of the Environment Code). The purpose of this approval is to ensure that the regulations adopted by ASN comply with the higher level regulations (Decree and Order) that they clarify. Approval is all or nothing: the Ministers either approve or reject approval (grounds shall be given for rejection, see Article R. 592-20 of the Environment Code) and may in no case modify ASN's resolutions.

ASN's regulations notably clarify the provisions of the "BNI" Order. The technical regulation is consistent with that of the other European States, because it includes the "reference levels" of the Western European Nuclear Regulators Association (WENRA). These regulations take account of the lessons learned from operation of the installations. The ASN regulations are listed in Appendix B.

### 7.2.3. Basic safety rules and ASN guides

ASN has developed basic safety rules (RFS in French) and ASN guides on various technical subjects. These documents contain recommendations which clarify safety objectives and describe practices ASN considers to be satisfactory to ensure compliance with them. They are not regulatory texts. A licensee may not follow these recommendations if it can demonstrate that the alternatives it proposes implementing are able to attain the objectives set.

The guides take account of the safety requirements for reactor design taken from the publications of the International Atomic Energy Agency (IAEA) and the reference levels, safety objectives or recommendations published by the Western European Nuclear Regulators Association (WENRA).

The list of RFS and guides can be consulted on the ASN website and is given in Appendix B.

### 7.2.4. French nuclear industry professional codes and standards

The nuclear industry produces detailed rules dealing with the state of the art and industrial practices, which it compiles in "industrial codes". These rules allow concrete transposition of the requirements of the general technical regulations, while reflecting best industrial practice. They thus facilitate contractual relations between customers and suppliers.

In the particular field of nuclear safety, the industrial codes are drafted by AFCEN, the French association for rules on design, construction and in service monitoring of nuclear steam supply systems, which comprises 60 French and international industrial firms, including EDF, Framatome and CEA. The RCC (design and construction rules) codes were drafted for the design, manufacture and commissioning of electrical equipment, civil engineering structures, mechanical equipment and fuel assemblies in NPPs.

Production of these documents is the responsibility of industry, not ASN.

ASN issued a position statement on the appropriateness of certain methods described in the AFCEN guide on which the RCC-M code (part of the RCC code relative to mechanical equipment) is based. This does not constitute an approval of the code, but a manufacturer which correctly applies these guides and the code is in the best position to ensure and demonstrate the compliance of its equipment with the essential safety requirements set out in the regulations.

With regard to the RSE-M code (in-service monitoring rules for mechanical equipment), ASN does not adopt a position with regard to its complete application but may issue a position statement on certain of its provisions concerning the transcription of regulatory requirements.

Regular technical exchanges are held every year between ASN and AFCEN, regarding the content of the codes and their updates, which help ensure that there is overall consistency.

### 7.2.5. Process to produce ASN regulatory and related documents

The procedure for drafting a text at ASN is presented in the following flowchart:

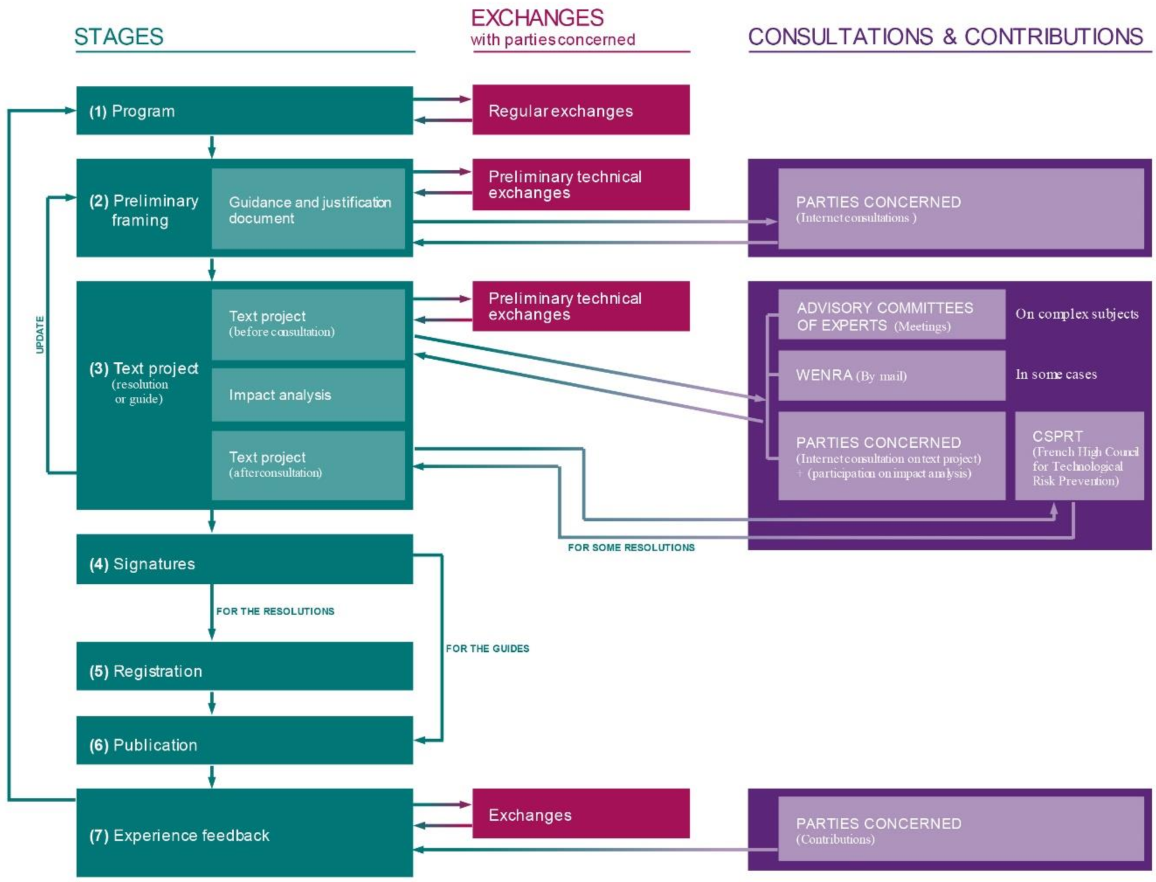



*Figure 7-2: Procedure for drafting a text at ASN*

ASN has created a Guidance and Justification Document (DOJ) which presents the subject of the text and its nature (resolution, guide, etc.), the types of installations or activities governed by the text, the objectives of the text with the reasons it was drafted or modified, the associated or related regulatory texts and guides (upstream, to be implemented, to be created, modified or repealed, etc.). This DOJ also takes account of international standards such as those issued by the IAEA and the recommendations and reference levels issued by the ICRP or WENRA.

It contains a presentation of the reasons for and preliminary justification of the planned provisions, any period of transition planned before entry into force of the text, the possibility of transposition to BNIs of provisions that are applicable to comparable ICPEs (technical applicability to BNIs of requirements imposed on ICPEs of the same nature).

It also indicates the organisation used to draft the text (working group, outside stakeholders), the steps involved in drafting and validation, and consultations whether mandatory or considered to be opportune, the schedule for the main steps in drafting up to and including publication and entry into force of the text.

It identifies the main new constraints or simplifications contained in the draft.

The DOJ is placed on-line and added to as the draft text progresses. All modifications to the DOJ are identified in the document.

ASN places great importance on consultation in the process for drafting its regulations and guides. It encourages participation by the stakeholders as of the beginning of the process, in order to facilitate the incorporation of their contributions and observations as early as the text guidelines definition stage and ultimately the assimilation of these texts by the licensees in particular. These stakeholders vary considerably: they can be environmental protection associations, media, local information committees, licensees, local authorities, administrations, organisations such as the High Council for the Prevention of Technological risks, or even foreign countries and their citizens.

The extensive participation organised by ASN enables the interests and constraints of all these stakeholders to be taken into consideration when drafting the texts, and also to highlight diverse skills and contributions. Open and broad governance also fosters the acceptance, implementation and durability of the provisions introduced by the resulting texts, as well as transparency with regard to nuclear safety.

The observations received are all published on the ASN website, with the exception of information that could jeopardise national defence confidentiality, facilitate the performance of acts that could jeopardise public health, safety, or security, or jeopardise industrial or commercial confidentiality and which can be transmitted by separate confidential mail.

The ASN departments responsible for drawing up a regulation conserve the provisions adopted and record the choices made during this process, notably to take account of the observations received from the stakeholders.

## 7.3. Authorisation procedures

The legislation makes provision for several BNI-related authorisations:

- the BNI creation authorisation (L. 593-7 of the Environment Code),
- the commissioning authorisation (L. 593-11 of the same Code),
- the change of licensee authorisation (R. 593-41 of the same Code),
- the BNI substantial modification authorisation (I and II of Article L. 593-14 of the same Code) and that for the performance of certain noteworthy modifications (L. 593-15 of the same Code).

Although commissioning does not require an authorisation, once the licensee has notified both the Minister responsible for nuclear safety and ASN of final shutdown of its BNI, it is carried out under the conditions prescribed in the decommissioning decree.

The following sections clarify the provisions of the Environment Code.

### 7.3.1. Safety options

An industrial firm intending to operate a BNI may, even before initiating the authorisation procedure, ask ASN for an opinion on some or all of the options it has adopted to ensure the safety of its facility (Article R. 593-14 of the Environment Code). The applicant is advised of ASN’s opinion, which may provide for additional studies and justifications that could be necessary for a possible creation authorisation application. This preparatory procedure does not take the place of the subsequent regulation reviews, but aims to facilitate them.

### 7.3.2. Creation authorisation application

The creation authorisation application for a BNI is filed by a licensee with the Minister responsible for nuclear safety and a copy of this application is sent to ASN (R. 593-15 of the Environment Code). The application is accompanied by a file comprising a number of items, including the detailed plan of the facility, the impact assessment, the preliminary version of the safety analysis report (PSAR), the risk management study and the decommissioning plan (R. 593-16 of the same Code).

When an ASN opinion is issued in the conditions defined in Article R. 593-14, the preliminary version of the safety analysis report identifies the questions already studied within this context, the additional studies performed and the additional justifications provided, notably those requested by ASN in its opinion. As necessary, it presents the modifications or additions made to the options which were the subject of ASN's opinion (R. 593-18 of the Environment Code).

ASN examines the BNI creation authorisation applications (L. 592-29 of the Environment Code).

#### *7.3.2.1. Public debate*

Pursuant to Articles L. 121-1 et seq. of the Environment Code, the creation of a BNI is subject to the public debate procedure when it involves a new nuclear power production site, or if the new site (not nuclear power production) corresponds to an investment of more than €300 M. The public debate focuses on the appropriateness, the objectives and the characteristics of the project. Moreover, as mentioned in § 7.3.2.2, the BNI creation authorisation and then the BNI decommissioning decree are granted following a public inquiry.

#### *7.3.2.2. Environmental assessment*

The Ordinance of 3 August 2016 modified the rules applicable to the environmental assessment, with the aim of:

- simplifying and clarifying the rules applicable to this assessment;
- transposing Directive 2011/92/EU of 13 December 2011 concerning the assessment of the impacts of certain public and private projects on the environment (as modified by Directive 2014/52/EU of 16 April 2014).

The Environment code states that projects which, by their nature, scope or location, are liable to have significant impacts on the environment or human health, shall undergo an environmental assessment according to criteria and thresholds defined by the regulations and, for some of them, after a "case by case" review.

With regard to basic nuclear installations (BNI), the following are concerned:

- the creation of a BNI, substantial modifications, decommissioning of a BNI;
- commissioning of a BNI when the impact assessment updated on the occasion of the commissioning authorisation application has significantly changed;
- noteworthy modifications if ASN considers that they are liable to have noteworthy negative effects on the environment.

The environmental assessment is a process involving several steps:

- production by the project owner of a report assessing the impacts on the environment (called the "impact assessment"). The environment shall be considered in its entirety: population and human health, biodiversity, land, soil, water, air and climate, material goods, cultural heritage and landscape, as well as the interactions between these components;

- the holding of the planned consultations, notably the consultation of the Environmental Authority, which issues an opinion on the environmental impacts assessment report, and consultation of the public and any States concerned;
- examination by the authority with competence to take the relevant decision (Ministry responsible for nuclear safety or ASN), of all the information presented in the impact assessment and received within the context of the consultations held and from the project owner.

### *7.3.2.3. The public inquiry*

In addition to a public debate organisation presented in § 7.3.2.1, the BNI creation authorisation is issued after the public inquiry (R. 593-21 of the Environment Code).

The purpose of this inquiry is to inform the public and obtain their opinions, suggestions and counter-proposals, in order to provide the competent authority with all the information it needs prior to any decision.

Pursuant to the Environment Code, the Prefect opens the public inquiry at least in every municipality which has any part of its territory located within a 5 km radius of the installation perimeter. The duration of this inquiry, set by the Prefect, is a minimum of one month. The file submitted by the licensee to support its authorisation application, comprising in particular the impact assessment and the risk management study, is made available. In an understandable format, this file gives the inventory of the risks that the projected installation represents and an analysis of the measures taken to prevent them. It also includes a non-technical summary intended to facilitate the general public's understanding of the information it contains. The opinion issued by the Environmental Authority and the written reply from the licensee to this opinion are enclosed with the file.

On the occasion of the public inquiry, the States concerned are consulted. The authority competent to take the BNI authorisation decision notifies the States concerned of the Order opening the public inquiry and sends them a copy of the inquiry file.

In addition, pursuant to article 37 of the Euratom Treaty, the creation authorisation for a facility liable to discharge radioactive effluents into the environment can only be granted after consulting the Commission of the European Union.

### *7.3.2.4. Creation of a Local Information Committee (CLI)*

The Environment Code states that *"a local information committee is created for any site comprising one or more basic nuclear installations* (...)*. This committee is tasked with a general duty of monitoring, information and consultation regarding nuclear safety, radiation protection and the impact of nuclear activities on people and the environment, with regard to the installations of the site. It disseminates the results of its work broadly in a form accessible to the greatest number"*. (Article L.125-17).

CLI costs are financed by the State, the local authorities and their groupings (L. 125-31 of the Environment Code).

It is the Chairs of the Councils of the *départements* in which the BNIs are located who create these CLIs.

A CLI comprises elected officials (members of Parliament, of the Senate, councillors at regional, *département* and municipal levels), one of whom is elected Chair, representatives of environmental protection associations, trades union organisations of the BNI employees, persons appointed for their expertise in the nuclear or information fields and, if the BNI site is located in a *département* on the border with a foreign State, representatives from the regions of the States, environmental associations and qualified persons from these same regions (L. 125-20 and R. 125-57 of the Environment Code).

At least once a year, they organise a public meeting and produce an activity report which is made public (R. 125-62 of the Environment Code). They are tasked with regularly reporting to the public the information they receive from the licensees, ASN and the other State departments (R. 125-64 of the same Code). The representatives of ASN and of the other State departments may attend the committee meetings and their works (II of L. 125-20 of the Environment Code). The CLI Chairman may ask the licensee to organise a visit of the installation for the members of the CLI, in order to present its operation to them.

The CLI can address any nuclear safety and radiation protection queries to ASN (L. 125-27 of the same Code). In the same way as the licensees and the State, ASN must also communicate all documents and information needed by the CLI to carry out its duties (L. 125-24 of the same Code) and consult the CLI concerning any project subject to a public inquiry (L. 125-26 of the same Code). The same provisions state that ASN may refer to it, if necessary, in the other cases.

The CLI may be given a hearing by the ASN Commission before ASN issues an opinion to the Government on a draft individual resolution concerning an installation (Article 3 of ASN resolution 2010-DC-0179 of 13 April 2010).

#### *7.3.2.5. The creation authorisation decree (DAC)*

Based on the technical examination carried out by ASN and the results of the consultations, a first draft decree authorising the creation of the installation is produced by the Minister responsible for nuclear safety, who sends it to the licensee (Article R. 593-25 of the Environment Code). The licensee has a period of two months in which to present its comments. The Minister also obtains the opinion of ASN. The licensees and the CLI can request a hearing at ASN before it issues its opinion (for the CLIs, see § 7.3.2.4).

The Minister responsible for nuclear safety draws up the draft decree, which is submitted to ASN for its opinion (R. 593-25 of the same Code). The BNI creation authorisation is granted by a decree from the Prime Minister issued following the report from the Minister in charge of nuclear safety (R. 593-26 of the Environment Code).

The creation authorisation decree defines the perimeter of the installation and determines the time until it is commissioned (Article L. 593-8 of the Environment Code). It does not set an authorisation duration. It mentions the essential components required for the protection of public security, health and safety, as well as of nature and the environment, which are the protected interests listed in Article L. 593-1 of the Environment Code.

#### *7.3.2.6. ASN requirements for DAC implementation*

For application of the DAC, ASN defines requirements relatives to BNI design, construction and operation, that it deems necessary for protection of the interests (public security, health and safety or protection of nature and the environment.

ASN also defines the requirements regarding BNI water intake and BNI discharges. The specific requirements setting the limits on discharges into the environment from the BNI (whether under construction or in operation) are subject to approval by the Minister responsible for nuclear safety.

### 7.3.3. Commissioning authorisation

Commissioning corresponds to the first use of nuclear materials in the installation (R. 593-29 of the Environment Code). In preparation for commissioning, the licensee sends ASN a file comprising the updated safety analysis report for the facility “as-built”, the general operating rules, the on-site emergency plan and the decommissioning plan.

The authorisation to commission a BNI is issued by ASN. ASN verifies that the BNI meets the objectives and rules defined by Articles L. 593-1 to L. 593-6-1 of the Environment Code. In this case, it authorises its commissioning, notifies the licensee of this authorisation and communicates it to the Minister responsible for nuclear safety and to the Prefect, as well as to the local information committee (R. 593-33 of the Environment Code). The commissioning process is described in detail in § 19.1.

### 7.3.4. The BNI modification authorisation

Any substantial modification of the facility must undergo a procedure similar to that for a creation authorisation application (II of L. 593-14 of the Environment Code).

A modification is considered to be substantial in the following cases:

- a change in the nature of the facility or an increase in its maximum capacity;
- a modification of the elements which led to its authorisation;
- addition, within the perimeter of the installation, of a new basic nuclear installation (R. 593-44 and 45 of the Environment Code).

The other modifications are "noteworthy" modifications of the installation and, depending on their significance, require either notification of ASN or authorisation by ASN (L. 593-15 of the Environment Code).

On 30 November 2017, ASN adopted the resolution “noteworthy modifications” to BNIs, which specifies the criteria for distinguishing the noteworthy modifications requiring ASN authorisation from those requiring notification, as well as the criteria concerning non-noteworthy modifications. This resolution also defines the requirements applicable to the management of noteworthy modifications, more particularly the internal check procedures to be implemented by the licensees. This resolution confirms the responsibility of the licensees for managing noteworthy modifications to their installations, while ensuring that they draw on an appropriate organisation, and enables ASN to make its oversight more proportionate to the specific implications of each modification.

### 7.3.5. Authorisations concerning the other facilities located within a BNI perimeter

The following are located within the perimeter of a BNI:

- the BNI;
- equipment and installations necessary for operation of the BNI;
- equipment and installations classified for protection of the environment (ICPE)[14] which do not necessarily have a direct link with the BNI.

The equipment needed for operation of the BNI are entirely subject to the BNI system, even if technically they are comparable to classified installations.

[14] ICPEs are non-nuclear installations subject to specific regulations.

The other equipment within the perimeter of the BNI, but not needed by it, and which by their very nature are subject to another administrative system (IOTA - installations, structures, works or activities with an impact on water – or ICPE) remain subject to this system (pursuant to I of Article L. 593-33 of the Environment Code). ASN nonetheless has competence to take individual measures and monitor them.

### 7.3.6. Decommissioning decree

When the operation of a basic nuclear installation or part of such an installation is definitively shut down, the licensee must carry out decommissioning as rapidly as possible, in economically acceptable conditions (pursuant to Article L. 593-25 of the Environment Code).

The decommissioning file presented by the licensee undergoes the same consultations and inquiries as those applicable to BNI creation authorisation applications and in accordance with the same procedures.

The decommissioning of a facility is prescribed by a decree, issued after consulting ASN. The decommissioning decree more particularly sets out the characteristics of decommissioning and its completion time-frame. Until the decommissioning decree comes into force, the installation remains governed by the provisions of its creation authorisation decree and the ASN requirements, which may be added to or modified if necessary.

Following decommissioning of the installation, ASN submits a delicensing resolution to the Minister responsible for nuclear safety, for approval (L. 593-30 of the Environment Code). It is then removed from the list of BNIs.

## 7.4. The system of regulatory inspection and assessment of nuclear installations

The law entrusts ASN with oversight of nuclear installations. In the interests of administrative efficiency, ASN has also been entrusted with oversight of pressure equipment and nuclear pressure equipment in BNIs and labour inspectorate in nuclear power plants. In addition, Ordinance 2016-128 of 10 February 2016 expanded the scope of ASN oversight and regulation to the suppliers, contractors and subcontractors of licensees, including for activities performed outside BNIs.

Control and regulation of nuclear activities is a fundamental responsibility of ASN. Its primary goal is to ensure that all BNI licensees effectively meet their obligations, notably their prime responsibility for nuclear safety and radiation protection of the public (see § 9.1). ASN incorporates the concept of proportionality when determining its actions, so that the scope and thoroughness of its oversight is commensurate with the nuclear, health and environmental safety issues.

ASN has a vision of control and regulation encompassing material, organisational and human aspects. The oversight priorities are defined with regard to the risks inherent in the nuclear installations, the behaviour of the licensees and the means they deploy to control them.

Oversight is carried out:

- before construction, during the review of the creation authorisation decree, by examination and analysis of the files, documents and information supplied by the licensee. This oversight aims to ensure that the information and justifications supplied are pertinent and adequate;
- during construction, by means of visits, inspections of all or part of the installation and during interventions with major implications, by means of documentary verifications and analysis of the results provided by the licensee. This oversight includes an analysis of any justifications provided by the licensee;

- during operation, by means of visits, inspections of all or part of the installation and during interventions with major implications (such as scheduled outages of nuclear reactors), by means of documentary verifications, by analysis of significant events, of the results provided by the licensee and the modification files. This oversight includes an analysis of any justifications provided by the licensee.

Following safety and radiation protection assessments, ASN implements its oversight action by issuing resolutions, binding requirements, inspection follow-up letters and technical instructions, plus penalties as applicable.

### 7.4.1. BNI oversight procedures

The ASN oversight procedures are tailored to the specificities and risks of the installations (NPPs, research reactors, nuclear waste facilities, etc.) and are implemented by means of the following actions:

- inspection, generally on the site. This consists in performing spot checks on the conformity of a given situation with regulatory or technical baseline requirements but may also include an assessment of the licensee's practices by comparison with current best practices (more details in § 14.2.3, § 19.2.4);
- analysis of the licensee's justifications to prove that its activities are acceptable in terms of radiation protection and safety (more details in § 14.1.3, § 18.1.3, § 18.2.3);
- analysis of operating experience feedback, more specifically through analysis of significant events (more details in § 19.6.4);
- approval of organisations and laboratories taking part in radioactivity measurements and radiation protection inspections, as well as qualification of pressure equipment monitoring organisations;
- presence in the field, which is also frequent outside actual inspections.

When ASN oversight actions reveal breaches of compliance with the regulations, enforcement measures or penalties (see § 7.5) may be imposed on the licensees.

### 7.4.2. ASN organisation for BNI oversight

For the purposes of its oversight, ASN has inspectors appointed and accredited by the ASN Chairman (L. 569-2 of the Environment Code and L. 1333-29 and 30 of the Public Health Code), subject to them having acquired the requisite legal and technical skills through professional experience, mentoring or training courses. They carry out their inspection activity under the authority of the ASN Director-General and have regularly updated practical tools at their disposal for the performance of their inspections. They take an oath and are bound by professional secrecy.

To obtain accreditation, an inspector must follow a course which depends on their field of accreditation: BNI inspection, nuclear aspects of medical activities, etc. While taking account of the particularities of each of these fields, the courses comprise:

- a training foundation course given to a large extent by experienced inspectors, but also by external instructors;
- participation in inspections;
- immersion of up to 2 weeks in an installation or facility of the type that the inspector will be required to inspect;
- mentoring.

Account is taken of the inspector's past experience, so that they can validate a part of the course on the basis of equivalence.

The accreditation process generally takes 1 year. The fact that an inspector is undergoing accreditation does not prevent them from playing an active part in an inspection, depending on the capabilities already acquired.

ASN has about 200 nuclear reactor inspectors, who receive technical support from IRSN (about 170 experts for nuclear reactors), whose duties are specified in § 8.1.6. ASN has no resident inspectors. The inspectors in the regional divisions (see § 8.1.2) are responsible for inspecting certain sites and also carry out inspections on all the sites in a regional division. In addition, to further strengthen the sharing of practices between the inspectors, each regional division inspector must carry out at least one inspection in an installation outside their division, every year.

In 2017, ASN created the position of chief inspector, whose main role is to coordinate ASN's inspection policy. This coordination concerns the construction and monitoring of the annual inspection programme, notably ensuring that inspection practices innovate in order to cover fields hitherto little addressed (skills of operators in the control room, licensee procurement policy, etc.). In this respect, the chief inspector oversees certain inspections that are complex or entail significant challenges.

### Focus 11 : Inspections with situational exercises of operating teams

Since 2021, ASN has developed specific inspections with situational exercises for the operating teams on the full-scope reactor simulator. The aim of these inspections is to verify the operating team's ability to manage an accident scenario, and in particular:

- over almost the entire duration of a shift, complying with the applicable best practices (operational communication, self-checking, responsibilities of the players, etc.),
- during the phases to reach the safe state,
- during changes of shift,
- the applicability in the field of the instruction sheets associated with the procedures.

Consequently, ASN asked the training department of the Civaux NPP to design an incident scenario that was both realistic, required little preparation time and comprised the following two aspects: the shift change between two operating teams in an incident situation in the one hand, and the operations to return to normal operation when the condition of the installation allows to do so in the other hand. The choice of that type of scenario resulted from ASN findings that:

- the operating team training focuses on the management of "emblematic" accidents which lead to highly degraded situations, to the detriment of incidents with lesser impact on safety but which are far more likely to occur,
- the operating team shift is currently little practised in training in an incident or accident situation whereas it is part of the routine in normal operation for the operating teams.

At Flamanville 3, the inspection team observed the management of a certain number of incidental and accidental events in a scenario developed by the inspectors in collaboration with EDF's training department, focusing on short- and medium-term management of the phases to reach the safe state. This inspection included a six-hour simulator simulation and blank validation by the operator of the maneuver sheets in the field.

During this situational exercise, a series of significant safety events where simulated. The various phases are not covered by the same rules: in a normal situation, it is the "highway code" of reactor operating that automatically applies, in other words the operating technical specifications, whereas in an incident or accident situation, operations are governed by specific operating instructions validated by ASN.

This inspection proved to be extremely useful and demonstrated the pertinence of using the simulator to observe the management of an incident or accident event. It also showed the benefits of combining the activation of the on-site emergency plan and application in the field of the operational instruction sheets for the procedures, in order to assess the overall working of the local emergency organisation.

This scenario was run in the presence of a team of inspectors, which enabled ASN to conduct an in situ examination of the performance of an operating team, its know-how and the applicability of the incidental- accidental operating instructions, and thus to assess the quality of the training of the NPP operating teams for accident situations.

He more specifically ensures that the inspectors' skills are developed (initial and continuing training) and that inspection practices develop (development of cross-inspections, etc.). To do this, he takes part in inspections to assess the development needs.

Many tools are available to the inspectors for their inspections. These are documentary tools:

- inspection general procedures and guides, such as inspection follow-up letter templates;
- inspection guides and help sheets, broken down into themes, detailing the technical aspects that can be inspected.

Digital tools have also been developed in recent years, in particular SIANCE, an inspection follow-up letters search tool using artificial intelligence, OURSIN, a tool to help with drafting of follow-up letters in the small-scale nuclear activities sector, or CANEVAS, for creating a detailed agenda.

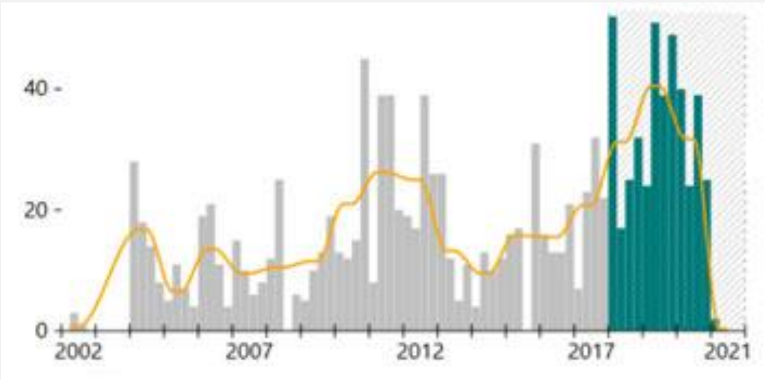
The numerous thematic discussion networks and collaborative spaces are also forums for discussion and sharing of practices.

### Focus 12 : Artificial intelligence system used by ASN

As part of its multi-year strategic Plan, ASN initiated work on the digital transformation of nuclear safety inspection. SIANCE (artificial intelligence system for nuclear inspection and assessment) is one of the projects involved in this action.

SIANCE aims to utilise the data from the ASN inspection follow-up letters (nearly 23,000 in 2020) to assist the inspectors in their work. Artificial intelligence methods can be used to explore a mass of text information that it would be impossible to analyse by humans alone, given the abundance of technical data contained in these letters.

For a given field (site, licensee, topic, equipment, time period, etc.), SIANCE enables the inspectors to obtain pertinent inspection reports. It can also display their geographical distribution and the number of findings in the form of graphics.




SIANCE is thus a tool to help define inspection programmes better targeted on particular topics or aspects to be inspected. By analysing inspection follow-up letters, SIANCE can also identify trends and detect early warning signs.

This tool is thus able to immediately analyse the content of these follow-up letters. The inspectors will thus be informed of the findings and good practices identified in the follow-up letters concerning a given field, at a licensee, over a given period, on a particular piece of equipment… with just one click!

The inspection carried out by ASN is based on the following principles:

- the inspection aims primarily to verify compliance with the provisions that are mandatory under the regulations. It also aims to assess the situation with regard to the nuclear safety and radiation protection implications; it seeks to identify best practices, practices that could be improved and assess possible developments of the situation;
- the scope and depth of the inspection is adjusted to the risks inherent in the activity and the way they are effectively taken into account by those responsible for the activity;
- the inspection is neither systematic nor exhaustive; it is based on sampling and focuses on the subjects with the highest potential consequences.

The inspections may be unannounced or notified to the licensee a few weeks before the visit. They take place in the workplaces of the entity being inspected, while it is carrying out its activities. They may concern the head office departments or design and engineering departments of the nuclear licensees, the workshops or engineering offices of the subcontractors, the construction sites, plants or workshops manufacturing the various safety important components.

ASN uses various types of inspections:

- routine inspections;
- reinforced inspections, which consist in conducting an in-depth examination of a targeted topic by a larger team of inspectors than for a routine inspection;
- in-depth inspections, which take place over several days, concern a number of topics and involve about ten or so inspectors. Their purpose is to carry out detailed examinations and they are overseen by senior inspectors;
- inspections with sampling and measurements. With regard to both discharges and the environment of the facilities, these are designed to check samples that are independent of those taken by the licensee;
- event-based inspections carried out further to a particularly significant event;
- worksite inspections, ensuring a significant ASN presence on the sites on the occasion of reactor outages or particular work, especially in the construction or decommissioning phases;
- inspection campaigns, grouping inspections performed on a large number of similar installations, following a predetermined template.

## 7.5. Measures designed to ensure compliance with the applicable regulations and the authorisation conditions

In certain situations in which the actions of the licensee fail to comply with the regulations in force, including individual resolutions, or when it is important that appropriate action be taken by it to remedy the most serious risks without delay, ASN may resort to enforcement measures and impose the penalties provided for by law. Moreover, criminal infringement reports (violation, misdemeanour) can be issued by the ASN inspectors and transmitted to the competent local Public Prosecutor's Office, which will assess whether or not to initiate prosecution.

***Enforcement measures and administrative sanctions***

ASN has a range of tools at its disposal regarding a licensee, more particularly:

- the inspector's observations;
- the official letter from the ASN departments (inspection follow-up letter);
- formal notice from ASN to comply with the regulations in force, within a time-frame determined by itself;
- enforcement measures or administrative sanctions, applied after formal notice has been served. These latter, as set out in law, are as follows:
    - deposit in the hands of a public accountant of a sum covering the total cost of the work to be performed;
    - the automatic completion of the work at the licensee's expense (the sums previously deposited may be used to pay for the work concerned);
    - suspension of operation of the facility until restoration of conformity;
    - a daily fine (an amount set per day, to be paid by the licensee until full compliance with the requirements of the formal notice has been achieved; this amount can be up to 10 million euros for a breach of the provisions applicable to BNIs);
    - administrative fine.

It should be noted that these last two measures are proportionate to the gravity of the infringements observed. Only the administrative enforcement committee, when referred to by the ASN Commission, may hand down the administrative fine when a formal notice decision, issued beforehand by ASN against a licensee to require compliance of the activity with the regulations in force, has not been met by the latter.

The law also makes provision for interim measures to safeguard security and public health and safety or protect the environment. ASN can therefore:

- provisionally suspend operation of a BNI, immediately notifying the Ministers responsible for nuclear safety, in the event of any serious and imminent risk;
- at all times, require the performance of assessments and the implementation of the steps necessary if the above-mentioned interests are threatened.

***Criminal violations***

The regulatory texts also make provision for criminal violations, misdemeanours or breaches. This is for example non-compliance with the provisions concerning the protection of workers exposed to ionising radiation, non-compliance with formal notice served by ASN, non-compliance with the provisions of ASN resolutions, or irregular management of radioactive waste. If violations not within the scope of competence of ASN are found, such as for example an irregularity comparable to fraud, and especially so if a misdemeanour is concerned, a report is sent to the Public Prosecutor's Office.

Any violations observed are written up in reports by the nuclear safety and radiation protection inspectors and transmitted to the Public Prosecutor's Office, which decides on what subsequent action, if any, is to be taken.

The Environment Code makes provision for criminal penalties, a fine or even a term of imprisonment (up to €150,000 and three years in prison), depending on the nature of the violation.

The number of formal notices served by ASN and the number of reports submitted concerning the licensees between 2016 and 2021 are shown in table 7-2.

| Year | Formal notice | Report transmitted to Public Prosecutor's Office | Number of labour inspection reports |
|---|---|---|---|
| **2016** | 6 | 2 | 1 |
| **2017** | 2 | 13 | 5 |
| **2018** | 5 | 14 | 2 |
| **2019** | 4 | 8 | 4 |
| **2020** | 2 | 11 | 8 |
| **2021** | 4 | 2 | 0 |

*Table 7-2: Administrative measures and reports concerning BNIs transmitted to the Public Prosecutor's Office*

# Article 8 Regulatory Organisation

**ARTICLE 8 REGULATORY ORGANISATION**

*Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 7, and provided with adequate authority, competence and financial and human resources to fulfil its assigned responsibilities.*

*Each Contracting Party shall take the appropriate steps to ensure an effective separation between the functions of the regulatory body and those of any other body or organisation concerned with the promotion or utilisation of nuclear energy.*

## 8.1. The Nuclear Safety Authority (ASN)

Act 2006-686 of 13 June 2006 (TSN Act) created an independent administrative authority, ASN, responsible for the regulation and oversight of nuclear safety and radiation protection for all civil nuclear activities.

The TSN Act gives ASN competence to issue technical resolutions clarifying the Decrees and Orders relating to nuclear safety and radiation protection. ASN must be consulted by the Government on general regulatory texts within its areas of competence (L. 592-25 of the Environment Code).

ASN examines all individual authorisation applications for BNIs. It grants all authorisations, with the exception of the creation authorisation, which is issued by the Government, further to the opinion of ASN.

The Act also gives ASN authority to impose prescriptions on the licensee throughout the lifetime of the facility, including during decommissioning, for example to request correction of an anomaly or prevent a particular risk. The nuclear safety and radiation protection inspectors designated by ASN oversee and control nuclear activities. Labour inspectorate duties in the NPPs is entrusted to ASN inspectors placed under the authority of the Minister responsible for labour for the purposes of these duties.

ASN's duties regarding BNIs (set out in Articles L. 592-19 et seq. of the Environment Code) are presented succinctly below:

- ASN is consulted on draft Decrees and Ministerial Orders of a regulatory nature dealing with nuclear safety (see § 7.2);
- At the request of the Minister responsible for nuclear safety, ASN examines BNI creation authorisation applications, BNI decommissioning files, as well as substantial modification requests concerning these facilities (see § 7.3.2, § 7.3.4, § 7.3.6);
- ASN verifies compliance with the general rules and specific requirements for nuclear safety and radiation protection applicable to BNIs, and the manufacture and operation of nuclear pressure equipment. It issues the required approvals to the organisations taking part in inspections (see § 7.4);
- ASN is involved in the management of radiological emergency situations. It provides technical assistance to the competent Authorities for the drafting of provisions within the emergency response plans to take account of the risks resulting from nuclear activities. When such an emergency situation arises, ASN assists the Government with all questions within its field of competence. It submits its recommendations on the measures to be taken concerning medical, health or civil security aspects, it informs the public about the situation, about potential releases into the environment and their consequences. For more details, see the specific chapter dedicated to Article 16 of the Convention;

- ASN takes part in public information within its areas of competence, notably by making the information in these fields accessible to the greatest number. It regularly reports on its activity, notably by submitting its annual report to Parliament, to the Government and to the President of the Republic (Article L.592-31 of the Environment Code). It also uses various channels, written media (monthly ASN newsletter, annual report) the *www.asn.fr* website, the public information and documentation centre, press conferences, seminars and exhibitions. For more details, see § 8.1.3.

### 8.1.1. The independence of ASN

ASN is an independent administrative authority. In this capacity, it receives no instructions from the Government or the head of State, nor from any other person or institution. ASN is a part of the State, but is not a ministerial department, does not answer to any Ministry, and is not subject to Prime Minister's arbitration in the event of disagreement with other public authorities.

Independence from the Government is consolidated by the method of appointment of the five Commissioners making up the Commission, which delivers ASN's opinions to the Government and takes the main decisions: three of the commissioners, including the Chairman, are appointed by the President of the Republic, while the other two are appointed by the President of the National Assembly and the President of the Senate respectively. The duration of the mandate of the members is a non-renewable six years.

ASN's independence is also guaranteed by the fact that the Commissioners cannot be revoked. A member's functions may only be terminated in the event of incapacity or resignation as recorded by a majority vote of the Commissioners. The President of the French Republic may also put an end to the term of any commissioner in the event of severe dereliction of duty.

This collegial way of working is a factor in the independence of ASN.

The ethical rules governing the ASN Commissioners, notably those designed to ensure the independence and impartiality of the Commissioners and to prevent conflicts of interest, are specified in the Ethics Charter of the ASN Commissioners and staff, which is given in Appendix 1 to the ASN internal rules of procedure. These internal rules of procedure are the subject of a resolution published in the Official Bulletin.

### 8.1.2. ASN organisation

#### *8.1.2.1. ASN Commission*

ASN is run by a Commission consisting of five Commissioners appointed by decree on account of their competence in the fields of nuclear safety and radiation protection. The ASN Commissioners exercise their functions on a full-time basis.

The Commission defines ASN's strategy. In this respect, it is involved in defining general policies, that is the ASN doctrines and action principles for its essential missions, which include regulation, oversight, transparency, the management of emergency situations, international relations, etc. In accordance with the law, the Commission gives ASN opinions to the Government and takes the main ASN decisions.

#### *8.1.2.2. The ASN departments*

Under the authority of the ASN Chairman, the ASN Director-General organises and manages ASN's head office departments and its eleven regional divisions.

The head office consists of 9 thematic departments, a General Secretariat, plus the Management and Expertise Office and the Regulation and Oversight Support Office (see Figure 8-1). The role of the ASN head office departments is to deal with generic subjects concerning the activities for which they are responsible. They take part in defining the general regulations and coordinate and manage the work of the teams in the regions responsible for field oversight of facilities and activities.

ASN's regional divisions operate under the authority of the ASN regional delegates who are the local ASN representatives. The divisions conduct most of the direct oversight of nuclear facilities, radioactive material transport and other small-scale nuclear activities. They review most creation authorisation application files submitted by operators within their geographical jurisdiction. They also support ASN's head office departments in their review of major decisions. In emergency situations, they assist the "*département*" Prefect who is responsible for the protection of the population of the "*département*".

Each ASN entity contributes to public information on nuclear safety and radiation protection, a task entrusted to ASN by law.

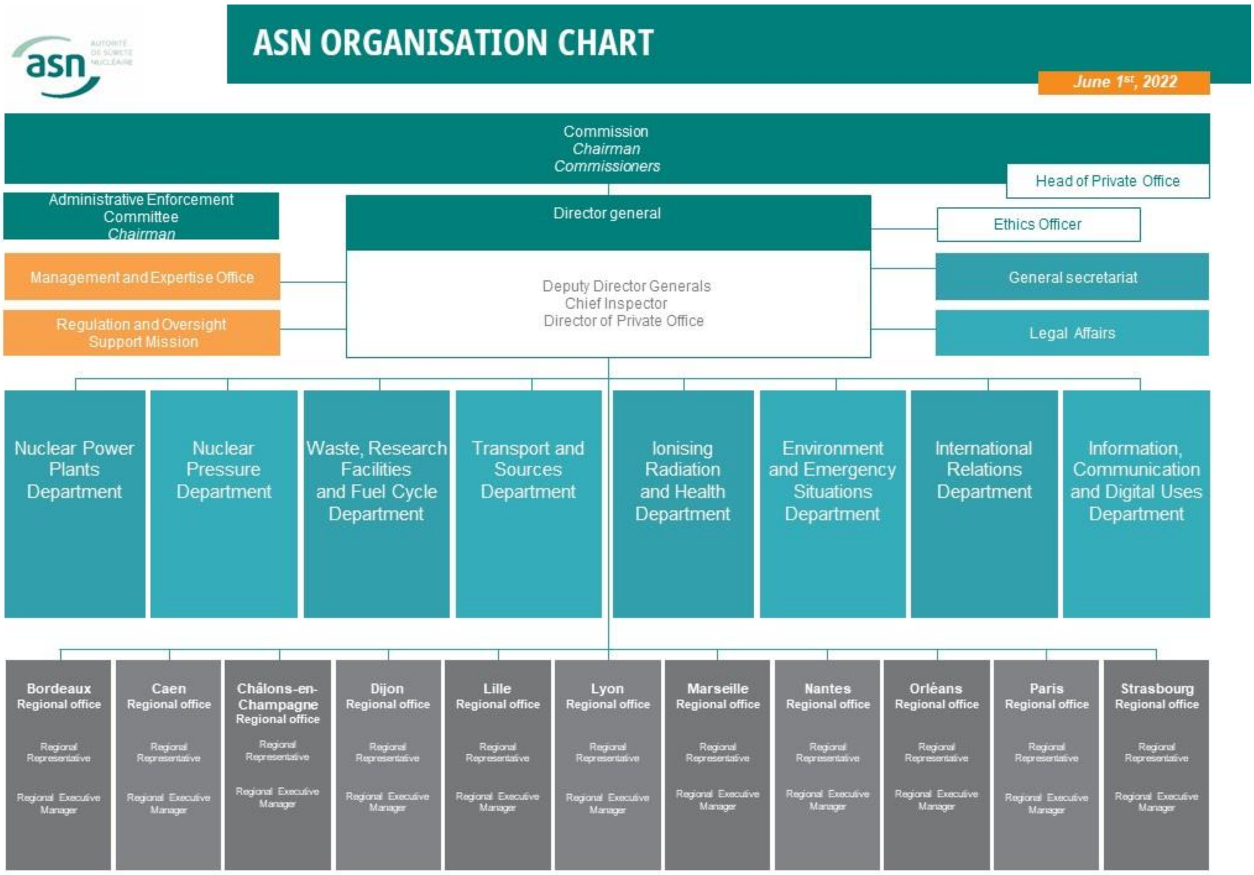



*Figure 8-1: ASN - General Organisation*

### 8.1.3. Openness and transparency

Information of the public is one of ASN's tasks, as enshrined in law. The Environment Code (Article L.592-1) states: *"[ASN] participates in informing the public and ensuring transparency in its areas of competence."* As an independent administrative authority, ASN is fully responsible for its communication: it is subject to no outside validation or arbitration.

ASN communicates actively with the general public, the media, the institutional public and professionals, notably via its website and its Official Bulletin, which publishes all of its decisions and resolutions. Throughout the year, ASN informs the citizens, the media, the institutional public and professionals of the situation of the Basic Nuclear Installations (BNIs) and small-scale nuclear activities with respect to the safety and radiation protection requirements. ASN works to ensure that citizens have reliable information on the nuclear risk and that they develop the right radiation protection reflexes in all circumstances. ASN develops complete communication vectors combining printed publications, the website, the social networks, press relations and meetings and exchanges with the stakeholders. It ensures that the principles of nuclear safety and radiation protection are understood by the widest possible audience, it produces explanatory documents and it endeavours to render even the most technical issues understandable.

It presents its entire regulatory and oversight activity and the actions it takes, and widely disseminates its resolutions and position statements, explaining them where necessary. ASN promotes the involvement of civil society and considers it very important that the citizens should contribute to decisions concerning nuclear safety and radiation protection: in this respect, it consults the stakeholders and the public on its draft resolutions (see § 7.2.5).

The website *www.asn.fr* lies at the heart of the public information system (more than 50,000 one-off visitors per month on average). ASN makes a large number of resources available on *www.asn.fr*:

- inspection follow-up letters,
- significant event notifications (as of level 1 on the INES scale),
- information notices and press releases,
- ASN's resolutions and the reference texts (Acts, Decrees, Orders, opinions, etc.),
- the opinions and recommendations of its Advisory Committees of experts,
- etc.

Any citizen can address requests for information to ASN, either on-line (at the address *info@asn.fr*) or by letter.

Most of the information notices, press releases and publications, and content of particular importance, are available in English on the ASN website.

Every year, ASN produces a report on the state of nuclear safety and radiation protection in France, which is presented to Parliament and to the media (Article L. 592-31 of the Environment Code). This report is public and is available on the ASN website in French and English. Every year, ASN organises regional press conferences to report on the state of nuclear safety as close as possible to the regulated facilities.

ASN provides the Local Information Committees (CLIs) with the necessary tools and assistance for them to provide reliable information to "layman" audiences. ASN considers that the smooth functioning of the CLIs contributes to safety and it maintains regular dialogue with them. It is attentive to ensuring that the CLI are as fully informed as possible, including by attending their public meetings (for more information on the CLIs, see § 7.3.2.4).

### Focus 13 : Public consultation on the continued operation of the 900 MWe reactors

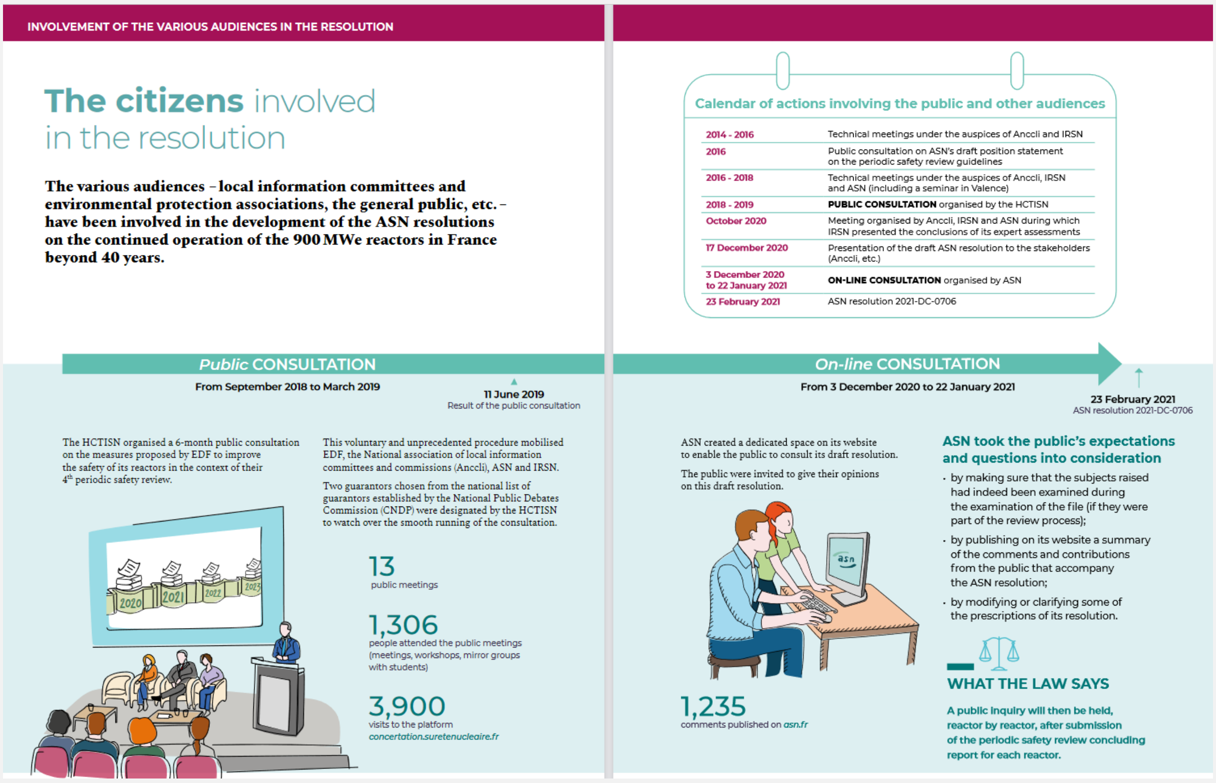
Acting on an ASN proposal, the High Committee for Transparency and Information on Nuclear Safety (HCTISN) (see § 8.2) decided to launch a public consultation on the generic phase of the 4th periodic safety review of the 900 MWe reactors in the French NPP fleet (32 reactors operated by EDF on 8 sites).

This unprecedented public consultation – for which no provision was made in the regulations – coincided with their 40th year of operation, in order to obtain the opinion of the public, both on-line and at local public inquiry meetings, regarding the conditions for continued operation of these 900 MWe reactors. The public inquiry process was organised with the aid of a number of players (HCTISN, ASN, IRSN, EDF, ANCCLI, CLI).

The public was asked to help determine the priority themes for the safety improvement debates, on the basis of 15 topics.

The public was able to hold discussions with experts from EDF, ASN and IRSN during the public meetings, to ask questions and obtain information from the on-line platform created for this public inquiry.

This public consultation was held from 6 September 2018 to 31 March 2019. The public was informed and its questions and opinions collected at both regional and national levels, via a digital platform. A total of 16 meetings attracting 1,300 participants was held around each of the 8 sites concerned, as well as within a number of higher education facilities.



### 8.1.4. ASN resources

#### *8.1.4.1. Human resources*

As at 31st December 2021, ASN's total workforce stood at 519 staff, including 292 in head office departments, 226 in the regional divisions and 1 abroad. Since 2017, the headcount has risen by 11, or +2.17%.

As at 31st December 2021, the average age of the ASN staff was 45 years old. This balanced age pyramid and the diversity of profiles in terms of recruitment, and thus of background, ensures that ASN has the qualified and complementary human resources it needs to fulfil its mission. In addition, training, the way younger staff are integrated and the transmission of knowledge guarantee the expertise required for the exercise of its missions. Competence is one of ASN's four key values. A mentoring system, allied with initial and continuous training, whether general, associated with nuclear techniques, or in the legal or communication fields, constitute essential aspects of the professionalism of ASN staff. The management of its staff's skills is based notably on a formalised series of technical training courses. In 2021, more than 2,400 days of training were provided to the ASN staff.

#### *8.1.4.2. Financial resources*

Since 2000, all the personnel and operating resources involved in the performance of the responsibilities entrusted to ASN have been covered by the State's general budget.

In 2021, the ASN budget amounted to €67.15 M. It rose by 7% between 2017 and 2021. The budget for the regulation and oversight of nuclear safety and radiation protection in France also includes the budget for technical expertise provided by IRSN, representing €84 M in 2021.

The ASN Commission issues a yearly opinion on the means needed for the oversight and regulation of nuclear safety and radiation protection (opinion available on the ASN website).

### 8.1.5. Management system

To guarantee and improve the quality and effectiveness of its action, ASN defines and implements a management system derived from the ISO and IAEA international standards and built around:

- a multi-year strategic plan and shared annual objectives;
- an organisation manual containing organisational notes and procedures defining the ASN internal rules of procedure for the satisfactory performance of each of its missions;
- internal and external audits of the implementation of the provisions set out in the management system;
- performance indicators for measuring the effectiveness of ASN's actions;
- listening to the stakeholders (public, elected officials, associations, media, trade unions, industry);
- annual reviews of the management system with the aim of continuously improving its operation.

### 8.1.6. ASN's technical support organisations

ASN benefits from the expertise of technical support organisations when preparing its decisions and resolutions. IRSN is the main one. In preparing its decisions and resolutions, ASN also relies on the opinions and recommendations of the Advisory Committees.

#### *8.1.6.1. French Institute for Radiation Protection and Nuclear Safety (IRSN)*

IRSN is an independent commercial and public establishment. Its duties are defined in the Environment Code (L. 592-45 et seq. of the Environment Code). It is the public expert in the field of nuclear and radiological risks. Its activities therefore cover numerous fields:

- security and safety of BNIs (nuclear reactors, plants, laboratories, waste) and of transports,
- intervention in the event of a radiological risk,
- environmental monitoring,
- radiation protection of persons in both normal and accident situations.

The Institute runs and implements research programmes designed to consolidate national public expert capability and contribute to the development of scientific knowledge concerning nuclear and radiological risks. IRSN also contributes to training and to public information about nuclear and radiological risks.

It is tasked with providing technical support for the public authorities with competence for safety, radiation protection and security, in both the civilian and defence sectors. When preparing its resolutions, ASN may consult IRSN on the technical files transmitted to ASN by the licensees. IRSN then carries out technical expert analysis and issues a technical opinion. The IRSN opinions are made public.

The Government consults ASN regarding the share of the State's subsidy to IRSN for the technical support it provides to ASN. A five-year agreement signed by ASN and IRSN determines the procedures for this technical support, which corresponds to about 440 full-time equivalent staff. It is described every year in a protocol which fine-tunes priorities according to the nuclear safety and radiation protection issues.

#### *8.1.6.2. Advisory Committees of experts*

In preparing some of its resolutions, ASN relies on the Advisory Committees' opinions and recommendations.

Advisory Committees (GPE) report to the ASN Director General. More specifically, the Advisory Committee for nuclear reactors (GPR) is consulted by ASN concerning the nuclear safety and radiation protection of nuclear reactors. The GPR analyses the conclusions of the technical expert analysis performed by IRSN at ASN's request and issues an opinion along with recommendations.

The GPE comprise experts individually appointed for their competence, from industrial, university and association backgrounds. They include foreign experts, which is a means of diversifying the approaches to the problems and benefiting from experience acquired abroad.

ASN publishes the opinions issued by the GPEs, as well as the subsequent position statements released by ASN.

### 8.2. The various State stakeholders involved in nuclear safety regulation and oversight

The regulation of nuclear safety and radiation protection in France depends essentially on three players: Parliament, the Government and ASN.

- Parliament intervenes in the field of nuclear safety and radiation protection notably by passing laws;
- The Government exercises regulatory power:
    - It is in charge of enacting the general regulations concerning nuclear safety and radiation protection. The Environment Code also tasks it with taking major decisions concerning BNIs (creation

authorisation and decommissioning decrees), for which it relies on ASN's opinion. It also has a number of consultative bodies:

- The High Council for the Prevention of Technological Risks (CSPRT) which assists the Ministers responsible for Installations Classified for Protection of the Environment (ICPE), for nuclear safety and for industrial safety. One of its duties is to examine any draft regulation or any question concerning BNIs that the Ministers responsible for these subjects or the ASN considers should be submitted to it. The CSPRT gives its opinion in all cases where the law or regulations so require, notably on draft decrees concerning BNIs;
- The High Committee for Transparency and Information on Nuclear Safety (HCTISN). Any question concerning information about nuclear safety and its regulation and oversight can be referred to the High Committee by the Minister in charge of nuclear safety, by the chairmen of the competent committees of the National Assembly and the Senate, by the Chairman of the Parliamentary Office for the Evaluation of Scientific and Technological choices (OPECST), by the chairmen of the CLIs or by the BNI licensees.

- The Government is also responsible for civil protection in the event of an emergency;
- The definition and implementation of nuclear safety policy is the responsibility of the Minister in charge of nuclear safety;
- The nuclear safety and radiation protection mission (MSNR) of the Ministry for Energy Transition, draws up, coordinates and implements the Government's duties concerning the nuclear safety and radiation protection of civil facilities.

- ASN is the independent administrative authority in charge of regulation and oversight of nuclear safety, radiation protection and nuclear activities (for more details, see § 8.1). It carries out its duties in the fields of regulation, authorisations, oversight and support for the public authorities in the management of emergency situations. It contributes to informing the public and ensuring transparency in its areas of competence.

  ASN reports on its activities to the OPECST, at the latter's request, and sends it its annual report on the state of nuclear safety and radiation protection. Several times a year, ASN is also called to hearings before Parliament about its activity, on subjects relating to nuclear safety and radiation protection and in the context of the budget bill.

  Moreover, as set out by the Act establishing the general status of independent administrative authorities and independent public authorities, ASN, in the same way as any other independent administrative authority:

  - sends the Government and Parliament a report on the performance of its duties and on its resources, before 1 June. This report is made public;
  - reports on its activity to the competent standing committees of the National Assembly and the Senate, at their request.

# Article 9 Responsibility of a licence holder

**ARTICLE 9 RESPONSIBILITY OF A LICENCE HOLDER**

*Each Contracting Party shall ensure that prime responsibility for the safety of a nuclear installation rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.*

## 9.1. Prime responsibility for the safety of a BNI

The French system of organisation and specific regulations for nuclear safety is based on the prime responsibility of the licensee. This responsibility is set out in Article L. 593-6 of the Environment Code: *"The licensee of a basic nuclear installation is responsible for the control of the risks and inconveniences that its installation can present for the interests mentioned in article L. 593-1."* These are protected interests defined in § 7.1.1, which notably concern, safety, radiation protection and protection of the environment.

This Article of the Environment Code also requires that the licensee *"puts in place and formalises an on-site emergency plan (PUI), an organisation and means for controlling incidents and accidents and mitigating their consequences for the abovementioned interests."*

This Article also requires that the licensee *"puts in place and formalises an integrated management system that takes into account the requirements relative to the protection of the abovementioned interests in the management of the installation."*

***EDF***

EDF S.A. is the named holder of the creation authorisation decrees for its BNIs and has responsibility as nuclear licensee. To do this, delegations of power are defined according to the management line. The management system implemented contributes to compliance with the rules of nuclear safety and radiation protection in the organisation and operation of the entity and, more generally, to the protection of the interests identified in Article L 593-1 of the Environment Code.

In accordance with the powers granted to him or her by the Board of Directors, the CEO has all the powers needed for EDF S.A. to exercise its duties as nuclear licensee. In particular, he or she determines the strategic orientations regarding nuclear safety and sets the general principles of organisation and resources to ensure that EDF S.A.'s responsibility as license holder is properly exercised, with the assistance of the Group Executive Director in charge of nuclear and thermal production (DPNT) and the Group Executive Director in charge of engineering and new nuclear projects (DIPNN).

He or she chairs the Nuclear Safety Council, which sets out the goals regarding all activities concerning fuel, operational engineering and modifications. He or she ensures consistency of the main orientations and actions of the different sectors of the company that may affect nuclear safety and radiation protection, including in areas such as purchasing of goods and services, implementation of training programmes, research and development, etc.

In order to define and implement these strategic orientations as organisational principles, the EDF SA CEO relies on the two Group Executive Directors within the EDF Group executive committee, as, given the powers delegated to them by the CEO, they guarantee that nuclear safety and radiation protection are taken into account within their respective perimeters (BNIs under construction / BNIs in operation). They are responsible for drawing up the general organisational principles such as to ensure correct performance of the function of nuclear licensee by EDF S.A. on the BNIs within their perimeter and implement these principles within these BNIs. They ensure that the design and construction of BNIs throughout their lifecycle comply with the applicable nuclear safety requirements. They are the primary points of contact for the nuclear safety regulator (ASN).

The Group Executive Director in charge of the Nuclear and Thermal Fleet delegates powers to the DPN Director, who is the representative of the EDF S.A nuclear licensee for all the facilities in operation.

The Plant Director (NPP), to whom powers are delegated by the DPN Director, has the necessary means to ensure compliance with the regulations by the BNIs within the NPP under his or her responsibility.

In addition to this management line given responsibility for nuclear safety and radiation protection, each level of the company calls on the services of an Independent Safety Organisation (FIS – see Focus 14 in § 10.2) which provides an independent view of how the nuclear licensee performs its duties. Each level in the company organises the integration of the FIS into the ad hoc bodies, so that this independent view can be provided at the appropriate level. At each level of the company, the FIS reports to the manager of the level concerned. The Inspector General for Nuclear Safety and Radiation Protection ensures that nuclear safety and radiation protection concerns are correctly addressed for the company's nuclear installations, and reports to the CEO in this respect.

The EDF organisation is detailed in Appendix C.

***CEA***

More particularly with regard to nuclear safety, CEA's safety policy is established, renewed and maintained in the form of a four-year continuous improvement plan. It is implemented annually by means of directives.

For the specific case of basic nuclear installations (BNIs), a protection of interests policy is defined, through which CEA - as the nuclear licensee - ensures that priority is given to the protection of these interests, and that improvement of these measures is sought on a permanent basis. CEA is committed to implementing this policy, defines the objectives and specifies the strategy for attaining them.

The protection of interests policy concerns BNIs, the operation of which is placed under the operational responsibility of the teams at the Energies Directorate (DES) in the Cadarache, Marcoule and Paris-Saclay centres, and applies throughout all phases in the lifetime of these facilities: design, construction, operation, final shutdown, dismantling, maintenance and surveillance.

The CEA organisation is detailed in Appendix C.

***ILL***

In accordance with French regulations on BNIs, the members of the ILL Management Board make an explicit commitment to the priority given to the protection of interests, through the definition of a Protection of Interests Policy (PMPI). This policy gives the main guidelines for topics related to the protection of interests for a period of 5 years. ILL has also set up an integrated management system (IMS) which guarantees that compliance with the protection of interests requirements is taken into account in all of its activities.

With regard to continuous improvement, following each annual IMS management review, the ILL Management Board sets priority annual objectives for the coming year, related to the protection of interest topics defined in the PMPI.

The ILL organisation is detailed in Appendix C.

***ASN oversight***

ASN oversight aims primarily to ensure that the licensees effectively meet their obligations. ASN carries out its oversight role by using the regulatory framework and individual resolutions, inspections, and if necessary, enforcement measures, in a way that is complementary and tailored to each situation, to ensure optimal control of the risks nuclear activities represent for people and the environment.

The oversight is based on in-depth technical discussions with the licensees, including the organisational aspects. Its integrated approach takes into account all aspects of protection of people and the environment.

## 9.2. Transparency and public information by the licensees

### 9.2.1. Measures taken by EDF

EDF's policy aims to ensure that dialogue and transparency result from clear and accurate information about events and their potential impacts. This policy of dialogue and transparency is sought and maintained with the staff and its representatives, the subcontractors, the oversight bodies, the local communities, especially the CLIs (see § 7.3.2.4), and all other nuclear safety stakeholders.

For example, these transparency and communication actions take a variety of forms: annual report, CLI meetings and thematic visits, meetings with elected officials, press releases, monthly newsletters, public information centre, website (www.edf.com), toll-free telephone number, answers to public queries about the safety, radiation protection and environmental protection measures taken.

In particular, the report required by Article L.125-15 of the Environment Code for each NPP describes the steps taken concerning nuclear safety and radiation protection, nuclear safety and radiation protection incidents and accidents, the nature and results of radioactive and non-radioactive environmental discharge measurements, the nature and quantity of radioactive waste stored on the facility site. This report is made public and transmitted to the CLI set up for each NPP.

In addition, EDF informs the public of any significant events occurring in its facilities, by publishing this on the website of the NPP, or in its external newsletter.

EDF takes part in the work of the HCTISN.

### 9.2.2. Measures taken by CEA

CEA carries out actions to promote transparency and public information, more specifically:

- participation in the public meetings of the CLIs, in order to inform them of research activities, of the changing regulatory situation of the facilities and of any events concerning nuclear safety and radiation protection. A CLI is set up for each CEA centre;
- the CEA general management takes part in the annual meeting of the representatives of all French CLIs for the EDF, Orano and CEA facilities;
- CEA takes part in the work of the HCTISN;
- pursuant to Article L. 125-15 of the Environment Code the annual report is published.

### 9.2.3. Measures taken by ILL

The ILL participates in a large number of actions to promote transparency and public information, more specifically:

- participation in the plenary meetings and public meetings of the CLI;

- annual drafting of a report published on the ILL website;
- participation in the industrial risks regional information campaigns;
- updating of its website (www.ill.eu) with information concerning legislation, reactor safety, environmental monitoring, security, inspections, emergency exercises and incidents. The reinforcements made as a result of the stress tests further to the Fukushima Daiichi NPP accident and the "hardened safety core" concept are presented on the ILL website (see Focus 19 in § 14.1.2.2). Question-and-answer sections were included;
- participation in technical and scientific forums.

# Article 10 Priority given to safety

**ARTICLE 10 PRIORITY GIVEN TO SAFETY**

***Each Contracting Party shall take the appropriate steps to ensure that all organisations engaged in activities directly related to nuclear installations shall establish policies that give due priority to nuclear safety.***

## 10.1. The regulatory framework

The Environment Code (Article L. 593-6) states that *"the licensee shall give priority to the protection of protected interests"*. These are the protected interests defined in § 7.1.1, which notably concern safety, radiation protection and protection of the environment.

The licensee accords this priority *"firstly by preventing accidents and mitigating their consequences on account of nuclear safety. It formalises this policy in a document that explicitly states this priority"*.

Furthermore, the BNI Order stipulates that the licensee shall be responsible for the dissemination to and the comprehension of this policy by any person liable to implement it, including outside contractors. It also requires that the licensee evaluate its policy for the protection of protected interests, as well as the effectiveness of its implementation, at least every five years (Articles 2.3.2 and 2.3.3).

In addition, this Order stipulates that "*the license defines and implements an integrated management system that ensures that the requirements relative to protection of the [protected] interests are always taken into account in any decision concerning the installation. This system aims primarily to ensure compliance with the requirements of the acts and regulations, the authorisation decree, and the requirements and resolutions of ASN, and the conformity of the policy [concerning protection of protected interests]*" (article 2.4.1*).*

## 10.2. Measures taken by EDF

At the highest level of EDF, the priority given to safety is enshrined in a Safety Policy signed by its CEO. This policy sets the requirements and principles so that priority is given to protection of interests, in all the decisions taken at all levels of the company, first of all by preventing accidents and mitigating their consequences in respect of nuclear safety.

This policy, which is inspired by international guidelines and safety requirements (IAEA SF N° 1 and GSR Part 2, INSAG 4 for safety culture, INSAG 13 for safety management, INSAG 18 for change management), aims to reaffirm the priority given to safety within the Group and to help each manager clearly embody this, with the involvement of the industrial partners.

In addition to this EDF Group Safety policy, each NPP director draws up a Protection of Interests Policy presenting their commitment to giving priority to the protected interests and the principles involved in implementation thereof. Moreover, the DPNT and the DIPNN drew up a joint protection of interests policy which applies to any EDF-SA entity carrying out Protection Important Activities (PIA) on behalf of an NPP and to external contractors carrying out PIA. To simplify the implementation and assimilation by all those who need to be familiar with it and the application of this protection of interests policy, the first page is common to all these policies.

The responsibility for implementing this policy in each professional sector lies with the corresponding management line. It reaffirms the priority given to safety, to allow the sustainable use of nuclear energy, with strong commitments in terms of behaviour and safety culture, the search for constant progress, openness to international best practices, preparedness for emergency situations, transparency and dialogue. This policy is disseminated to each member of staff and to each contractor and subcontractor.

Each NPP director establishes an integrated management system for all the BNIs under his or her responsibility, which contributes to compliance with the rules of nuclear safety and radiation protection in the organisation and operation of their entity and, more generally, to the protection of the interests identified by the Environment Code. In this respect, he or she ensures that priority is given to protection of the abovementioned interests and its constant improvement, principally by preventing accidents and mitigating their consequences in terms of nuclear safety. He or she aims to ensure the development of continuous improvement and the adoption of best practices, including those identified internationally.

Continuous improvement is promoted and organised, calling on all the skills within the Group and also the international organisations with competence for nuclear safety. Operating experience feedback is collected, analysed, presented to the correct decision-making level and integrated. The Group's nuclear licensees regularly receive international assessments, in particular OSART and IAEA missions dealing with the topic "leadership and management for safety". Similarly, four Peer Reviews per year are conducted by WANO on the fleet in service. Their recommendations are taken into account in the improvement plans.

With regard to the independent safety assessment, certain provisions are unique, such as the creation of an independent safety organisation, and the Operational Nuclear Safety committee, which allows a transverse safety analysis of operating events, with the contribution of the management from all the plants.

### Focus 14 : The independent safety organisation of EDF

An "independent safety organisation" (FIS) is notably in place:

- in each NPP, the independent safety organisation (FIS), consisting of safety engineers and auditors, performs day-to-day verification of the actions and decisions taken by the departments in charge of operating the installations, as regards safety;
- at the DPN, the FIS checks and assesses the operation of the FIS in each NPP;
- at Group level, the EDF internal inspectorate, in particular the general inspector reporting to the Chairman of the EDF group, assisted by a team of inspectors, represents the highest level of independent verification of nuclear safety within the EDF group.

In complete independence from the operational lines, the FIS verifies the assimilation and implementation of the principles and requirements linked to the protection of interests. It reports to the head of the entity concerned. It alerts the next higher level if it so deems necessary.

With regard to development of the safety culture, EDF has produced the following, based on international practices:

- a safety culture guide, which presents the traditional approach followed by EDF and the common points of reference in terms of safety culture;

- a range of tools making it possible to determine a position, to debate and discuss safety practices within a unit, the departments and the safety teams;
- other provisions, such as operating experience feedback, or internal and international assessments (IAEA, combined EDF/WANO).

EDF reinforces the safety culture in each NPP, by developing the safety leadership and the corresponding "Safety Culture" roadmap. In order to reinforce the safety leadership, a Safety Perception Questionnaire (SPQ), now joined to the WANO baseline requirements, is conducted every two years, alternating with a self-assessment regarding safety management practices. These can be used to take account of feedback and any whistle-blower alerts from the staff as a whole and to have the results debated in the management and work collectives. The resulting lines of progress are incorporated into the multi-year Safety Culture roadmaps so that progress can continue to be made on safety issues, within the NPP and increasingly within the departments. These roadmaps comprise different types of improvement actions in response to the NPP/departments diagnostic, covering training, the use of safety management levers and practices (risk assessment, work reliability enhanced practices, inspection/monitoring, etc.), but also the time set aside for sharing and for debate within the teams.

### 10.3. Measures taken by CEA

Nuclear safety is a major priority at CEA. The management of safety is built around:

- a well-defined organisation, in which each member at each level is trained in, made aware of and given responsibility for the role which is clearly assigned to him or her (see Appendix C);
- a safety culture that is taught, maintained and developed;
- staff that are professional, skilled and capable of teamwork.

At the central level, the Chairman sets the broad guidelines and defines measures designed on the one hand to implement the legislative, regulatory and specific provisions applicable and, on the other, CEA's nuclear safety management. The Chairman also makes final strategic decisions.

In 2006, CEA adopted a security policy, incorporating nuclear safety, via a four-year continuous improvement plan.

The Nuclear Security and Safety Division (DSSN), which assists the Chairman, defines a protection of interests policy for the BNIs under the Energies Division (DES). This protection of interests policy is extracted from the four-year continuous improvement plan with respect to nuclear safety. This policy is the subject of a CEA letter of engagement, signed by the Chairman.

At the local level, the centre directors and facility managers ensure that it is applied in each facility for which they have responsibility. To this end, the letter of engagement signed by the Chairman is posted whenever possible within the BNIs.

For CEA, the DSSN applies nuclear safety doctrine (legislative texts, Orders, ASN resolutions) via prescriptive documents and recommendations or guides intended for the DES nuclear safety players.

The monitoring function is carried out by entities separate from and independent of those constituting the line of action. The monitoring function consists in assessing the effectiveness and adequacy of the actions taken and of their internal technical monitoring.

At the level of the Chairman, the monitoring function is performed by the General and Nuclear Inspectorate (IGN). The IGN carries out scheduled inspections and reactive inspections in response to significant events. The IGN Director may decide on the inspectorate's intervention on relevant topics.

CEA is also committed to a self-assessment approach based on a certain number of indicators for monitoring safety and the correct working of the organisation.

In addition, CEA continues to reinforce its organisation, notably:

- the organisation of technical support for facilities in certain fields of expertise;
- organisational arrangements concerning management of contractors;
- the organisation of decommissioning operations.

### 10.4. Measures taken by ILL

Nuclear safety has always been and remains the priority at ILL. Management of safety at ILL is based inter alia on a clearly defined organisation.

The ILL Director assumes responsibility as nuclear licensee. In this field, two departments report directly to him/her:

- A Radiation Protection-Safety-Environment Department (SRSE),
- A Quality-Safety-Risks Unit (CQSR) set up in 2018 in particular to reinforce safety independence.

The ILL Deputy Director, Head of the Reactor Division, is given powers by the Director to assume responsibility for the operation, safety and security of the reactor and its annexes. In the field of safety, he/she calls on the services of a Safety Unit (CS) which reports directly to him/her.

The roles and responsibilities of the two entities - CQSR and CS – are clearly identified and described in the IMS mentioned in § 9.1. The CQSR is thus in charge of carrying out independent safety checks and assessments.

The protection of interests policy mentioned in § 9.1 is systematically given to new colleagues and sent out to all staff every year, following the IMS management review.

All levels of the staff also periodically receive ILL internal training in the safety culture. Furthermore, ILL staff are particularly aware of the safety, owing to the size of the ILL (small number of hierarchical levels): they are actively involved in improving the quality and safety of their activities, on a day to day basis, as well as in the IMS continuous improvement process.

### 10.5. ASN oversight of the measures taken by the licensees

ASN oversees the BNI licensees to ensure that they give priority to safety, at three levels:

1. the inspections assess how the licensees give priority to safety in their activities and evaluate the level of the safety culture. These inspections can concern safety policy, actions taken to coordinate and develop the safety culture, and correct assimilation of the safety culture by the players. The inspections can also examine how decisions are made if a safety problem arises. Apart from the usual documentary review and working situation observation techniques, the ASN inspectors may resort to individual interviews, for which they have been specifically trained: the aim of these interviews is to have the persons interviewed – who work in the field - explain their activity and its context (in particular the sense given to their work);

2. analysis of significant events, which provides a different perspective from inspection, both in terms of analysing the root causes of events and the proposal of preventive/corrective measures by the licensee: this offers a different view of the licensee’s safety culture;
3. a more general view is also obtained periodically during the safety management reviews on the licensees' premises. The conclusions of these reviews are presented to the Advisory Committee of Experts for Nuclear Reactors (see § 8.1.6).

ASN monitors the BNI licensees' safety management policy and system by:

- verifying that the commitments made by the licensee are met, in particular when they lead to concrete measures being taken in the facilities concerned;
- within the framework of the reviews of generic subjects with major implications, examining the organisations put into place by the licensee and how they function, including from the managerial perspective;
- analysing the methods for assessing licensee safety management, the means of leveraging improvements that they identify and the gains achieved by the organisational modifications implemented.

## 10.6. ASN internal provisions

On behalf of the State, ASN ensures the oversight of nuclear safety and radiation protection to protect people and the environment.

Since 2012, ASN has had an integrated management system based on international standards, such as IAEA's GSR Part 1 and GSR Part 3 standards, and ISO standard 9001. Its quality policy declaration positioned the management system at the heart of its organisation for the performance of its nuclear safety and radiation protection regulation and oversight duties in line with its values (competence, rigorousness, independence and transparency) and its ambition (exercise oversight that is recognised by the citizens), for assessment and continuous improvement of ASN’s actions and how it carries out its duties.

The integrated management system promotes the involvement of everyone in the performance of ASN’s duties. This system also takes part in disseminating ASN’s common culture to all the personnel, as described in the “our collective commitment” document. It contributes to creating the framework needed to implement a rigorous approach and a questioning attitude.

The safety culture lies at the heart of ASN’s values and practices. ASN formally set out the guiding principles for its regulation and oversight actions in its strategic plan. These constitute the foundation of a shared culture and collective know-how. ASN adopts a thorough questioning attitude: it does not simply accept the licensee’s initial answers and continues its questioning until it obtains all necessary information (as was for example the case with regard to the carbon concentration anomaly affecting the large equipment items). If a deviation is detected, it always asks whether it could extend to other items of equipment or other installations. ASN's organisation provides for decisions to be determined collectively. This enables each person, regardless of their position in the hierarchy, to express themselves and be listened to in a receptive and constructive manner.

ASN gives priority to safety, as witnessed by its position statements, for example the decision to shut down the four Tricastin reactors until the seismic resistance of the embankment is increased, and its position on the repairs to the eight penetration welds on the Flamanville EPR steam lines before commissioning.

# Article 11 Financial and human resources

**ARTICLE 11 FINANCIAL AND HUMAN RESOURCES**

*1. Each Contracting Party shall take the appropriate steps to ensure that adequate financial resources are available to support the safety of each nuclear installation throughout its life.*

*2. Each Contracting Party shall take the appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety related activities in or for each nuclear installation, throughout its life.*

## 11.1. Financial resources

### 11.1.1. The regulatory framework

The Environment Code requires that the licensee must *"have the technical, financial and human resources, described in a notice, and implement the means needed to exercise its responsibility"* (article L. 593-6).

The Environment Code requires that the authorisation for the creation a BNI takes account of "*the technical and financial capacities of the licensee*". These capacities must enable it to carry out its project while protecting the interests mentioned, *"in particular to cover the costs of decommissioning of the installation and rehabilitation, monitoring and maintenance of its site or, for radioactive waste disposal facilities, to cover the costs of final shutdown, upkeep and surveillance"*. (Article L.593-7).

The BNI Order includes provisions requiring that the licensee put in place adequate resources – in particular financial resources – for defining, implementing, maintaining, evaluating and improving an integrated management system (article 2.4.2).

ASN Guide No. 30 recommends that *"the licensee's financial resources enable it to deal with reasonably predictable economic risks which could have an impact on the protection of the protected interests, whether these risks are specific to the BNI (for example, unscheduled major maintenance operations), or global (for example, the market risk)"*.

The legal arrangement aims to secure the funding for nuclear costs, in compliance with the "polluter-pays" principle. The Environment Code defines the arrangements for securing the financing of the nuclear costs linked to the decommissioning of nuclear facilities, the management of spent fuels and the management of radioactive waste (articles L. 594-1 to L. 594-14). The Environment Code also stipulates that the licensees must make a prudent assessment of the costs of decommissioning their facilities, and the cost of managing their spent fuel and their radioactive waste (article L. 594-1). The nuclear licensees must thus make provision for this financing by creating a portfolio of dedicated assets equivalent to the anticipated costs. They are obliged to submit triennial reports on these costs and annual update notices to the Government. The securing of funding is under the direct supervision of the State. The General Directorate for Energy and the Climate (DGEC) at the Ministry for Energy Transition is the competent administrative authority for this supervision: it analyses the situation of the licensees and may prescribe the necessary measures in the event that this is insufficient or inadequate. Whatever the case may be, the nuclear licensees remain responsible for the satisfactory financing of their long-term costs.

Finally, with regard to civil liability, the maximum amount of the licensee's liability for the nuclear damage caused by each nuclear accident is set at 700 million euros (Article 597-4 of the Environment Code). Each licensee is required to take out and maintain insurance or a financial guarantee for the amount of its liability.

### 11.1.2. Measures taken for nuclear power reactors

With a net installed power of 120 GWe worldwide as at 31 December 2021, for global production of 529.7 TWh, the EDF Group has one of the largest electricity production fleets in the world. On mainland France, the net production of electricity by EDF in 2021 was 462 TWh, including 360.7 TWh from nuclear production (62 GWe installed capacity), 62.4 TWh from hydraulic power (20 GWe) and 38.6 TWh from fossil fuels (5.5 GWe).

In 2021, the Group achieved consolidated sales of 84.5 billion euros, an EBITDA of 18 billion euros and a Group share of net income of 5.1 billion euros.

With regard to nuclear production in France, the EDF Board gave its approval in principle to the "Grand carénage" major overhaul programme in early 2015, the aim of which is to renew the French nuclear fleet, increase the safety level of the reactors and, if the relevant conditions are met, extend their continued operation. The total amount of the investments between 2014 and 2025 for the reactors in service - initially evaluated at 55 billion euros$_{2013}$ - or 60 billion euros in present-day terms, was re-evaluated at 50.2 billion euros in present-day terms.

This industrial programme is being gradually implemented in order to meet the objectives of the Energy Transition Act, multi-year energy programmes, the ASN opinions and requirements and the procedures involved in allowing reactor operation beyond 40 years.

Furthermore, to secure financing of its long-term nuclear commitments, EDF has in previous years set up a portfolio of assets exclusively devoted to meeting provisions linked to dismantling of the NPPs and the back-end fuel cycle facilities. As at 31st December 2021, these dedicated assets represented a value of 28.9 billion euros. The three-yearly reports concerning these costs, and the annual update memoranda, are transmitted to the DGEC.

EDF thus has the financial resources to meet the safety needs of each nuclear facility throughout its lifetime.

### 11.1.3. Measures taken for research reactors

#### *11.1.3.1. CEA's Cabri reactor*

Most of the CEA budget comes from the State. In this budget, 10 million euros are allocated annually to the Cabri facility, including about 2 million for safety. This amount is considered to be sufficient to cover the costs associated with safety (periodic safety reviews, preventive maintenance, periodic checks and tests).

With regard to the financial capacity for the decommissioning phase and in accordance with the regulations, CEA is setting up a provision for decommissioning, and for the management of the spent fuel and waste from the Cabri reactor, expected by the end of its operating lifetime. The estimate of this provision is presented to the DGEC in a three-yearly report; a memo updating this report is produced every year.

#### *11.1.3.2. The ILL high-flux reactor (HFR)*

ILL, a private law company founded in 1967, is financed primarily by France, Germany and Great Britain, via its associates (CEA, CNRS, FZJ, UKRI). This is governed by an agreement between these three countries. This agreement has just been prolonged by the signing of the 6$^{th}$ amendment which guarantees that ILL will have the funding it needs to operate for the next 10 years (2024 to 2033).

Within this framework, for the duration of operation of the ILL, the Management therefore presents a 10-year budget (investment and operation) to its French, German and British associates, twice a year. This multi-year budget comprises all the expressed needs and more particularly those related to the safety of the BNI: financing of sufficient and competent human resources, investments for the modifications made further to the periodic safety review and changes to the regulations, maintenance, etc. This balanced budget is voted by the ILL associates, twice a year.

The ILL's annual average budget is €100 M, 20% of which is devoted to reactor-related investments (safety improvements, overhaul, maintenance) and to modernisation of the scientific instruments.

With regard to the financial capacity for the decommissioning phase, spent fuel and waste management, and in accordance with the regulations, the ILL is setting up a provision for the decommissioning planned at the end of its operating life. The estimate of this provision is presented to the DGEC in a three-yearly report, with a memo updating this report being produced every year. Therefore, and in accordance with the ILL agreement, the Governments of the associates undertake to cover this provision by recognising a debt held by ILL on each one of them (which corresponds to coverage of the debt by an asset equal to the debt of the associates). This recognition is made every year. This process is also validated by the auditors.

#### 11.1.4. Oversight by the authorities

The three-yearly reports presenting the evaluation of the costs related to decommissioning and waste management are examined by the DGEC. The DGEC asks ASN to examine the technical hypotheses (notably those related to the reprocessing of spent fuels) underpinning these cost evaluations and notably to ensure the consistency between the evaluation of the costs presented by the licensees and the decommissioning, spent fuel and radioactive waste management strategy. An annual review report is submitted to the DGEC by ASN regarding the analysis of the three-yearly reports of each licensee and the annual update memoranda.

### 11.2. Human resources

#### 11.2.1. The regulatory framework

It is up to the licensee of a BNI to have sufficient, appropriate and qualified human resources. The regulatory requirements concerning the human resources that must be available to the licensee of a BNI are more particularly contained in the Environment Code (Article L 593-6) and the BNI Order (Article 2.1.1).

In addition, the BNI Order states that "*the protection important activities, their technical inspections, the verification and evaluation actions are carried out by persons with the necessary skills and qualifications*" (Article 2.2.2). The licensee must therefore adopt appropriate training procedures in order to maintain and develop the skills and qualifications of its own personnel or those of outside contractors.

Pursuant to the ASN "emergency" resolution, the licensee must *"define the members and the skills of the emergency teams, according to the human actions required and the intervention conditions liable to be encountered. The licensee takes the organisational measures enabling it to ensure that these personnel and these skills can be mobilised at any moment and for an appropriate duration, in particular making provision for the necessary shift changes".*

#### 11.2.2. Measures taken for nuclear power reactors

At the end of 2021, the workforce of EDF's Nuclear Operations Division (DPN), responsible for operating the nuclear reactors, stood at 22,700, spread among the NPPs in operation, one plant under construction (FLA3) and the 2 national engineering units. Engineers and management account for 36% of the workforce, supervisors 60% and operatives 4%.

To these 22,700 staff must be added EDF's human resources devoted to design, to new constructions, to engineering of the NPPs in service and the support functions and to dismantling of nuclear reactors:

- about 5,670 engineers and technicians in the engineering centres split among management (80%) and supervisors (20%);
- nearly 230 engineers and technicians from the nuclear fuel division (DCN);
- more than 750 engineers and technicians from EDF's research and development division (EDF R&D).

Since 2006, EDF has been devoting considerable efforts to guaranteeing the skill levels and the careers of the staff, by adopting a Forward planning of employes and skills (GPEC) approach, based on harmonised principles for all the NPPs, built up gradually from actual feedback from the field. These aspects are the subject of specific monitoring, coordination and oversight.

EDF has a coordinated national training organisation and a professionalisation unit for industrial performance devoted to developing and carrying out training courses. Generic training is available, in particular "design safety" and "operating safety" courses. The members of the emergency organisation follow regular training and exercises both locally and nationally. Some training exercises are organised jointly with the public authorities.

Between 2008 and 2018, the nuclear production division underwent a significant renewal of its human resources, with considerable turnover (12,000 new arrivals), which required a considerable amount of training. The new arrivals systematically follow an initial "Académie des Savoirs Communs" (introductory basic training) course of 8 weeks covering operation, the safety and quality culture, security and radiation protection. Depending on the work area, the course continues with an "Académie de Savoirs Spécifiques Métier" (specific professional training) course to learn the fundamentals of a given profession (e.g. Operations technician). Over and above the basic and professional training courses, specific training on annual topics can be proposed in the professions on the basis of lessons learnt: for example, training devoted to lessons learnt about non-compliances with the operating technical specifications has been set up for all the operations teams. In addition, Training Committees in the plants define "just in time" training in order to safeguard the performance of certain sensitive activities, notably by using simulators for operations or "mock-up spaces" for maintenance. For the professions in which the stakes are higher (control, safety engineer, etc.) a qualifications system is organised. Regular retraining is held and coordinated within the individual entities. Skills management at the DPN is based on operating experience feedback from the other international licensees. Systematic Approach to Training (SAT) is being gradually deployed in professions with safety implications. This effectiveness of this systematic approach is due to the fact that the training is tailored to meet the requirement, targets the right person and occurs at the right time. The training programme is designed to achieve competence objectives, according to the appropriate teaching options. To ensure that the skills of its employees are acquired, maintained and developed, each unit conducts a formal annual review by means of interviews between each employee and his or her direct manager. Common core subjects define the organisations and the reference jobs. For these jobs, baseline requirements create the link between the activities carried out and the means of acquiring the skills.

With regard to nuclear engineering, a "Skills Development Plan" (PDC) approach has since 2006 involved all the units concerned (engineering, production, R&D). This approach aims to develop the skills of the engineering disciplines and, through a cross-cutting, forward-looking approach, helps the units prepare their Forward planning of employes and skills choices.

### 11.2.3. Measures taken for research reactors

#### *11.2.3.1. CEA's Cabri research reactor*

Sufficient numbers of competent staff work internally on the Cabri research reactor to carry out safety-related activities (operation, maintenance, studies):

- two safety engineers, who have safety-criticality qualifications,
- two radiation protection officers in charge of monitoring the facility and the radiological monitoring of the personnel,
- the head of the facility and the head of the BNI hosting department,
- workers in the support units (technical departments) and from the subcontractors for maintenance and periodic checks and tests.

There is also BNI support for specific safety studies or monitoring:

- engineers in the safety support unit on the Cadarache site,
- an engineer dedicated to Cabri in the safety unit on the Cadarache site.

Finally, the facility may from time to time call on the Nuclear Safety Security and Safety Division (DSSN) and experts at CEA.

The Cabri reactor personnel in charge of activities related to nuclear safety receive training specific to their positions. They are qualified and licensed for the activities under their responsibility, in accordance with a procedure applied to all of CEA's BNIs:

- the separation of qualification and licence responsibilities;
- the confirmation of qualification by a manager;
- the confirmation of qualification, notably by validating the skills acquired during professional experience and not solely by training;
- giving consideration to the diversity of the means of skills acquisition (initial and continuous professional training, professional experience, self-training, tutoring);
- the traceability of the qualification and licence decisions.

The head of the Cabri facility follow specific training before taking up the position. This training covers management of staff and operations, nuclear safety at CEA, the operational legal responsibilities of the licensee, radiation protection and waste management.

All of the Cabri reactor personnel follow a safety culture training programme drawn up by the Nuclear Safety and Security Division (DSSN). This training covers the theory, regulatory and operational aspects of the safety culture.

#### *11.2.3.2. The ILL high-flux reactor (HFR)*

ILL has sufficient and competent internal human resources enabling it to manage its activities and more particularly those related to the operation and safety of the reactor (studies, projects, maintenance, etc.). The subcontracting rate for these activities is very low (less than 20%).

Moreover, since 2016, in order to meet safety requirements, the ILL has appreciably increased the size of its teams. The institute thus increased the number of safety engineers in the safety unit (CS), reporting to the head of the Reactor Division, as well as in the quality-safety-risks unit (CQSR) reporting to Senior Management.

For surveillance of the facility and radiological monitoring of the personnel, the size of the radiation protection unit workforce was also increased and placed under the responsibility of a radiation protection engineer.

For environmental surveillance, the ILL set up a new laboratory in 2010, with a workforce composed of several technicians and one engineer.

Skills management for the ILL personnel required to intervene on Protection Important Activities (PIA) is handled by applying a dedicated IMS process. The unit heads are therefore responsible for ensuring that their colleagues are competent to carry out PIA within their scope of activity. They guarantee that these colleagues have followed all the regulatory and internal training necessary for performance of the PIA, including training using the mentoring system. The ILL Training Centre provides technical support for the unit heads with regard to deployment of the employee skills development plan.

To this end, the unit head identifies the skills needed for each activity and - for each employee - the training course required in order to obtain these skills. In this course, two types of training are possible:

- theory training, focusing on the one hand on general knowledge of the nuclear sector and the resulting particularities at ILL (safety, security, radiation protection, quality, etc.) and, on the other, the particular technical and documentary knowledge needed to carry out activities or operations;
- practical training using the mentoring system, the purpose of which is to gain expertise in the various activities or operations in the field.

Particular attention is paid to the training and retraining of reactor operators, with a 9-week program enabling them to operate the reactor in all the operating domains specified by the General Operating Rules. The future reactor operator is also trained to operate the facility in an accident situation.

This training course comprises:

- an initial part taught by the INSTN, covering the general nuclear knowledge needed to operate the reactor,
- a specific part taught jointly by the ILL and the INSTN, making a bridge between the general knowledge and the specific aspects of the ILL reactor, notably in the fields of neutronics, thermalhydraulics, instrumentation and control, and OHF,
- a final part, “Reactor Operations” taught by the ILL, the aim of which is to acquire the specific technical knowledge needed to operate the reactor. The reactor operator skills are also developed to include management of incident/accident operations and emergency situations, by means of simulation tools.

### 11.2.4. ASN oversight

ASN oversight regarding skills and human resources is based primarily on inspections. The workforces, hiring, training, monitoring of the skills of outside contractors and the organisation put in place by the licensee to manage these topics, are subjects regularly covered by the inspections.

ASN has found that the large-scale personnel turnover faced by EDF has led to an unprecedented effort in terms of training and support for the new hires, as well as the deployment of the professional sector academies for training the new arrivals on the sites.

# Article 12 Human factors

**ARTICLE 12 HUMAN FACTORS**

***Each Contracting Party shall take the appropriate steps to ensure that the capabilities and limitations of human performance are taken into account throughout the life of a nuclear installation.***

## 12.1. The regulatory framework

The BNI Order stipulates that organisational and human factors must be taken into account in the same way as technical aspects when applying rules regarding the design, construction, operation, final shutdown, decommissioning, maintenance and monitoring of Basic Nuclear Installations (Article 1). The BNI Order requires that the nuclear safety case be made using a prudent deterministic approach, incorporating the technical, organisational and human aspects (Article 3.2).

The implementation of these principles was then clarified in the ASN resolution concerning the safety analysis report of BNIs, known as the "RDS" resolution. Pursuant to this resolution, the safety analysis report must in particular cover the following subjects:

- the contribution of organisational and human measures to demonstrating the limitation of risks,
- the organisational principles implemented by the licensee and their appropriateness for demonstration of the nuclear safety case,
- the way organisational and human factors (OHF) are taken into account in the design.

This resolution stipulates that *"the safety analysis report describes and provides justification for the main design, construction and operating measures implemented by the licensee in technical, organisational and human terms to ensure conditions that allow the persons intervening to preserve nuclear safety."*

Guide No. 22 on the design of pressurised water reactors recommends that:

- the socio-technical system shall be designed so as to create the best possible conditions for the personnel to perform the activities associated with operation of the installation;
- the design of the socio-technical system shall minimise the possibilities of inappropriate human actions and foster the ability of the personnel to detect and manage unforeseen events;
- the search for design provisions shall be gradual and, if necessary, iterative;
- the design provisions shall be validated using appropriate assessment methods and means (user tests, mock-ups, simulation, etc.) in conditions that are as representative as possible of those that will be encountered in operation.

## 12.2. Measures taken for nuclear power reactors

Organisational and Human Factors (OHF) are taken into account in the engineering and operating activities by:

- implementation of the Socio-Organisational and Human (SOH) impacts analysis in any design, modification and decommissioning project with safety implications; Following on from what has been done since the end of the 1980s in new design projects, the SOH approach was initiated in 2006, to ensure that human and organisational aspects are taken into consideration in any technical, documentary and organisational changes. After nearly 10 years of construction and deployment of this approach, the following progress can be observed today:

- an SOH expert is present in each engineering unit, providing expertise to senior management and project managers,
- oversight of projects and files within the units, identifying the designs/changes with SOH implications and ensuring that the necessary measures are taken in all phases up to deployment in the nuclear fleet,
- changes to the practices of the design managers, incorporating human and organisational aspects, jointly with the operator and with the support of internal and external expertise, in particular for the field analyses, the validation phases, and to define the change management actions with the operator,
- a key role for the transverse units regarding the various nuclear fleet plant series, to ensure cooperation between engineering and licensee in the design/change work,
- gradual implementation, with coverage of projects with major stakes: Periodic safety reviews, EPR UK, Grand Carénage, Colimo[15], or security projects.

- support for actions to improve operations, carried out with the operational personnel by HF experts: Human Factors Consultants on the sites and the national experts (UNIE - Operation Engineering Unit, R&D). The incorporation of OHF aspects during operations is extensively supported by the work of the site HF Consultants and by the national teams (UNIE – Operation Engineering Unit, R&D). One or two HF consultant(s) are present on each site (one HFC per pair of reactors). Their work is usually relayed by HF correspondents in the departments. Their duties cover three main fields: development of safety management and the safety culture, improvement of socio-technical and organisational situations, development of Human Factors skills. Over the last few years, they have in particular supported safety management and safety culture approaches: events analysis method, change in risk analysis, support with human performance practices, implementation of operational decision making, safety culture image projection.

## 12.3. Measures taken for research reactors

### 12.3.1. CEA reactors

In 2008, CEA set up an organisation dedicated to organisational and human factors. It comprises:

- specialists in the Nuclear Safety and Security Division (DSSN) and in the safety support units of the CEA centres;
- contacts in the BNIs;
- correspondents in the monitoring units reporting to each centre director.

The specialists make up the centre of expertise which coordinates the network of OHF players. A network meeting is held for one day every year, to discuss OHF experience through testimonials from CEA employees and outside contributors.

These OHF stakeholders intervene to:

- perform OHF analyses in the facilities, following the emergence of identified problems or events;

[15] The Colimo project aims to modernise lock-out methods and practices in order to increase the serenity and security of operating and maintenance personnel.

- perform systematic OHF interventions during the periodic safety reviews, or for requests more specifically concerning the operation phases and the operations relating to the handling of fuel and experimental devices;
- integrate OHF into the various steps of the new facility design projects.

Training courses on the consideration of OHF in activities presenting both safety implications and a significant OHF component continued, and training in the integration of OHF into events analysis was provided in the various CEA centres.

In terms of R&D, CEA has closed its research partnership agreement with the École des Mines de Paris. The two theses included in this agreement were defended in 2020 and 2021. They concerned the study of monitoring mechanisms for contractor activities in quasi-integration and the study of knowledge transmission during periods of transition between two contractors, respectively. The work involved in the practical application of these two theses is currently ongoing. The aim is thus to examine how these two theses can enhance the training courses, the OHF documentary baseline, etc.  This can concern various topics, for example such as the transformation of basic skills into expert skills, or changes to the working of an organisation as a result of the training given.

### 12.3.2. The ILL high-flux reactor (HFR)

In 2019, the ILL installed an OHF correspondent tasked with assessment (event analysis, OEF, etc.) and technical support (projects, training, etc.) in the field of organisational and human factors.

The management personnel in the reactor division and the radiation protection, safety, environment department, plus the safety engineers, received specific instruction in organisational and human factors.

For discussions on OHF and in order to stay abreast of changes in this field, ILL’s OHF correspondent is a member of CEA’s OHF stakeholder network and in this capacity takes part in the annual days held by CEA.

## 12.4. ASN oversight

ASN monitors the steps taken by the licensee to improve the integration of organisational and human factors into all phases of a nuclear reactor lifecycle, by means of inspections or during reviews of authorisation applications.

With regard to the engineering activities during the design of a new facility or the modification of an existing one, ASN checks that the licensee correctly deploys the SOH approach enabling it to take account of people and organisations in the development of systems and in the changes to equipment and organisations.

ASN also monitors the activities carried out for the operation of existing reactors, throughout their service life. ASN in particular checks the steps taken by the licensee to incorporate organisational and human factors on a day to day basis, the organisation of work and the intervention conditions by the workers or the subcontractor personnel, all of which can have an impact on the safety of facilities and workers, along with skills, training and qualifications management carried out by the licensee.

Finally, ASN checks the analysis of operating experience feedback concerning reactor design, construction and operation. ASN more particularly checks the licensees’ organisation for analysing events, the methodology employed and the depth of the analyses carried out to ensure that the underlying causes (organisational and human) of events are looked for and, lastly, the development and implementation of the follow-ups to the analyses, whether in the short, medium or long term.

# Article 13 Quality Assurance

**ARTICLE 13 QUALITY ASSURANCE**

***Each Contracting Party shall take the appropriate steps to ensure that quality assurance programmes are established and implemented with a view to providing confidence that specified requirements for all activities important to nuclear safety are satisfied throughout the life of a nuclear installation.***

## 13.1. The regulatory framework

The BNI Order (Articles 2.5.1 to 2.5.7) includes general provisions that the licensee must follow for the protection important components and activities (PIC[16] and PIA), such as to guarantee that they effectively protect interests, including the safety of the installation. More specifically, the licensee must define the requirements that each protection important component or activity must comply with so that it can fulfil its role as stipulated in the safety case. Therefore, these requirements are referred to as "defined requirements". In addition:

- The PICs must be qualified so as to guarantee their ability to perform their functions with regard to the loadings and ambient conditions associated with the situations in which they are needed;
- The PIAs must be carried out in such a way as to comply with the defined requirements for these activities and for the PICs concerned by these activities. They must be carried out by persons with the necessary skills and qualifications and checked by different persons.

The BNI Order (Article 2.4.1) stipulates that the licensee must define and implement a plant-specific integrated management system enabling it to ensure that the requirements concerning protection of the interests of the BNI system are systematically taken into account in all decisions concerning its facility. The licensee must thus set up, formally define and seek to improve a plant-specific integrated management system ensuring that the requirements concerning the protection of the protected interests are taken into account in the management of its facility.

This Order also requires that:

- the detected deviations and significant events be corrected with due diligence and that preventive and corrective measures be implemented (Article 2.6.1);
- the licensee monitor its contractors and check that the organisation implemented to guarantee quality does indeed operate satisfactorily (Article 2.2.3).

ASN Guide No. 30 presents policy recommendations for the protection of protected interests and the licensees' plant-specific integrated management system.

## 13.2. Measures taken for nuclear power reactors

In order to control the protection of interests throughout the lifecycle of a BNI (design, construction, operation, decommissioning), the management of the Nuclear and Thermal Production Division (DPNT) and the Engineering and New Nuclear Project Division (DIPNN) drew up a document (PMPI) specifying the

[16] The PICs are broader than the systems, structures and components (SSC) defined by the IAEA.

responsibilities and organisational principles implemented to meet the provisions of the regulations, the plant-specific integrated management system (IMS), the protection important components and activities and the activities management provisions governed by the IMS (including management of deviations and significant events). This document applies to the BNI operators of the DPN and the DIPNN and the entities of the DPNT, the DIPNN and EDF Hydro carrying out protection of interest activities on behalf of BNI licensees in France.

In this respect, each NPP director defines a plant-specific integrated management system which complies with the regulatory provisions of the Environment Code and the BNI Order.

The plant-specific integrated management system is part of the Management System (Integrated Management System for the DPN) and its purpose is to ensure that the requirements concerning the protection of interests stated in Article L. 593-1 of the Environment Code are taken into account when performing the activities governed by the IMS. The activities governed by this IMS are the activities important for interests and activities explicitly required by a regulatory text to be part of the IMS (example: OEF processing, significant events processing, regulations compliance watch, document management, contractor monitoring, etc.). This system is a means of creating and periodically updating the list of PICs and corresponding defined requirements (ED), consistently with the Safety Analysis Report applicable to the BNI, along with the list of PIAs and corresponding ED, consistently with the principles adopted.

The IMS is based on the principle of continuous improvement: it is described, implemented, assessed and continuously improved via annual reviews.

The activities governed by the IMS are carried out by the BNI operator or entrusted to national entities or outside contractors. The following organisational provisions shall be adhered to:

- Each entity (EDF SA, subsidiaries of the EDF Group and outside contractors) working for a BNI operator applies the joint DPNT-DIPNN protection of interests policy and ensures that the various persons involved in performance of the PIA under its responsibility has understood the risks and the corresponding stakes. For outside contractors, this policy is referenced in the contracts;
- Each EDF SA entity performing activities governed by the IMS of a BNI operator implements a management system capable of controlling these activities. This system specifies the measures implemented in terms of organisation and resources to control these activities; it is based on documented information;
- Each EDF SA entity working on behalf of a BNI operator develops the safety culture of the persons involved in performing activities governed by the SGI and under its responsibility;
- Each EDF SA entity working on behalf of a BNI operator performs an annual analysis of the control of the activities governed by the IMS (including the PIA). It sends the senior management of the BNI licensee a summary of the analyses performed for use in the BNI licensee's management review;
- Each BNI operator and each EDF SA entity entrusting all or part of the performance of an activity governed by the IMS to a BNI operator or an outside contractor, requires the implementation of a management system such as to ensure the control of this activity. For the outside contractors, these requirements are defined in the General Quality Assurance Specification (SGAQ) which is referenced in the contracts, or in the contractual documents; the requirements of the SGAQ applicable to contracts with an impact on protected interests are those of standard ISO 19443.

  It should be noted that the entities of the DIPNN and the entities of the DPNT are engaged in an ISO 19443 certification process.

***Relations with contractors***

The maintenance of reactors in the French nuclear power fleet is to a large extent subcontracted by EDF to outside contractors. The decision to implement this industrial policy lies with the licensee. A system of prior contractor qualification has been put in place by EDF. It is based on an assessment of the technical know-how and the quality organisation of the subcontractor companies and is formally written up in the Social Requirements document, one of the contractual documents, created by the work of the CSFN (Nuclear Sector Strategic Committee), with EDF and its main contractors.

To ensure the quality of its services, EDF first of all ensures that its contractors are capable of performing the services satisfactorily. It then monitors the activities entrusted to its contractors. This monitoring does not relieve the contractor of its contractual responsibilities, notably those concerning the implementation of the technical and quality assurance requirements. Contracts between the ordering customer and its contractors clearly define the responsibilities of each party, the applicable requirements and the commitments in terms of quality and results.

Furthermore, in order to strengthen the quality of the partnership with the contractors, an improvement programme is put into place. This more specifically focuses on the quality of work done, contracts giving more importance to the “best bidder”, and facilitation of the working conditions in the field.

With regard to the risk of possible fraud or counterfeit (Counterfeit, Fraudulent and Suspect Items - CFSI - as defined by the IAEA), EDF has, since 2017, been implementing specific provisions aiming to prevent and detect these risks, notably:

- creation of a whistle-blower system guaranteeing anonymity, which can also be used by anybody from outside EDF;
- appointment of an "ethics and compliance" correspondent within each EDF entity. This correspondent is there to be consulted by the personnel of the EDF entity regarding potential fraud and counterfeit risks concerning the activities EDF itself performs within this entity. He/she is connected to a network of Ethics and Compliance correspondents, managed by the head of the EDF Group. In the event of a report made on the EDF or ASN whistle-blower sites, the entity’s Ethics and Compliance correspondent processes the alerts or has them processed (on a need to know basis for the purposes of the investigation, limiting the number of persons informed to that strictly necessary), in order to understand and circumscribe the potential risks and take the necessary interim measures, while complying with the provisions of the Sapin 2 Act of 9 December 2016;
- awareness-raising actions on the importance of integrity and the safety culture;
- data integrity and conservation (archival of end-of-manufacturing reports, for example);
- manufacturing inspection measures on suppliers' premises focusing more on the detection of CFSI issues;
- implementation of calculation review means;
- the General Quality Assurance Specification appended to the contracts EDF places with its suppliers, imposing a duty to issue alerts and monitoring of its subcontractors;
- incorporation of the CFSI risk into the supplier qualification process, through specific questions.

Since the beginning of 2021, the entities of the EDF Group as a whole have initiated a process of ISO 19443 standard certification, the provisions of which comprise specific training, detection, supplier monitoring and information requirements with respect to the CFSI aspects. At the beginning of 2022, a large number of EDF entities had already been certified as ISO 19443 standard compliant (for the others, this is in progress). This process reinforces the way in which the CFSI risk is addressed.

## 13.3. Measures taken for research reactors

### 13.3.1. CEA reactors

According to the BNI Order, each centre and each operational division defines its integrated management system for the areas under its responsibility. In practice, it is up to the facility heads to implement in their own local system the rules defined for the centre in which their facility is located and those of the operational division to which they report. The defined requirements for the PICs and PIAs are formally identified in this local system.

The management system of the Energies Division (DES) and the Cadarache centre (where the Cabri research reactor is located) includes quality, health/safety and environment (QSE). It is certified compliant with standards ISO 9001, ISO 14001 and OHSAS 18001.

In addition, the DES, which is responsible for the Cabri and JHR research reactors, organises regular audits of its units or their contractors, in order to measure the progress made and assess the ability of the suppliers and contractors to meet CEA's quality requirements.

For the Cabri research reactor, these audits concern both the quality of activities linked to the programmes and the quality of the activities linked to their safe operation.

### 13.3.2. The ILL high-flux reactor (HFR)

Since the end of 2017, ILL has adopted an integrated management system (IMS) which has the primary aim of ensuring compliance with the requirements concerning protected interests. The IMS structure is based on an approach in which the processes are grouped into categories and cover all the ILL activities linked to the protection of interests:

- "operational" processes for the core activities at ILL (operation of the reactor and the scientific instruments for scientific output),
- "support" processes for the activities supporting the core activities (human resources, safety, radiation protection, etc.),
- "control" processes, for the activities specific to the integrated management system (continuous improvement, documentation management, etc.).

Operation of the IMS is based primarily on:

- the process coordinators, who ensure that their process is correctly applied and improved,
- the quality, safety, risks unit (CQSR), which guarantees the overall consistency and improvement of the IMS,
- the management's engagement which, via the Protection of Interests Policy, sets the short and medium-term priority strategic lines and ensures that the human resources needed for operation of the processes are available.

The "safety" process comprises the identification methodology and the list of PICs and PIAs, along with the corresponding defined requirements. The operational PIAs undergo an upstream risk assessment to define the hold points in the activity which cannot be lifted without a prior technical inspection.

A process defines the monitoring of the contractors working on PIAs, which uses specifically trained managers. In addition, audits of the working personnel are carried out by the CQSR in accordance with an annual programme or in response to a particular event.

Continuous improvement of the system and the protection of interests is ensured by the anomalies and deviations management and OEF processes, but also via process reviews and IMS management reviews, as well as internal audits, or spot checks carried out by the CQSR.

**Focus 15 : ILL's transformation of its quality assurance system into an integrated management system**

Before 2017, the ILL had a quality assurance system compliant with the 1984 Quality Order but not fully compliant with the BNI Order of February 2012. Following formal notice served by ASN, the ILL thus decided to completely overhaul this system, leading to the current IMS and to improvements in terms of clarification of roles and responsibilities, documentation management and traceability, improved formalisation of technical oversight and independent verifications. The safety management organisation was also extensively modified with the addition of an independent safety entity reporting to the management (CQSR).

This IMS, implemented at the end of 2017, was deployed and adapted until the end of 2020. At the end of 2021, a high level of assimilation by the ILL personnel had been achieved and the continuous improvement process was mature.

## 13.4. ASN oversight

### 13.4.1. Quality assurance in the construction and operation of reactors

During its inspections on sites under construction or in operation, ASN focuses on checking that the provisions defined by the BNI Order for PICs and PIAs are complied with, and that the licensee follows the procedures and requirements it has defined in this respect in its management system. More specifically, for the PIAs, the adequacy of resources for the tasks, staff training, working methods and the quality of the documentation associated with the operations are thus checked, along with the procedures for licensee monitoring of protection important operations and their technical inspections.

### 13.4.2. Quality aspects related to the use of contractors

The supply of PICs and realisation of PIAs (maintenance, studies) for the French NPP fleet reactors are partly subcontracted by EDF to outside companies. ASN's role is to check that even when subcontractors are used, EDF continues to fully exercise its responsibility for the safety of its installations. This oversight of EDF's control of the quality of the goods and services supplied and constituting PICs or PIAs, can thus concern:

- on the one hand the modalities adopted by EDF to inform all outside contractors of the provisions necessary for application of the BNI Order;
- on the other, EDF's monitoring of these suppliers.

For the purposes of this oversight activity, the regulations state that ASN can carry out inspections at the suppliers and issue binding requirements on the licensee regarding the activities carried out by these suppliers.

In the particular case of the design and manufacture of nuclear pressure equipment, ASN may directly conduct an inspection of the NPE manufacturers, to ensure that these manufacturers meet the safety requirements of the regulations with which they are required to comply.

With regard to the choice of the contractors, pursuant to the legislative provisions adopted in 2016, ASN checks that when EDF considers entrusting performance of a PIA to an outside contractor, the licensee:

- assesses the bids, on the basis of the criteria related to the protected interests;
- ascertains beforehand that the companies it is considering using have the technical capability to carry out the work in question and control the associated risks.

ASN reinforced its oversight of the EDF procurement chain for PICs intended for NPPs. As part of this oversight, ASN examines compliance with the regulatory requirements applicable to PIAs for manufacturing operations, the ability of the suppliers to manufacture equipment meeting the safety requirements and how the risk of fraud is addressed. During these inspections, ASN also checks EDF's monitoring of its suppliers and their subcontractors.

ASN also carries out inspections in the various engineering departments on the monitoring of the contractors involved in the design studies.

# Article 14 Assessment and verification of safety

**ARTICLE 14 ASSESSMENT AND VERIFICATION OF SAFETY**

*Each Contracting Party shall take the appropriate steps to ensure that:*

*i) comprehensive and systematic safety assessments are carried out before the construction and commissioning of a nuclear installation and throughout its life. Such assessments shall be well documented, subsequently updated in the light of operating experience and significant new safety information, and reviewed under the authority of the regulatory body;*

*ii) verification by analysis, surveillance, testing and inspection is carried out to ensure that the physical state and the operation of a nuclear installation continue to be in accordance with its design, applicable national safety requirements, and operational limits and conditions.*

## 14.1. Assessment of safety

### 14.1.1. The regulatory framework

The Environment Code contains a creation authorisation procedure, which may be followed by a number of licensing operations during the life of a BNI, from its commissioning up to final shutdown and decommissioning, including any modifications made to the facility. These aspects are detailed in § 7.3.

The Environment Code specifies the content of the file required **for the creation authorisation** of a basic nuclear installation (Article R. 593-16). This file in particular includes the preliminary version of the safety analysis report, which comprises the inventory of risks presented by the installation and the analysis of the measures taken to prevent these risks or mitigate their consequences. The drafting of the preliminary version of the safety analysis report, the required content of which is specified in Article R. 593-18, is thus based on a safety assessment of the installation.

The Environment Code specifies the content of the required file **for the commissioning authorisation** of a basic nuclear installation (Article R. 593-30). This file comprises the safety analysis report containing the update of the preliminary version of the safety analysis report and the information allowing to assess the conformity of the installation built with the provisions of the creation authorisation decree. The BNI Order requires that the nuclear safety case be made using a prudent deterministic approach, incorporating the technical, organisational and human aspects (Article 3.2).

With regard to **modifications to the installation occurring during operation**, the "modifications" resolution specifies the criteria for distinguishing the noteworthy modifications requiring ASN authorisation from those requiring notification. Noteworthy modifications include the changes made by the licensee:

- to the systems, structures and components (SSCs) of the installation, their authorised operating conditions, the elements which led to its authorisation or its commissioning authorisation or, as applicable, its decommissioning conditions;
- and liable to affect public health and safety or the protection of nature and the environment.

This resolution defines the content of the modification file (including the safety analysis report update) as well as the requirements applicable to the management of noteworthy modifications, more particularly the internal check procedures to be implemented by the licensees.

The Environment Code specifies that the licensee of a BNI must periodically carry out a **periodic safety review** of its installation, taking into account international best practices (Article L. 593-18). *"This review shall allow [...]*

*an update of the assessment of the risks or detrimental effects presented by the installation [...], notably taking account of the condition of the installation, experience acquired during operation, changes to existing knowledge and to the rules applicable to similar installations"*. Furthermore, the Environment Code states that *"the steps proposed by the licensee during the periodic safety reviews beyond the thirty-fifth year of operation of a nuclear power reactor are, following a public inquiry, subject to the ASN authorisation procedure mentioned in Article L. 593-15"* (Article R. 593-19). This arrangement enables the public to give its opinion on the continued operation of the nuclear power reactors beyond the time initially considered in their design.

Independently of the authorisation and review procedures, the Environment Code provides for the possibility - *"in the event of a threat to the interests mentioned in Article L. 593-1"* - of ASN prescribing the assessments and implementation of the measures made necessary, at any time (Article L. 593-20).

The "RDS" resolution explains the expected content of the safety analysis report:

- demonstration that the technical, organisational and human provisions adopted enable a level of risk that is as low as reasonably achievable under economically acceptable conditions;
- the description of the incidents and accidents that could occur and the steps taken to prevent them, limit their probability or mitigate their consequences;
- assessment of the potential consequences, whether or not radiological, of the incidents and accidents considered.

### 14.1.2. Assessments made at the various stages in the lifetime of the installations

#### *14.1.2.1. Before operation*

***Flamanville EPR reactor***

A high level of safety was sought in the design studies for the Flamanville EPR reactor, with the following objectives:

- The prevention and mitigation of the consequences of simple initiating events liable to occur in the various reactor states, whether at power, intermediate states, or shutdown states with the core completely unloaded into the spent fuel pool. The following were carried out in order to meet these objectives:
    - design studies for the control systems for the main physical parameters of the installation,
    - design studies for the automation systems aiming at returning the installation to its normal operating range before soliciting the protection systems and automatic reactor shutdown (signals and control cluster drop),
    - design studies for the safeguard systems (ECCS-RHRS, MSRT, EFWS, RBS, ...) and their support systems,
    - design studies for the 3rd containment barrier, consisting notably of an inner containment (wall, basemat, liner), a depressurised annulus between the inner and outer containments and a penetrations isolation system.
- The deterministic consideration of the accidents corresponding to multiple failures (common mode failures, or failure of a safety system actuated further to a simple initiating event), which led to the sizing of the RRC-A (Risk Reduction Category A) provisions, such as the diversified reactor scram signals, start-up of the SBO ultimate backup diesels, installation of a standstill seal system (SSSS) on the reactor coolant pumps, opening of a pressuriser line dedicated to feed and bleed, cooling of the spent fuel pool by the 3rd spent fuel cooling system (PTR) train;

- Deterministic consideration of the internal hazards following a study principle similar to that used for simple initiating events;
- Deterministic consideration of external hazards with high severity levels, whether hazards of human origin (airplane crash, explosion, etc.), or hazards of natural origin (earthquake, extreme temperatures, etc.). Over and above the load cases they represent, the consequences of some of these hazards are studied, more particularly with respect to the internal initiating events they are liable to cause;
- The "practical elimination" of accident situations with core melt, which could lead to large or early releases, by taking physical measures to prevent them from appearing, such as depressurisation of the primary system by opening one of the two "Feed and Bleed " and "Severe Accident" pressuriser lines, and the catalytic recombination of hydrogen by the reactor building's passive autocatalytic recombiners;
- The deterministic consideration of hypothetical core melt accident situations liable to occur. The RRC - B (Risk Reduction Category B) provisions aim to preserve long-term containment (protection of the basemat by spreading in a corium catcher and flooding system / removal of residual heat by the EVU spray function) and to limit releases and protect the populations (implementation of static and dynamic containment functions). Control of releases also implies the systematic identification and processing of all situations which could lead to bypassing of the containment;
- The use of Probabilistic Safety Assessments in addition to the deterministic approach for the choice of the multiple failures to be considered and to confirm the technical options adopted:
  - level 1 PSA (non-hazard) and Hazard PSAs, the aim of which is to quantity the risk of core melt beyond an overall target of $10^{-5}$ per unit and per year of operation, considering all types of failures and hazards,
  - level 2 PSA (non-hazard), the aim of which is to quantify the risk of releases into the environment associated with the various scenarios resulting from the level 1 PSA and thus confirm the analyses of practical elimination of situations able to lead to large or early releases, as well as the analyses showing that the releases associated with core melt sequences at low pressure only require population protection measures that are limited in both space and time.

Following the design PSAs which, at the beginning of the project, were able to guide the design of the reactor and make it possible to assess the various possible design options, the PSAs produced to back up the commissioning authorisation application file, are able to check that the design and sizing is adequate for the general safety objectives determined at the outset. These PSAs notably allowed:

- verification that a balanced reactor safety design has been obtained, in other words that there are no scenarios making an excessive contribution to the overall frequency of core melt,
- identification of the RRC-A (Risk Reduction Category A) situations, while for each one ensuring that there are effective particular provisions capable of reducing the risk of core melt,
- a judgement to be made on the "practical elimination" of certain core melt sequences leading to large or early releases (such as containment by-pass sequence, reactivity accidents, etc.), in addition to the deterministic measures taken to prevent them,
- confirmation of the robustness of the design to internal and external hazards.

***JHR Reactor***

The safety case presented in the JHR safety analysis report is based on implementation of the principle of defence in depth for all installation states. The aim of the safety analysis approach in the JHR BNI is to demonstrate that the steps taken in the design, to apply the various levels of defence of depth, are able to reduce the risks of accidents, whether or not radiological, and the scale of their consequences, to levels that are as low as possible in economically acceptable conditions. In this respect, the JHR project pays particular attention to containment, which notably led to the creation of a leak collection zone around the singularities (penetrations and airlock) of the reactor containment.

In order to advance the safety of a technological irradiation reactor, this approach was systematically applied in order to ensure that the defence in depth approach was consistent between the installation and the experiments carried out inside it. Thus, even if it enables similar activities to be carried out, the JHR reactor represents significant developments with respect to the OSIRIS reactor concerning both the experiments and safety.

In accordance with the BNI Order, the nuclear safety case for the JHR reactor was produced using a prudent deterministic approach:

- The incident and accident operating conditions, characterised by an initial state and a postulated trigger event leading to a sequence of effects, and the risk mitigation situations (including controlled severe accidents, such as a BORAX type explosive reactivity accident) are the subject of a deterministic safety analysis;
- The list of hazards liable to compromise the safety of the installation is defined by the BNI Order, differentiating between internal hazards and hazards originating outside the installation. They are also the subject of a deterministic safety analysis.

#### *14.1.2.2. In operation*

***The periodic safety reassessments***

<u>The EDF reactors</u>

In accordance with the regulations, EDF carries out periodic safety reviews of its reactors every ten years taking account notably of the condition of the facility, the experience acquired during its operation, changes to knowledge and the rules applicable to similar facilities. The “safety reassessment” part leads to the implementation of modifications designed to improve safety.

The safety reassessment is based on in-depth analyses, comprising deterministic and probabilistic assessments, incorporating operating experience feedback, the previous periodic safety reviews, evolution of knowledge and the incorporation of new regulatory requirements. These analyses lead EDF to define a range of material or operational modifications which help improve safety, in accordance with the orientations adopted at the beginning of the review. In most cases, these modifications are grouped into modification batches, which offers greater consistency in the batch of modifications and industrialisation of their application: this thus facilities planning, documentary updating and operator training.

Given the similarity between the reactors in a plant series, the periodic safety reviews of the reactors are carried out in two complementary phases: a first “generic” phase, common to all the reactors of a given plant series, which were designed using a similar model; a second "specific" phase, which takes account of the characteristics specific to each facility, notably its geographical location.

The EDF 900 MWe reactors were commissioned between 1977 and 1987 and the first of them have reached their fourth periodic safety review. This fourth periodic safety review presents particular challenges:

- some items of equipment are reaching their design-basis lifetime. The studies concerning the conformity of the installations and the management of equipment ageing therefore need to be reviewed to take account of the degradation mechanisms actually observed and the maintenance and replacement strategies adopted by EDF;
- the safety reassessment of these reactors and the resulting improvements must be carried out in the light of the new-generation reactors, such as the EPR, the design of which meets significantly reinforced safety requirements, notably with regard to mitigation of the radiological consequences of accidents without core melt, in order to significantly reduce the occurrence of situations involving the implementation of population protection measures, and reduction of the risk of accident with core melt and mitigation of its consequences.

### Focus 16 : Safety objectives of the fourth periodic safety review of the 900 MWe reactors

For the 4$^{th}$ Periodic Safety Review of the 900 MWe plant units, EDF set itself the goal of moving towards the safety objectives of the EPR type 3rd generation reactors and to reduce early or large releases, in order to avoid long-term environmental effects. EDF thus implemented provisions in two areas:

1. Avoid all risk of radioactivity dispersal into the soil, by making the risk of melt-through of the reactor building foundations (basemat) a residual one, thanks to dry spreading of the corium and its cooling by passive flooding (immersion under water); this solution is in principle similar to that used on the EPR to stabilise the corium;
2. Avoid opening the containment venting device (filter U5) for accident scenarios with loss of safeguard systems, by implementing a special system called EAS ND which enables the water inventory (volume of water) to be maintained in the primary system and the residual heat from the core to be removed by transfer into the containment.

These objectives applied to the existing reactors are those of principle n.1 of the Vienna Declaration on Nuclear Safety (VDNS) which is formulated for new reactors.

In this respect, EDF extended its safety case to include the prevention and mitigation of severe accidents, including in extreme situations beyond the design basis, and has defined major modifications (see Focus 17 in § 14.1.2.2).

### Focus 17 : Safety improvements implemented with the fourth periodic safety review of the 900 MWe reactors

The modifications implemented, which are detailed below, have the following aims:

1. Limit the radiological consequences of accidents without core melt: implementation of the resupply of the steam generator emergency supply tank by the fire-fighting water production system, increasing the atmospheric discharge capacity of the turbine bypass unit, interconnection of the ultimate backup diesel generator sets of the even and odd reactor numbers, lowering of the equivalent iodine limit of the radiochemical specifications of the primary system water, etc.;

2. Avoid massive releases and the long-term environmental effects of accidents with core melt: stabilisation of the corium under water by passive reflooding after dry spreading in the reactor pit and

the adjacent Incore instrumentation room (see Focus 9 in § 6.3.1), removal of residual power to the exterior of the containment without opening the venting device (see Focus 9 in § 6.3.1);

3. Reduce the risk of spent fuel assemblies melting in the storage pool: putting in place of a diversified system for cooling the spent fuel pool in the fuel building;

4. Improve the hazard resistance of the installation: reinforcement of the polar crane to withstand the extreme earthquake, modifications (unit heaters, ventilation systems, etc.) to reduce the temperature in the premises in heatwave situations, lightning protection measures, etc.

CEA's Cabri research reactor

CEA carries out periodic safety reviews on its BNIs every ten years. The periodic safety review comprises several parts:

- an analysis of the experience acquired during the previous decade, entailing a comparison with operating experience feedback from similar installations,
- an examination of the conformity of the installation (conformity with the applicable and regulatory baseline requirements, qualification of the PICs, state of ageing of the civil engineering structures and main equipment items, state of the functional systems such as nuclear ventilation, obsolescence of electrical equipment),
- a safety reassessment, incorporating all internal and external hazards.

On the basis of the conclusions of this periodic safety review, CEA draws up an action plan specifying the envisaged on-site modifications and, as necessary, the compensatory measures implemented pending their performance. More specifically, the work done on an overhead crane has increased its reliability, which constitutes a significant improvement in terms of safety.

The ILL HFR reactor

During the last periodic safety review, in 2017, the ILL placed particular emphasis on:

- technical and regulatory conformity,
- verifications by means of analysis and testing of the technical requirements for safety important equipment,
- control of handling, fire and explosion risks,
- control of risks linked to extreme natural hazards,
- the safety reassessment.

The safety improvements planned under the periodic safety review aim to increase the facility's ability to withstand internal and external hazards and to implement an operational hardened safety core (see Focus 19 in § 14.1.2.2).

The main improvements carried out or planned concern:

- increased reliability of the polar crane lifting system;
- safeguarding the tritium inventory by transforming tritium gas into tritiated water;
- the addition of fire risk control provisions: automatic sprinkler extinguisher system in the reactor building's experimentation areas;

- seismic reinforcement of the reactor building and its protection important equipment, in order to take account of changes to seismic standards, and the reinforcement of the adjacent buildings to guarantee their stability or at least ensure that they do not represent a hazard for the reactor building;
- the installation of an ultimate flooding system supplementing the measures to prevent the risk of draining of the pile block in the event of a break on the reactor primary coolant system;
- installation of the (redundant) groundwater system to guarantee that the fuel remains flooded and cooled. This system may also be used for fire-fighting;
- the installation of the (redundant) seismic depressurisation system enabling the reactor containment to be kept at negative pressure with extraction filtration;
- the installation of automatic cut-out of all non-seismic electrical power supplies when a seismic threshold is reached, to avoid any post-earthquake electrical fire;
- the creation of a new operational emergency management centre to deal with an extreme natural hazard situation.

***Modifications made during operation***

During the operations phase, the licensees regularly make changes to the equipment and the operating rules. These changes can be the result of processing of deviations or operating experience feedback. In any case, they are based on an assessment of their safety consequences.

***Stress tests***

In France, the stress tests initiated after the Fukushima Daiichi NPP accident were part of a dual framework: on the one hand, the performance of a nuclear safety audit of the French civil nuclear facilities in the light of the events at Fukushima, which was the subject of a referral to ASN on 23 March 2011 by the Prime Minister and, on the other, the organisation of the actual "stress tests" on the NPPs requested by the European Council at its meeting on 24 and 25 March 2011.

The stress tests were carried out according to European specifications and were performed on all the nuclear facilities, that is including research facilities, fuel cycle facilities and the facilities currently under construction (EPR, JHR and ITER).

The stress tests consist of a targeted re-assessment of the safety margins of the nuclear facilities in the light of the events that occurred at Fukushima Daiichi, namely extreme natural phenomena (earthquake, flooding and a combination of the two), that overloaded the safety functions of the installations and led to a severe accident. They first of all look at the effects of these natural phenomena; they then look at the case of a loss of one or more of the safety important systems affected at Fukushima Daiichi (electrical power supplies and cooling systems), regardless of the probability or the cause of the loss of these functions; finally, they deal with the organisation and the management of any severe accidents that could occur as a result of these events.

The purpose of these assessments is to evaluate the robustness of the facilities beyond their design basis, by identifying on the one hand the situations which would lead to a sudden deterioration of the accident ("cliff edge effect") and, on the other, measures such as to avoid these situations.

### Focus 18 : Safety improvements of the NPP reactors following the stress tests

Following the stress tests performed after the Fukushima Daiichi NPP accident, EDF implemented modifications to all of its reactors in service in order to improve:

- protection against internal or external hazards, notably by reinforcing protection against flooding;
- electrical supply means: installation of additional electrical power supplies (back-up diesel generators), increased autonomy for the batteries used in the event of total loss of electrical power supplies;
- the provisions for the prevention of accidents with core melt: for example, installation of high-temperature seals on the reactor coolant pumps to withstand a loss of cooling for an extended period of time, emergency water make-up in the reactor coolant system when it is open, installation of standardised pipe connections for the mobile equipment (for the FARN in particular);
- the provisions for preventing uncovering of fuel assemblies in the pool: for example, provisions to prevent accidental rapid draining of the spent fuel pools, reinforcement of the spent fuel pool instrumentation;
- the management of accidents with core melt: for example, installation of redundant instrumentation to detect reactor pressure vessel melt-through, installation of redundant instrumentation to detect the presence of hydrogen in the containment;
- emergency management: reinforcement of the seismic resistance and flood resistance of the emergency management premises, strengthening of the team preparation in the event of an earthquake, means to deal with site isolation in the event of flooding, storage of mobile resources, reinforcement of means of communication, emergency organisation for management of accidents affecting several reactors on the same site, and coordination if necessary with neighbouring industrial operators;
- the means for providing an on-site response by deploying a nuclear rapid intervention force (FARN): capacity for simultaneous intervention on all the reactors of a damaged site in less than 24 hours. The FARN supplies water, compressed air and electricity by means of its own mobile equipment. The FARN is described in more detail in § 16.1.3.2 and in Focus 30 in § 16.1.3.2.

Additional modifications designed to avoid large releases and long-term environmental consequences have been defined and are being implemented in the French NPPs as part of the periodic safety reviews, which aim for the safety objectives applicable to the new generation of reactors (see § 6.3).

EDF also defined changes to the EPR reactor, presented in Chapter 18.

### Focus 19 : Safety improvements of the ILL HFR reactor following the stress tests

Following the stress tests performed after the Fukushima Daiichi NPP accident, the ILL designed, installed and commissioned a "hardened safety core" on two redundant trains which allows, in the event of an extreme natural hazard:

- to prevent the risk of drainage of the pile block in the event of a break on the reactor's primary coolant system by installing an ultimate flooding system resupplying the pile block with water from the reactor pool;
- to prevent the risk of loss of water inventory in the channels, pool and pile block, by installing a groundwater system supplying the reactor pool from aquifers;
- to maintain a negative pressure in the building, containing radioactive materials in the filters and traps and controlling accidental releases by installing a seismic depressurisation system activated in the event of an accident or external hazard;
- to prevent a fire risk following an earthquake by cutting all electrical power supplies outside the "hardened safety core";
- to have an emergency command post robust to extreme natural hazards and to the accidents which could occur in the industrial environment of the site.

## 14.1.3. ASN oversight

### *14.1.3.1. Before operation*

***Flamanville EPR reactor***

In May 2006, EDF submitted a creation authorisation application to the Ministers in charge of nuclear safety and radiation protection, for an EPR type reactor with a power of 1,650 MWe on the Flamanville site, which was already home to two 1300 MWe reactors.

The Government authorised its creation through Decree[17] 2007-534 of 10 April 2007, after a favourable opinion issued by ASN following the examination process. After the issue of this Creation Authorisation Decree and the building permit, construction of the Flamanville EPR reactor began in September 2007.

EDF sent its partial commissioning authorisation application in March 2015. ASN reviewed this application and in October 2020 issued the corresponding authorisation, which enables fresh fuel and source clusters to be allowed onto the site and stored in the pool (see Focus 20 in § 14.1.2.2 and Focus 34 in § 19.1.2).

EDF sent its commissioning authorisation application in 2015, accompanied by the safety analysis report, the general operating rules, the on-site emergency plan, the decommissioning plan, the updated impact assessment and the risk management study. Since then, the commissioning authorisation application file has been updated several times by EDF.

[17] This decree was modified in 2017 and 2020 to extend the time allowed for commissioning of the reactor.

With the help of IRSN, ASN is reviewing the reactor commissioning authorisation application (corresponding to the first loading of fuel into the reactor). ASN more particularly collected the opinion of its Advisory Committees on various topics, more specifically:

- safety classification,
- accident studies,
- design of the safety systems,
- fuel storage and handling,
- protection against the effects of internal and external hazards,
- probabilistic safety assessments,
- severe accidents and their radiological consequences.

A review was also conducted on the extent to which the reactor control means matched the organisation of the operating team, and examined the design of the human-machine interface and the feasibility of the tasks entrusted to the operating team.

ASN is also examining the other regulatory documents submitted by EDF with the commissioning authorisation application. The details of this review as well as the oversight of the construction of the Flamanville EPR reactor are presented in Chapter 19.

ASN also assesses the regulatory compliance of the nuclear pressure equipment (NPE) most important for safety, referred to as "level N1", corresponding to the reactor pressure vessel, the SGs, the pressuriser, the reactor coolant pumps, the piping, notably that of the main primary and secondary systems, as well as the safety valves.

Oversight by ASN and the approved organisations is carried out at the different stages of the design and manufacture of the NPE. It takes the form of an examination of the technical documentation of each equipment item and inspections in the workshops of the manufacturers, as well as at their suppliers and subcontractors.

### Focus 20 : Reception of the nuclear fuel on the Flamanville EPR reactor site

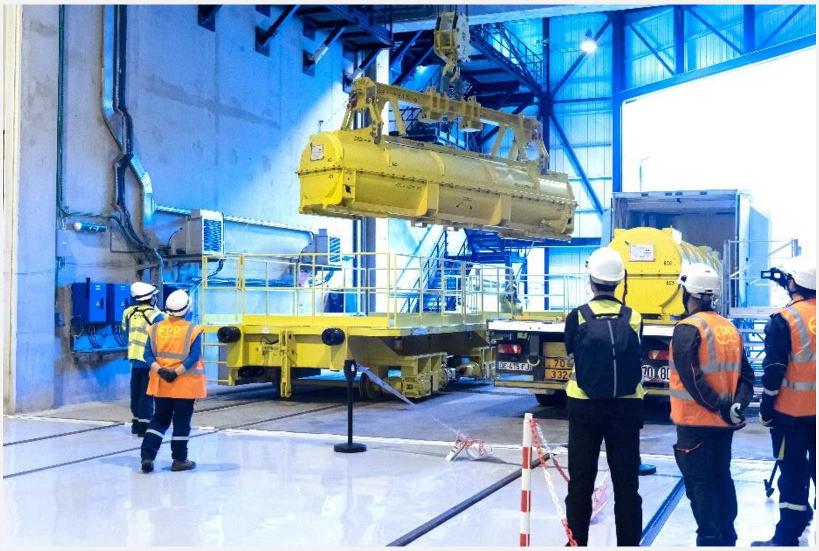
ASN examined the partial commissioning authorisation application in March 2015, which enables fresh fuel and source clusters to be allowed onto the site and stored in the pool.

If an assembly were to be dropped when being handled during reception and storage of fresh fuel, there would be a risk of dispersal of radioactive substances. Following its examination, ASN considers that the steps taken by EDF to prevent this accident scenario and mitigate the consequences were it to happen are appropriate.

ASN carried out an inspection on the Flamanville site on 18 and 19 August 2020 in order to evaluate the licensee's readiness for the fresh fuel reception, handling and storage operations. The checks carried out during this inspection showed that the state of the installation and the licensee's readiness for arrival of the fuel on the site were adequate.

On 8 October 2020, ASN authorised the arrival of nuclear fuel on the Flamanville EPR reactor site. Since then, EDF has received the fuel assemblies and stored them in the pool of the building provided for this purpose.

This authorisation is one of the steps prior to commissioning of the Flamanville EPR reactor. The commissioning of the installation, that is loading of fuel into the reactor vessel, is subject to authorisation by ASN.





***CEA's JHR reactor***

In March 2006, CEA submitted a creation authorisation application to the Ministers in charge of nuclear safety and radiation protection, for the JHR research reactor with a power of 100 MW on the CEA Cadarache site.

For the purposes of the creation authorisation application, the ASN examination notably covered the design of the installation's civil engineering in particular with regard to hazards (fire, combination of external or internal hazards), the classification and qualification process, the containment, operating situations and severe accidents and their radiological consequences, in particular the BORAX accident.

The Government authorised its creation through Decree[18] 2009-1219 of 12 October 2009, after a favourable opinion issued by ASN following the examination process.

In December 2021, CEA sent ASN the safety analysis report for the installation before the commissioning authorisation application. ASN defined an examination roadmap: the corresponding examinations will be performed with the support of IRSN and the Advisory Committees of Experts.

#### *14.1.3.2. In operation*

For the periodic safety review, ASN initially adopts a position on the safety objectives proposed by the licensee. It then examines the conclusions of the conformity examination and the studies associated with the safety reassessment performed by the licensee, supplementing it by inspections as necessary. For the purposes of this

[18] This decree was modified in 2019 to extend the time allowed for commissioning of the reactor

examination, ASN relies on IRSN and the Advisory Committees of experts. Following this examination, ASN may set binding technical requirements notably concerning the implementation of the provisions proposed by the licensee, or demand additional provisions.

For the 4th periodic safety review of the 900 MWe nuclear reactors (see Focus 21 in § 14.1.3.2), ASN issued a position statement on the objectives of this periodic safety review, that is the level of safety to reach for the continued operation of these reactors: the safety objectives to be adopted for this review were defined in the light of the objectives applicable to the new generation of reactors. This approach meets the requirements of Council Directive 2014/87/Euratom of 8 July 2014. It complies with principle n.2 of the Vienna Declaration on Nuclear Safety (VDNS).

In 2020, with the support of IRSN, ASN finalised its examination of the generic studies linked to the 4th periodic safety review. In 2018 and 2019, ASN more particularly obtained the opinion of the Advisory Committee for nuclear reactors as well as the opinion of the Advisory Committee for nuclear pressure equipment on:

- the accident studies in the safety case;
- the ability of the installations to withstand internal and external hazards;
- the probabilistic safety assessments;
- the management of accidents with core melt;
- ageing and obsolescence management;
- mechanical strength of reactor pressure vessels.

Following the review of the generic phase of the 4th periodic safety review, ASN issued a resolution at the beginning of 2021 on the conditions for the continued operation of the reactors. ASN underlined the ambitious objectives of the fourth periodic safety review of the 900 MWe reactors and the substantial work done by EDF during this generic phase. It also underlines the scale of the modifications planned by EDF, the implementation of which will bring about significant safety improvements. These improvements in particular concern management of the risks linked to hazards (fire, explosion, flooding, earthquake, etc.), the safety of the fuel spent fuel pool and the management of accidents with core melt.

ASN prescribed the implementation of the major safety improvements planned by EDF as well as a number of additional measures it considers necessary in order to achieve the objectives of the periodic safety review and thus bring the level of safety of the 900 MWe reactor more in line with that of the most recent reactors (third generation).

Following this generic phase, EDF will - from 2020 to 2031 - carry out the specific phase of the fourth periodic safety review of each of the 900 MWe reactors. The measures proposed by EDF will then give rise to a public inquiry. ASN will then submit for public consultation the draft requirements it feels to be necessary for continued operation of each of the reactors.

### Focus 21 : ASN resolution on the continued operation of the 900 MWe reactors

Following its review of the 4th periodic safety review of the 900 MWe nuclear reactors, ASN considers that the provisions planned by EDF, supplemented by the answers to the prescriptions issued by ASN, will enable the periodic safety review targets to be met and bring the safety level of the 900 MWe reactors more in line with that of the most recent reactors (third generation), notably:

- by improving how “hazards” (earthquake, flooding, explosion, fire, etc.) are taken into account. The reactors could also handle more severe hazards than those hitherto considered;
- by reducing the risk of accident with core melt and mitigating any consequences of this type of accident. These provisions will thus lead to a significant reduction in environmental releases during this type of accident;
- by limiting the radiological consequences of the accidents studied in the safety analysis report. This will significantly reduce the occurrence of situations requiring population protection measures (sheltering, evacuation, ingestion of iodine);
- by improving the provisions for managing accident situations affecting spent fuel pools.

In its resolution, ASN also asks EDF to report annually on actions taken to comply with the requirements and their deadlines. Further, ASN asks EDF to report annually on its industrial capacity and that of external contractors to carry out modifications to the installations within the deadlines. ASN requests that these elements be made public.

***Noteworthy modifications to the installations***

ASN examines the acceptability of the noteworthy modifications subject to its authorisation. These modifications can come from operating experience feedback or from changes made to the safety case. They are sometimes linked to reactor equipment modifications.

***Stress Tests***

ASN examined the stress tests performed by the licensees, jointly with its technical support organisation, IRSN, and collected the opinion of the Advisory Committee for nuclear reactors. In addition, ASN conducted a campaign of inspections targeting topics related to the Fukushima Daiichi NPP accident. These inspections comprised field checks on the conformity of the licensee's equipment and organisation with the existing baseline safety standards.

At the European level, the results of these stress tests were also examined by a peer review carried out under the supervision of the European Nuclear Safety Regulators Group (ENSREG[19]) in April 2012.

Following this review, ASN issued resolutions setting binding requirements. These resolutions concern the facilities examined in 2011, comprising the 59 EDF nuclear reactors (including the Flamanville 3 EPR), the three highest-priority CEA research reactors (Osiris, Masurca and JHR) and the high-flux reactor at the Laue Langevin Institute. These requirements, specific to the issues of each facility, significantly reinforce the robustness of the facilities beyond their design-basis levels. The binding requirements applicable to the NPPs were integrated into the national action plan at the end of 2012, issued within ENSREG, which was updated until its closure in 2020.

[19] ENSREG was created in March 2007 and brings together the heads of the safety regulators from the European Union Member States, as well as representatives of the European Commission.

## 14.2. Verification of safety

### 14.2.1. The regulatory framework

Provision is made for the verification of the safety of a BNI by various legislative and regulatory measures instituting the periodic safety reviews, in-service monitoring of NPE, checks on PICs and PIAs and the processing of the deviations discovered.

The Environment Code states that the licensee of a basic nuclear installation must periodically conduct a **periodic safety review** of its installation, taking account of international best practices (Article L. 593-18). In addition to the safety reassessment described in § 14.1.2.2, this review shall make it possible to assess the installation's conformity with all the rules that apply to it, in order to verify its safety; the applicable rules are the result of the regulations and guides, authorisation documents, and documents applicable to the licensee.

The Articles (Article 2.4.1, 2.6.1, 2.6.2 and 2.6.3) of the BNI Order specify the provisions binding on the licensee to ensure conformity with the requirements applicable to its installation. It in particular requires that the licensee define and implement an integrated management system, notably with the aim of verifying compliance with the requirements of laws and regulations, the authorisation decree and the binding requirements and resolutions of ASN and provisions concerning the detection and processing of deviations.

ASN Guide No. 21 sets out recommendations for processing conformity deviations affecting safety important equipment, but which do not render this equipment unavailable. The general operating rules in effect specify the time taken to restore the availability of the affected equipment, but do not cover a situation in which the deviation compromises the availability of the equipment in certain conditions (for example in the event of an earthquake). This Guide more particularly focuses on:

- specifying the time objectives for correction of these deviations, by explaining ASN doctrine with respect to the notion of "time-frame appropriate to the issues" mentioned in the BNI Order (Article 2.6.3);
- determining the procedures for analysing the combined effect on the installation of several conformity deviations, that the licensee must carry out pursuant to this same Order (Article 2.7.1).

In addition, the regulations comprise various provisions concerning the management of ageing, notably:

- provisions requiring in-service monitoring of certain non-replaceable nuclear pressure equipment, such as the reactor pressure vessels (Article R. 557-14-2 of the Environment Code);
- provisions which require that, as of the design stage, equipment ageing be taken into account, notably the alteration of materials over time and the consideration of ageing phenomena under irradiation (Order of 30 December 2015 on nuclear pressure equipment);
- design, construction, testing, inspection and maintenance provisions, which ensure that the qualification of the SSC is maintained as long as required (Article 2.5.1 of the BNI Order);
- provisions requiring periodic surveillance programmes on equipment, designed to verify that there are no faults or that - if there are - they do not develop, along with a programme to monitor the material properties degradation modes and a documentary survey to precisely identify the actions to which the equipment has been subjected (Order of 10 November 1999);
- provisions concerning the monitoring of the ageing of SSC, notably the incorporation of provisions into the design to facilitate monitoring of the anticipated ageing mechanisms and detect deterioration or unexpected behaviour, which could occur during operation of the BNI (Guide No. 22).

### 14.2.2. Verifications performed by the licensees

#### *14.2.2.1. Periodic checks and tests, in-service inspections, conformity check during the periodic safety reviews*

Checks and tests, in-service inspections and monitoring of operation are carried out to ensure that the physical state and the operation of a nuclear installation continue to be in accordance with its design, applicable safety requirements, and operational limits and conditions.

***Nuclear reactors***

The periodic tests on safety important equipment contribute to monitoring the availability of this equipment and **ensure compliance with the required characteristics**. The periodic test rules for safety important equipment are incorporated into the general operating rules of the reactors. They set the nature of the technical checks to be performed, their frequency and the criteria for determining the satisfactory nature of these checks. The periodic test rules are regularly revised to take account of modifications to the installation and in the light of operating experience feedback.

The actions that contribute to the management of ageing and conformity (surveillance, maintenance, inspection, processing of detected deviations, replacement of equipment) serve to ensure that the facilities comply with their safety baseline requirements, that is to say all the rules governing the safe operation of the facility. These actions must be carried out on a daily basis.

#### Focus 22 : Detection and processing of deviations to ensure conformity of electronuclear reactors

Concrete measures are taken to process deviations and thus ensure the design conformity of the EDF fleet of reactors. They are supplemented by other inspection programmes to check and maintain the conformity of the installations. Some deviations processing is detailed below:

- At the end of 2017, EDF reinforced the flood protection works on the Tricastin NPP in order to guarantee their ability to withstand a Safe Shutdown Earthquake (SSE). The ability to withstand the Maximum Historically Probable Earthquake (MHPE) was guaranteed (see Focus 1 in § 6.2);
- In June 2017, on the Belleville NPP, EDF detected under-thicknesses on the fire-fighting water supply system in the pumping station. A break of the pipes concerned could have led to flooding the pumping station and compromise the availability of the reactor's heat sink. Consequently, between 2017 and 2019, EDF performed checks in the pumping stations of all the reactors and carried out the necessary repairs and replacements on reactors concerned in the fleet (see Focus 4 in § 6.2);
- Between 2017 and 2022, EDF conducted an inspection campaign to guarantee the ability of its electricity sources to withstand the Safe Shutdown Earthquake (SSE). These checks were performed on a large number of equipment items and consist in verifying the good condition of the pipes and supports, the compensating sleeves, the ventilation valves, threadlocking of the bolted fasteners of the diesels and correct insertion of the electrical lugs. The necessary repairs or reinforcements were made (see Focus 2 in § 6.2).

With regard to the possibility of fraud or counterfeit (CFSI as defined by the IAEA), EDF adapted its surveillance practices, notably making greater use of unannounced inspections or joint inspections.

### Focus 23 : New measures to prevent fraud

To prevent the risk of fraud, EDF adapted its surveillance practices, notably making greater use of unannounced inspections or cross-inspections. Thus, since the discovery of irregularities at the Creusot Forge plant, EDF has adjusted its inspection of manufacturing in the suppliers' plants, or of on-site repairs and modifications, as follows:

- during the call for bids phase, introducing the possibility of assessing the industrial scheme proposed by the bidders and recommending that certain suppliers be banned or used with reservations,
- revision of the contractual specifications, notably SGAQ AIP (General Quality Assurance Specifications for Protection Important Activities) in order to incorporate particular requirements addressing CFSI risks,
- organising unannounced inspections,
- organising cross-check monitoring (for example, ultrasound cross-inspections, measurement of chemical composition, inter-laboratory tests for the tensile tests, re-viewing of radiographic films),
- comparison with the original reports issued by the organisations,
- preventive visits to certain suppliers, with cross-inspections without any cases of CFSI needing to have been confirmed.

In addition, at the initiative of the GIFEN (French Nuclear Industries Group), numerous suppliers initiated the ISO 1943 certification approach, which enables additional structural guarantees to be provided in addressing the CFSI risk.

The periodic safety review is an ideal framework for verifying the sufficiency and effectiveness of the provisions implemented to maintain the **conformity of the installations**.

On the occasion of the periodic safety reviews, EDF deploys substantial means to verify the conformity of the installations, with the aim of guaranteeing the conformity of the reactors with the applicable baseline requirements, particularly on the basis of:

- the examination of plant unit conformity (ECOT), which supplements the existing operating and maintenance provisions (periodic tests, maintenance programmes), by means of physical and/or documentation inspections,
- the complementary investigations programme (PIC), the aim of which is to confirm the assumptions concerning the absence of in-service degradation in areas not covered by the preventive maintenance programmes,
- processing conformity deviations identified during the operation of the installations,
- the provisions for management of ageing and obsolescence and the particular tests to be carried out during the ten-yearly outage inspections.

These provisions are carried out in addition to routine maintenance, in-service monitoring and processing of any deviations detected during operation.

### 14.2.2.2. *Ageing management*

***EDF***

For its nuclear power reactors, EDF has implemented an **ageing management** strategy based on three lines of defence: anticipation of ageing in the design, monitoring of the actual condition of the facilities and the repair, renovation or replacement of equipment actually or potentially affected.

Ageing management is based in particular on design, operating, in-service monitoring and routine maintenance measures, supplemented by exceptional maintenance. It notably contributes to maintaining the qualification of the PICs. In this respect, it comprises:

- analyses of the ageing mechanisms and of the capability for continued operation of the components for all the reactors, with regard to the behaviour of the equipment items and demonstrating management of the ageing of this equipment,
- a specific analysis of each reactor to verify that the generic analyses do indeed cover the particularities of each reactor, and to demonstrate the reactor's ability for continued operation,
- maintenance programmes, periodic tests, renovations,
- obsolescence management programmes decided nationally or locally.

#### Focus 24 : Specific provisions for the 4th periodic safety review of 900 MWe reactors in terms of compliance and ageing management

For the 4th periodic safety review, EDF carried out extensive work to verify the compliance of certain equipment or systems, based on an extensive base of ECOT checks, supplemented by field visits. These checks covered some fifteen topics, such as systems involved in containment (in particular those related to civil engineering), diesel-powered emergency generators, and systems used for recirculating the water present at the bottom of the reactor building sumps, which are necessary in certain accident situations. In addition, EDF has carried out design reviews for systems important to safety whose design studies have not been re-examined since commissioning of the installations, whose operating experience is unfavourable or whose failure would significantly increase the risk of core meltdown in an accident situation. These checks (ECOT and field visit) are carried out on each 900 MWe reactor.

EDF has also implemented a major programme of work on equipment ageing in view of the continued operation of the facilities beyond 40 years. To do this, EDF's industrial programme consists in:

- demonstrating the ability of the non-replaceable items to fulfil their function beyond 40 years (reactor pressure vessel and containment),
- demonstrating the ability of the replaceable items to fulfil their function beyond 40 years or else replacing or renovating them. EDF in particular defined a strategy in order to extend the validity time of the initial qualification for accident conditions (including earthquake) of the electrical and mechanical equipment. It consists in verifying that an equipment item qualified for an initial duration and operated for this period of time remains able to perform its functions for an additional duration in all its operating conditions. If this cannot be confirmed, the equipment is replaced.

***Research reactors***

CEA deploys continuous monitoring programmes via periodic checks and tests (CEP) and manages the ageing and obsolescence of the safety important structures and equipment (PIC), in order to ensure compliance with the defined requirements.

For CEA's BNIs, and in particular the Cabri reactor, the rules governing the periodic checks and tests are included in the general operating rules. These rules set the nature, frequency and criteria for determining whether the checks are satisfactory. These rules are regularly revised to take account of changes to the facility and operating experience feedback.

Analysis of the results of the periodic checks and tests and the visual inspection are used for long-term monitoring of the civil engineering structures and PICs. Moreover, the examination performed during the periodic review is a means of checking that the installation complies with its baseline safety requirements.

For the Cabri reactor, on the occasion of the last periodic safety review, the condition of the civil engineering was examined with respect to the risks related to its ageing. Visual assessments (whether or not destructive) highlighted certain localised faults or deterioration: renovation work was therefore carried out (renovation of portions of the tightness liner of the reactor building and on the roofs of the building annexes).

The obsolescence of the electrical equipment is a particular subject for assessment. For the Cabri reactor, a diagnostic of the high and low voltage electrical networks showed the need for an upgrade, with replacement of the High-Voltage / Low-voltage station.

In 2019, the ILL drew up an ageing management plan based on identification of the ageing mechanisms, the protection important equipment concerned by these mechanisms and the corresponding monitoring activities (nature, scope and frequency). The obsolescence topic is covered in the maintenance plans.

This ageing management plan was applied to the reactor containment by periodic checks and tests (evolution of the leakage rate and condition of the concrete containment) and on the pile block by monitoring the fluence of its components and replacing them if necessary. It will be expanded to cover the polar crane and the casks handling gantry, with implementation of trend monitoring, before 2023, appropriate to the expected degradation mechanisms. By 2027, this plan will also be expanded to cover all safety important equipment, which already undergoes trend monitoring of periodically inspected parameters, is covered by a maintenance plan and undergoes a check on the conformity with its technical and safety requirements.

### 14.2.3. ASN oversight

ASN ensures that the periodic tests on the safety important equipment are pertinent. It carries out this verification when examining the reactor commissioning authorisation application (examination of the general operating rules) and then the applications for authorisation to modify the general operating rules. During inspections, it also verifies that these periodic tests are carried out in accordance with the test programmes stipulated in the general operating rules.

ASN examines the remediation procedures and deadlines proposed by the licensee if deviations are detected.

The conformity of the installations is regularly checked by ASN via the numerous inspections it conducts on the sites.

For the periodic safety review, ASN's examinations verify that the provisions adopted by the licensee to maintain the conformity of the installations are sufficient and effective.

In addition, ageing management was the subject of the first Topical Peer Review stipulated by Council Directive 2014/87/Euratom (see Focus 25 in § 14.2.3).

### Focus 25 : European level peer review on ageing management by the safety regulators

Ageing management of power reactors and research reactors with a thermal power greater than 1MWth was the subject of a Topical Peer Review. Its goals were to:

- enable the participating countries to review their provisions with regard to ageing management in order to identify the best practices and possibilities for improvement;
- enable European sharing of the individual experiences of the participating countries and identify problems in common which they all have to address;
- provide the participating States with an open and transparent framework for developing improvements further to the conclusions of the review.

For the purposes of this review, ASN produced a report in 2017, with contributions from EDF, CEA and the ILL, the conclusions of which are:

- EDF's nuclear reactors ageing management approach is appropriate, in particular with respect to the requirements of the international standards, and is accompanied by a large-scale research and development programme,
- the ageing management programmes for the research reactors need to be set out in more formal terms.

Following the peer review and its conclusions, improvement measures were defined in France on:

- the incorporation of ageing phenomena specific to long construction phases or prolonged reactor outages in the ageing management programmes;
- the performance of "opportunity" inspections of underground pipes when they become accessible as a result of other works;
- the development of ageing management programmes for the research reactors.

These improvement measures were integrated into the national action plan produced in 2018. At the end of 2020, these measures had been implemented, thus enabling this plan to be closed.

# Article 15 Radiation protection

**ARTICLE 15 RADIATION PROTECTION**

*Each Contracting Party shall take the appropriate steps to ensure that in all normal operational states the radiation exposure of the workers and the public caused by a nuclear installation shall be kept as low as reasonably achievable and that no individual shall be exposed to radiation doses which exceed prescribed national dose limits.*

## 15.1. The regulatory framework

The regulatory framework was updated in 2018 to ensure transposition of the new Euratom 2013/59 Directive, published on 5 December 2013, into French regulations (Public Health, Labour and Environment Codes).

This framework applies to all nuclear activities, that is mainly the activities entailing a risk of exposure of persons to ionising radiation linked to the use either of an artificial source, or of a natural source. This framework therefore applies to Basic Nuclear Installations.

Article L. 1333-2 of the Public Health Code recalls the general principles of radiation protection (justification, optimisation, limitation), which were laid down at the international level by the International Commission on Radiological Protection and reiterated in Directive 2013/59/Euratom.

ASN Guide No. 22 contains the requirements for optimisation of radiation protection at the reactor design stage.

The Environment Code states that the licensee of a basic nuclear installation must define an organisation responsible for advising it regarding all questions related to the risks and detrimental effects of ionising radiation (Article R. 593-112). This organisation is built around a competence centre which acts as radiation protection adviser as defined by the Public Health Code (Articles R. 1333-18 and R. 1333-19).

The BNI Order contains provisions on radiation protection, in particular on the discharge of radioactive effluents and on waste management.

### 15.1.1. Protection of workers

The Public Health Code, the Environment Code and the Labour Code contain provisions for the protection of workers within BNIs.

As per the Labour Code, the employer must take all necessary steps to ensure the safety and protect the health of the workers (Article L. 4121-1 et seq. of the Labour Code) and therefore implement measures to protect workers against the risks from ionising radiation.

The Labour Code makes provision for collective protection measures (Articles R. 4451-18 to R. 4451-20). The licensee is responsible for taking collective protection measures to ensure compliance with the principles of radiation protection (Articles L. 593-42 of the Environment Code and L. 1333-27 of the Public Health Code). Any area in which the workers are liable to be exposed to levels of ionising radiation exceeding certain defined thresholds must be identified and marked out. Specific and appropriate signage shall be provided (Articles R. 4451-22 to R. 4451-25 of the Labour Code).

For all workers (salaried or otherwise) liable to be exposed during their professional activity, the Labour Code also sets provisions more specifically concerning:

- dose limits for workers;
- dosimetric and medical monitoring of workers;
- the functional organisation of radiation protection within the establishment.

#### *15.1.1.1. Dose limits for workers*

The dose limits for workers are defined in Article R. 4451-6 of the Labour Code:

- for the whole body, the effective dose exposure limit value is 20 mSv for twelve consecutive months;
- for the organs or tissues, the limit values are set at:
    - 500 mSv for the extremities and skin; for the skin, this limit applies to the average dose over a total surface of 1 $cm^2$, irrespective of the exposed surface;
    - 20 mSv for the crystalline lens of the eye: this new limit value (previously 150 mSv) will only be applicable as of 1 July 2023. Interim provisions contain a cumulative limit value of 100 mSv for the period from 1 July 2018 to 30 June 2023, provided that the dose received during one year does not exceed 50 mSv.

Finally, in a radiological emergency situation, the lifetime total effective dose of a response worker shall in no case exceed 1 sievert (Article R. 4451-9 of the Labour Code).

#### *15.1.1.2. Dosimetry monitoring of workers*

The Labour Code requires that the results of individual dosimetry monitoring be transmitted to the ionising radiation exposure information and monitoring system, the management of which is entrusted to the Institute for Radiation Protection and Nuclear safety (R. 4451-66).

The Labour Code stipulates that *"The Institute for Radiation Protection and Nuclear Safety produces an annual summary of the worker exposure measurement results, including the ionising radiation exposure levels, taking account notably of the professional activities and the nature of the exposure, along with an analysis of these data."* (R. 4451 - 129).

The Labour Code stipulates that *"the worker shall have access to all of their individual dosimetry monitoring results and to the effective dose concerning him or her. He or she asks that they be forwarded to the occupational physician or to the Institute for Radiation Protection and Nuclear Safety"* (R. 4451-67).

### 15.1.2. General protection of the population

Several provisions of the Public Health Code help protect the public against the dangers of ionising radiation as a result of nuclear activities. They concern:

- dose limits for the general public;
- discharge limits;
- environmental radiological monitoring.

#### *15.1.2.1. Dose limits for the general public*

The effective annual dose limit received by a member of the public as a result of nuclear activities is set at 1 mSv; the dose limits for the crystalline lens of the eye and for the skin are set at 15 mSv/year and 50 mSv/year respectively (average value for any 1 $cm^2$ area of skin) (Article R1333-11 of the Public Health Code). The method of calculating doses and the methods used to estimate the dose impact on a population are defined by the Order of 1 September 2003.

#### *15.1.2.2. Environmental discharge limits*

The Environment Code gives ASN competence for setting out requirements concerning effluent discharges by BNIs.

The BNI Order imposes several general provisions, in particular the limitation of discharges from the design stage and the use of the best available techniques.

In its "Discharge" resolution, ASN set binding requirements regarding the control of detrimental effects and the impact on health and the environment, applicable to all French BNIs. In addition, in its "Modalities" resolution, ASN defined the modalities of water intake and consumption, effluent discharges and environmental monitoring specifically applicable to nuclear reactors. This resolution combines generic requirements in a single text and constitutes a minimum regulatory base that ASN builds on in each individual resolution, if additional requirements concerning management of intakes and discharges prove to be necessary in the light of the specific features of the site and its environment. ASN individual resolutions governing discharges also stipulate the minimum checks that have to be made by the operator, in particular concerning effluents and environmental monitoring.

#### *15.1.2.3. Radiological monitoring of the environment*

The French regulations require that the licensees of nuclear facilities carry out radiological monitoring of the environment around their facility (BNI Order and "Discharges" resolution).

More specifically, the monitoring carried out must aim in particular at:

- quantifying discharges of radioactive substances and verifying compliance with any applicable limit;
- detecting a malfunction of the facility (article 4.2.2).

The Public Health Code provides for the creation of a national environmental radioactivity monitoring network (RNM) which has the two-fold goal of information transparency - by providing the public with the results of this monitoring and information about the radiological impact of nuclear activities in France - and quality for the environmental radioactivity measurements, by setting up a system of laboratory approvals, issued by ASN resolution (Article R. 1333-25). If they are to be input into the RNM database, the measurements must have been taken by laboratories approved by ASN. This network is managed by the Institute of Radiation Protection and Nuclear Safety.

The Public Health Code requires that the average individual doses received by the population as a result of authorised nuclear activities be estimated at least once every five years by the Institute for Radiation Protection and Nuclear Safety and be included in a public report published on the Institute's website (Article R.1333-27).

## 15.2. The provisions implemented

### 15.2.1. Radiation protection of workers

#### *15.2.1.1. Monitoring of workers*

**Pursuant to Article R.4451-66 of the Labour Code**, an external exposure monitoring system for persons working in facilities in which ionising radiation is used has been put in place. This system is based primarily on the mandatory wearing of passive dosimeters for workers liable to be exposed and enables compliance with the regulatory limits applicable to workers to be checked.

The data recorded indicate the cumulative exposure dose over a given period. They are collated in the SISERI system (*siseri.irsn.fr*) managed by the IRSN and are published annually.

At the national level, the SISERI system consolidates the following data:

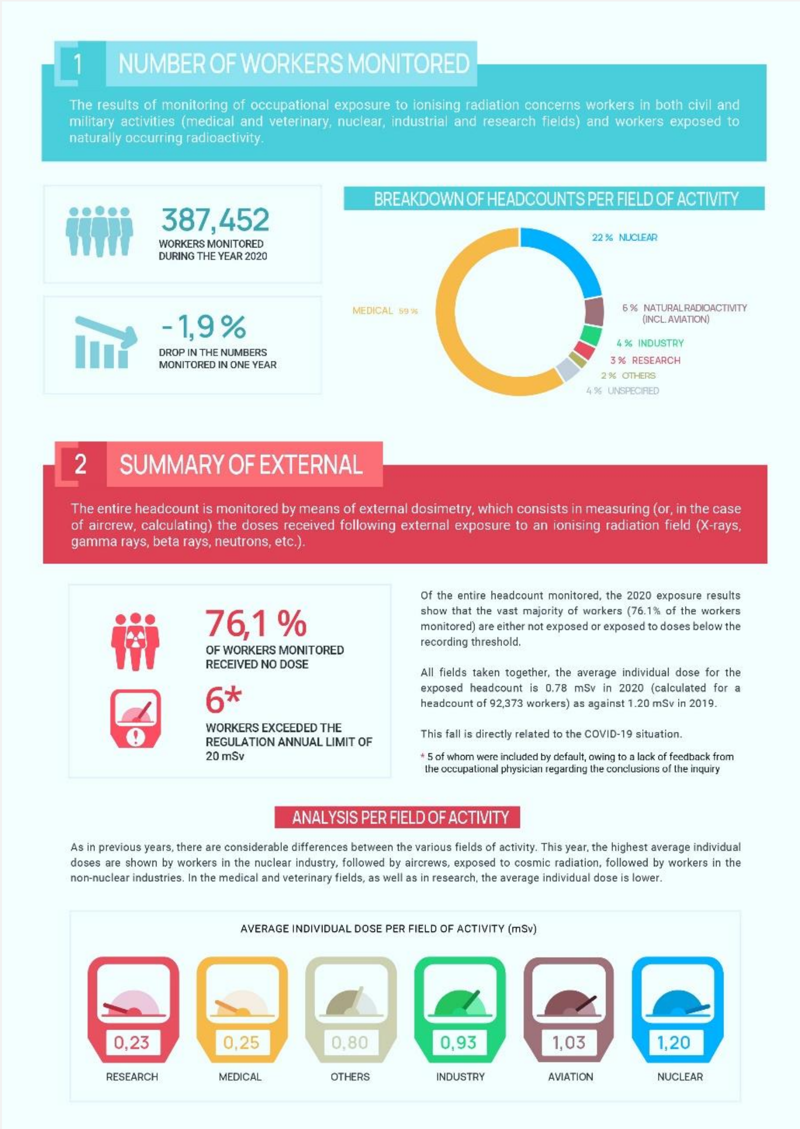
- passive external dosimetry, the results of which are supplied by the dosimetry organisations;
- operational external dosimetry, the results of which are sent in by the radiation protection advisers for the BNIs;
- monitoring of internal exposure, the results of which are supplied by the medical biology laboratories or the occupational health services, and the internal doses calculated by the occupational physicians;
- other data concerning the monitoring of flight crews, radon exposure or naturally occurring radioactivity.

If one of the limit values is exceeded, the occupational physician and the employer are immediately informed. The occupational physician notifies the employee concerned.

In accordance with article R. 4451-129 of the Labor Code, the IRSN draws up a report on the monitoring of workers exposed to ionizing radiation. The 2020 results are presented in Focus 26 below.

### Focus 26 : 2020 results for occupational exposure to ionising radiation in France in 2020

The report on the monitoring of occupational exposure to ionizing radiation concerns workers in civilian or military activities (medical and veterinary, nuclear, industrial and research fields) and workers exposed to natural radioactivity. For each field of activity, the report is based on data from individual monitoring of external exposure of workers recorded in the SISERI system (387,452 workers, including 22,838 workers exposed to natural radioactivity, mainly civil or military aviation personnel exposed to cosmic radiation).

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### 15.2.1.2. Optimisation of radiation protection of workers

***Nuclear power reactors***

**Pursuant to the principle of optimisation of radiation protection**, EDF implements a dose optimisation approach based on four pillars:

- **Reduced contamination of systems:** the controlled injection of zinc into the primary system is a means of reducing the contamination of the systems. To date, this system has been implemented on research reactors which have replaced their steam generators and has demonstrated its effectiveness in reducing Dose Equivalent Rates (DeR) for the first operating cycles following replacement of these components. The studies have been unable to reach a conclusion regarding the benefits of the continuous injection of zinc, outside the cycles following replacement of the steam generators. The priority actions taken to reduce the source term today focus on the processing of certain radionuclides, such as $^{110}Ag^{m}$;

  Since 2004, clean-out has also been performed on the residual heat removal (RRA) and chemical and volume control (RCV) systems on those reactors where priority is given to reducing the source term. For the period 2016 – 2021, 16 interventions were carried out on the NPP fleet. A multi-year programme is updated every year, according to the changes to the radiological status of each reactor and the dosimetric gains evaluated over 5 years, to confirm the priority interventions. Operating experience feedback from the reactors cleaned out over the past 15 years shows a dosimetric gain confirming the benefits and effectiveness of this clean-out in order to reduce worker dosimetry. Over the period 2019-2021, the overall gain is 1,171 M.mSv.

- **Preparation for interventions and dose optimisation:** The process, common to all nuclear sites (EDF and contractor staff) is based on the following key points:
  - perform a forecast dosimetry evaluation for each operation (collective and individual dose),
  - carry out an optimisation analysis of these operations according to the potential dosimetry,
  - set a collective and individual dosimetry target for each operation not to be exceeded, as a result of this optimisation analysis,
  - carry out experience feedback work, with analysis of deviations and good practices to be used for the benefit of future operations.

  After an experimental phase and validation of an industrial prototype, the period 2016 – 2018 enabled all the sites to be fitted out with a centralised monitoring station (video monitoring of worksites, remote-transmission of radiological measurements and dosimetry data, remote-monitoring of equipment important for the protection of workers, etc.). The general adoption of this development now enables each site to have a tool to help with monitoring and managing the working conditions.

  During the radiation protection equipment studies and development programmes run by EDF with the manufacturers, new equipment has also been developed for gradual deployment. Two "Gamma Cameras" were thus trialled to improve characterisation of the source term, optimise processing actions and dosimetry. A new "high-performance beta" measurement probe was also qualified in order to improve the measurement of low levels of contamination in environments where the radiological environment can fluctuate.

- **Use and dissemination of experience feedback:** to limit the doses received by the workers, EDF set up alert thresholds in the operational doses management application common to all NPPs. These thresholds are set at 13 mSv for the pre-alert and 18 mSv for the alert. If the pre-alert threshold is reached, and following consultation with the workers, physicians and radiation protection officers, the individual dosimetry is optimised over 12 months. If an alert threshold is reached, access to areas with a risk of exposure to ionising ration is then temporarily suspended.

The jobs subject to the highest exposure are given specific follow-up which is bearing fruit, as the individual doses are falling significantly. Only just over 3% of workers exceed the 6mSv threshold, and the dosimetry average remains at below 1 mSv per worker (0.96 mSv in 2021). These results are also obtained in a context of significant maintenance and modification work on the EDF nuclear fleet, for which the years 2019 and 2021 constitute the 2 historical records in the volume of hours worked in the nuclear zone, with more than 7 million hours per year.

- **Implementation of specific processes for activities involving a significant risk of exposure to radiation:** they apply to access to a prohibited areas (dose equivalent rate higher than 100 mSv/h), to limited stay areas (dose equivalent rate higher than 2 mSv/h) and to performance of radiographic inspections. Specific organisations were also designed and formally adopted, and each site is periodically assessed by teams from a Nuclear Inspection unit (independent of the operating sites) with regard to its compliance with common baseline requirements defining the targets and performance to be achieved.

Significant dose reductions are thus observed over the long term. The collective dose per year and per reactor went from 2.4 M.Sv in 1992 to a value of between 0.6 and 0.7 M.Sv per reactor since 2017. With regard to the individual dose, the dosimetry of the most highly exposed workers has fallen considerably. Since 2015, no worker has exceeded the 15 mSv threshold over one year. With regard to the annual results for the period 2019 - 2021, no worker was exposed to an annual dose of greater than 14 mSv, and an average of 138 workers received an annual dose higher than 10 mSv (or 0.26% of the workers).

***CEA's Cabri research reactor***

The assessment of the radiological risks for the jobs occupied is part of an optimisation process. Thus, whole-body dose constraints for the CEA employees were set at 1 mSv over one year.

The optimisation process on Cabri takes the form of:

- a job study comprising an initial calculation phase upstream of the test to be performed on the new loop, identifying the operations for which the risk of external exposure is in principle significantly higher than the others,
- dosimetry operating experience feedback (OEF): analysis of the operational dosimetry results is able to consolidate the evaluations made by calculation,
- updates of the job study to take account of OEF and supplement the evaluation by performing 3D calculations on particular operations.

The effectiveness of the system in place is proven by the record of doses received by the personnel of the facilities and the personnel of outside contractors for the years 2015-2020:

- over this period, the annual collective dose for the CEA employees assigned to the Cabri research reactor was on average 1.6 M.mSv; that of the employees of outside contractors working on the Cabri reactor was on average 0.74 M.mSv;
- over this period, no CEA employee and none of the employees of the outside contractors was exposed to an annual effective dose higher than 1 mSv.

***The ILL HFR reactor***

The ILL Director is assisted by the Radiation Protection Safety Environment Department (SRSE) which advises him or her with application of the regulations and with implementation of the prevention policy in the fields of conventional safety and radiation protection. With regard to the prevention of the risks of exposure to ionising radiation, the SRSE acts as a Radiation Protection Competence Centre as defined by the Labour Code and the Environment Code.

The optimisation of radiation protection is based on:

- the radiation protection instructions issued by the Radiation Protection Competence Centre. These may be general instructions or instructions specific to a high-risk worksite or experiment;
- the participation of radiation protection technicians in defining work procedures, to define the means of prevention and protection, along with any radiation protection measures to be taken during the operation,
- the production of formal dosimetry forecasts in the work permit applications,
- the performance of in-depth optimisation studies for worksites on which the forecast collective dose is higher than 10 M.mSv and/or the forecast individual dose is higher than 2 mSv.

The effectiveness of the overall radiological protection system in place is demonstrated by the dose history. More specifically, over the past three years (2019, 2020 and 2021), no employee received an annual dose higher than 1.8 mSv and the collective dose (including the ILL personnel, guest researchers and contractors, or about 2,000 people) over this period was less than 66 M.mSv, or an average individual dose of below 0.048 mSv.

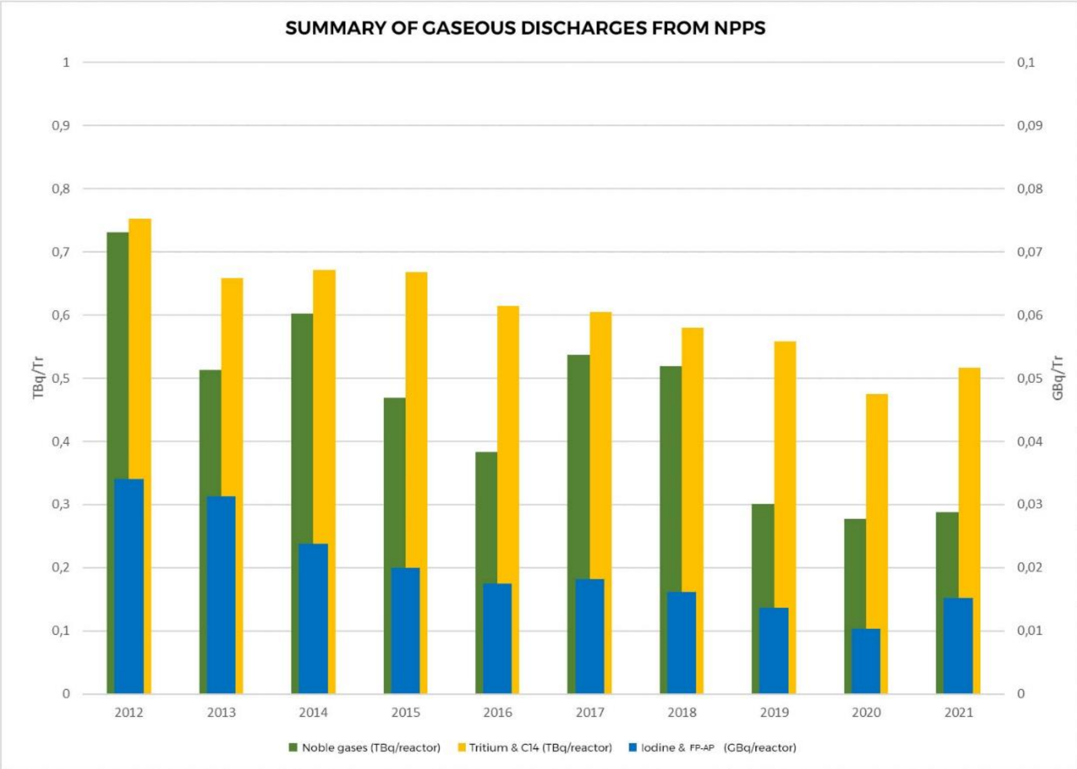
### 15.2.2. Radiation protection of the public

#### *15.2.2.1. Discharge of radioactive effluents*

***Nuclear power reactors***

From the moment PWR operations started, EDF took steps to reduce and control discharges. EDF is therefore attempting to limit discharges, mainly by improving the effluent collection and treatment circuits and by reducing its production at source. These steps have led to an extremely significant reduction in the activity of liquid effluent discharges (except for tritium and carbon 14), for which the discharged activity has now reached an all-time low level of about 0.2 GBq/reactor/year since 2008 (discharge activity (except tritium and carbon 14) divided by 100 since 1985 and divided by 10 since 1994).

Tritium and carbon 14 discharges, which are directly correlated with the power output by the units, remain stable.



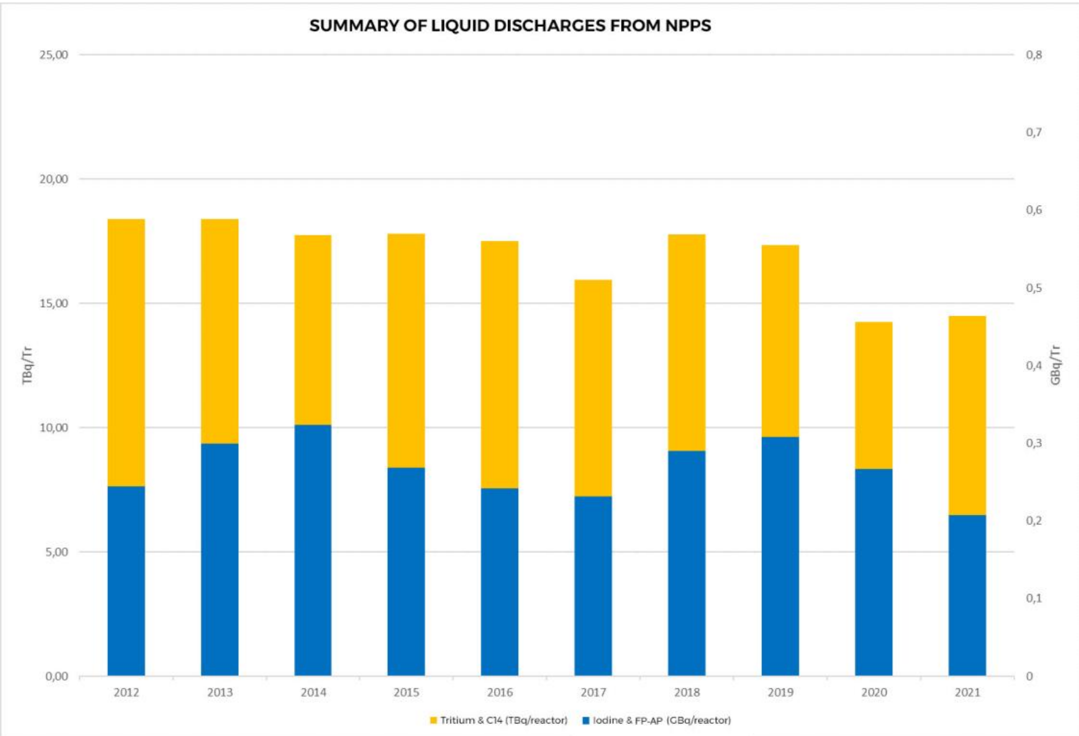




*Figure 15-1: Summary of discharges from NPPs in TBq and GBq per plant unit (2012 – 2021)*

FP: other fission products / AP: other activation products

For 2021, the annual average discharge values of liquid and atmospheric radioactive effluents per reactor, all plant series included, were those given in the following table:

| Radioactive discharges | Discharges of liquid radioactive effluents (GBq per reactor) | Discharges of gaseous radioactive effluents (GBq per reactor) |
|---|---|---|
| **Carbon 14** | 9.5 | 175 |
| **Iodine** | 0.0050 | 0.014 |
| **Tritium** | 15000 | 342 |
| **Fission products – Activation products** | 0.2 | 0.0014 |
| **Noble gases** | Not applicable | 297 |

*Table 15-3: Average annual liquid and gaseous radioactive discharges per reactor for 2021*

The dosimetric impact that can be attributed to radioactive effluent discharges from the sites today mainly concerns tritium and carbon 14. This is about one µSv/year and more than 2,000 times lower than the average dose that can be attributed to naturally occurring radiation alone in France (≈ 2,900 µSv/year on average). This impact is less than the threshold of 10 µSv/year, a threshold below which a possible "health" risk is considered by the international organisations (ICRP, IAEA) to be negligible.

***Research reactors***

Cabri

The liquid discharges from research reactors are managed in dedicated facilities. The facility which receives the effluents from a research reactor is determined according to the activity and nature of these effluents. The gaseous discharges from the reactors are discharged directly from the research reactor by vents. The gaseous discharge limits are controlled and these discharges are permanently monitored.

The gaseous discharges and liquid discharges from CEA's Cabri research reactors are low. The gaseous discharges for the period 2010-2020 are shown in Figure 15-2.

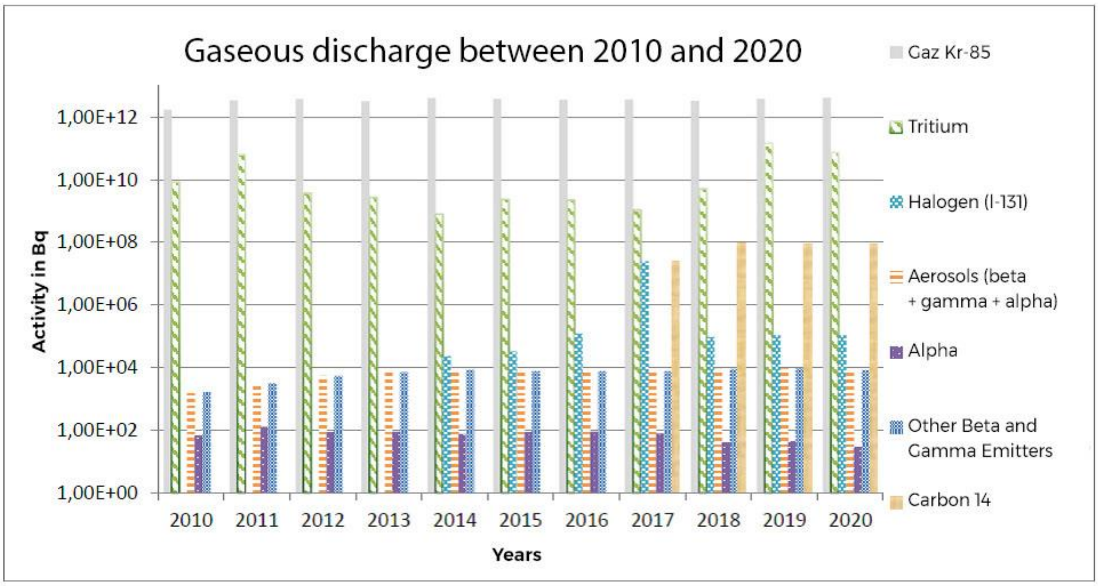



*Figure 15-2: Cabri gaseous discharges in Bq*

ILL

The annual variability of gaseous and liquid discharges is directly correlated with the major maintenance work on the HFR, such as changing pile block components or work on installations containing tritiated deuterium.

The gaseous and liquid discharges are shown in Figures 15-3 and 15-4.

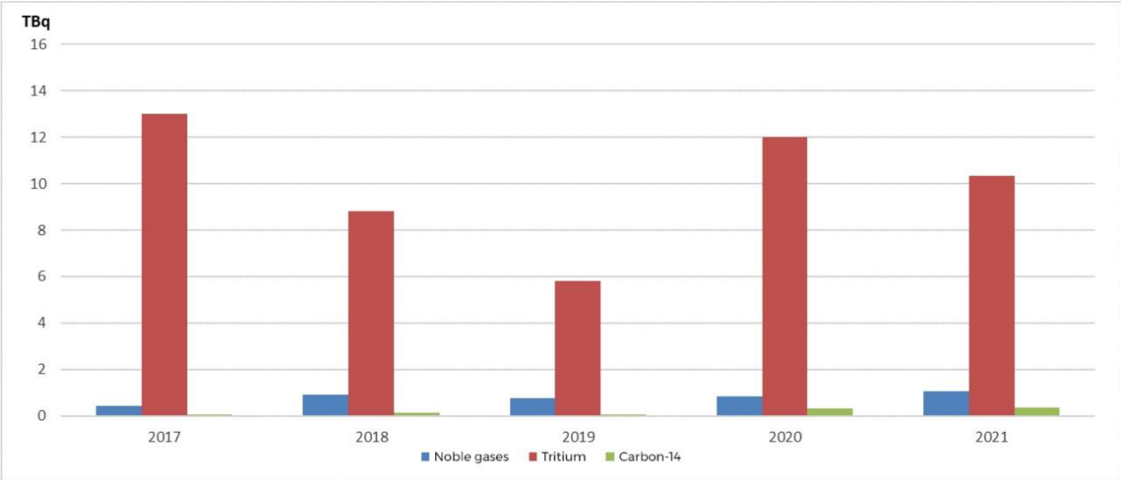



*Figure 15-3: ILL gaseous discharges in TBq*

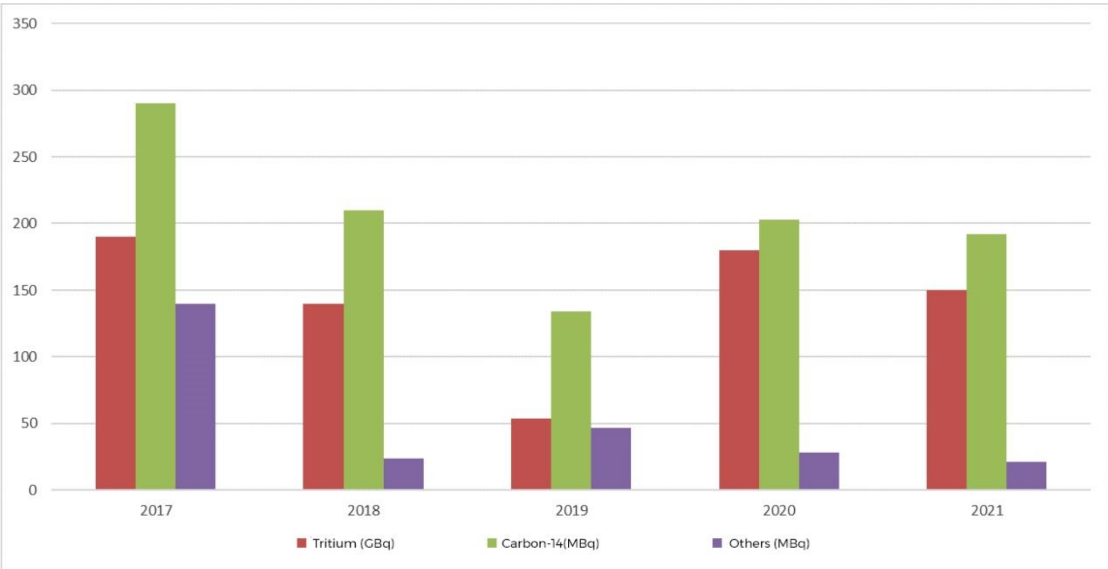



*Figure 15-4: ILL liquid discharges in GBq and MBq*

### 15.2.2.2. Environmental monitoring

Monitoring of the radiological state of the environment is carried out by:

- the licensees who carry out monitoring around their facilities:
    - EDF has set up a programme for environmental monitoring appropriate to each of its nuclear installations. It comprises a fixed programme of continuous and periodic measurements (daily to annual, representing more than 40,000 measurements per year for each NPP - see Appendix D). At

its own initiative, EDF supplemented this surveillance with radio-ecological monitoring carried out every year on all nuclear sites in operation. This monitoring has been performed on the entire fleet since 1992 and gives a spatio-temporal overview of the radiological state of the environment of the installations;
  - CEA has set up a programme to monitor the environment around the Cadarache site which houses the Cabri research reactor;
  - the ILL has set up a programme to monitor the environment around the HFR site.
- IRSN has a legal duty to monitor environmental radioactivity nationwide. More specifically, in the vicinity of the nuclear facilities, IRSN has its own monitoring networks and conducts regular monitoring in addition to that carried out by the nuclear licensees (Andra, CEA, EDF, French Navy, Orano, etc.). IRSN uses two approaches:
  - continuous on-site monitoring using independent systems (remote-monitoring networks) providing real-time transmission of results, plus an alert function in the event of an unusual rise in the measured radioactivity:
    - the recently refurbished Téléray network, based on 450 measurement detectors);
    - the Hydrotéléray network, which comprises 7 monitoring stations located on the major rivers;
    - the OPERA continuous air sampling network with measurements in the laboratory.
  - laboratory processing and measurement of samples taken from various compartments of the environment (air, water, soil and foodstuffs), whether or not close to facilities liable to discharge radionuclides.

IRSN's analysis and interpretation of all the environmental measurements are presented regularly in a report that is made public (see Focus 27 below).

### Focus 27 : Environmental monitoring

In 2019 and 2021, the radiological states of the French environment for the periods 2015-2017 and 2018-2020 were published, presenting IRSN’s analysis and interpretation of all environmental measures from the RNM.

Depending on the sites, this shows overall stability of the activity levels measured in the environment of the nuclear installations by comparison with the previous reports, or a reduction in these levels correlated with the reduction in the discharges from certain installations.

Based on the results of the measurements taken in the various environmental compartments (air, water, soils, milk, agricultural produce, etc.), IRSN conducted an assessment of the radiological exposure of the populations through the various possible exposure routes, showing that the doses received by the populations around the sites are generally very low, of the order of one microsievert per year. The result of these assessments is also consistent with the radiological impact assessments carried out by the licensees every year on the basis of the actual discharges from the installations, in accordance with the regulatory provisions.

Finally, using the measurement results, it assesses the environmental impact in France of various events which occurred over the period 2018 – 2020 (accidental release of selenium 75 by a Belgian facility in May 2019, fire in the laundry at La Hague in February 2020, forest fires in the zones contaminated by the Chernobyl accident in the spring of 2020 and fire in a nuclear submarine in Toulon port in June 2020). Although very small traces of these events were occasionally measured on the environmental radioactivity monitoring equipment operated by IRSN in France, no abnormal rise in ambient radioactivity was detected during these events, which had no health impact on the population.

All the measurement results obtained are entered into the Réseau National de Mesures de la radioactivité de l'environnement (RNM), which is accessible via the Internet (see Focus 28 below) and whose mission is to contribute to the monitoring of the population's exposure to ionizing radiation and to inform the population.

**Focus 28 : Reference website for environmental radioactivity measurements in France**

France has established a unique system to make available to the public on a dedicated website (*www.mesure-radioactivite.fr*) all the results of radioactivity measurements carried out in the environment by the various actors (government services, local authorities, non-governmental organizations, public establishments and nuclear operators) involved in monitoring environmental radioactivity.

This website gives everyone completely transparent access to the 300,000 measurements taken annually in France (which in 2022 comprised almost 3 million data), in the various environmental compartments (air, water, soil, fauna and flora) and in food products. This website, a unique initiative in Europe, makes it possible for everyone to gain a clearer understanding of the radioactivity monitoring carried out where they live and gives an overview of the level of radioactivity across the country in the various environmental compartments and foodstuffs.

## 15.3. ASN oversight

### 15.3.1. Exposure of workers

One of ASN's duties is to check compliance with the regulations relative to the protection of workers liable to be exposed to ionising radiation in BNIs. The scope of ASN's oversight covers all workers active on the sites, both licensee and external contractor staff, for the entire operating cycle of the facility.

This oversight takes two main forms:

- performance of inspections:
  - specific to radiation protection, scheduled one to two times per year and per site;
  - during reactor outages in the nuclear power plants;
  - following ionising radiation exposure incidents;
  - in the EDF head office departments responsible for the company radiation protection policy and the consistency of its implementation on the various sites.
- examination of files concerning the radiation protection of workers, which can cover:
  - significant radiation protection events notified by the licensee;
  - design, maintenance or modification files with national implications, produced under the responsibility of the licensee;
  - documents produced by the licensee concerning application of the regulations.

In addition, since 2011, ASN has carried out an annual campaign of "tightened" inspections in a geographical area, on the topic of protection of workers against ionising radiation. These tightened inspections mobilise a team of six to eight ASN inspectors and two to three IRSN experts, for a day and a half per NPP. Their purpose is to run a simultaneous inspection on several radiation protection topics in order to obtain an overview of the radiation protection organisation in the plant, based notably on numerous field observations.

The topics inspected are the organisation and management of radiation protection, the integration of operating experience feedback, the management of worksites, the application of the optimisation approach, the management of radiological cleanliness and of radioactive sources. Situational exercises were also used to check the organisation for dealing with contaminated workers and processing atmospheric contamination detection alarms inside the reactor building.

This type of inspection campaign allows to evaluate the system for the collection and the analysis of the licensee's operating experience feedback (results from practices used in the field, analysis of events that have occurred).

### 15.3.2. Exposure of the public

ASN carries out inspections to check that the licensees are complying with the regulatory provisions regarding management of discharges. ASN also carries out inspections, with sampling and measurement, with the support of laboratories. In addition, the licensees regularly send liquid and gaseous radioactive effluent samples to an independent laboratory for analysis. The results of these "cross-checks" are communicated to ASN. This programme of cross-analyses defined by ASN is a way of ensuring that the accuracy of the measurements taken by the licensee laboratories is maintained over time.

Moreover, as with the field of occupational radiation protection and using the same principle, ASN carries out annual "tightened" inspection campaigns in a geographical area on the topic of environmental protection and in particular on compliance with regulatory requirements regarding management of discharges. These inspections consist of unannounced situational exercises designed to assess the organisation and the means used to contain dangerous liquid substances spilled on the site.

ASN updated the regulatory requirements for discharges from several nuclear reactors over the period 2016-2022. ASN ensured that the discharge limits were set for these sites according to the best available techniques and taking account of experience feedback from the NPPs in operation.

# Article 16 Emergency preparedness

**ARTICLE 16 EMERGENCY PREPAREDNESS**

1. ***Each Contracting Party shall take the appropriate steps to ensure that there are on-site and off-site emergency plans that are routinely tested for nuclear installations and cover the activities to be carried out in the event of an emergency.***

   ***For any new nuclear installation, such plans shall be prepared and tested before it commences operation above a low power level agreed by the regulatory body.***

2. ***Each Contracting Party shall take the appropriate steps to ensure that, insofar as they are likely to be affected by a radiological emergency, its own population and the competent authorities of the States in the vicinity of the nuclear installation are provided with appropriate information for emergency planning and response.***

3. ***Contracting Parties which do not have a nuclear installation on their territory, insofar as they are likely to be affected in the event of a radiological emergency at a nuclear installation in the vicinity, shall take the appropriate steps for the preparation and testing of emergency plans for their territory that cover the activities to be carried out in the event of such an emergency.***

## 16.1. Emergency plan and programmes

### 16.1.1. The regulatory framework

The preparedness of the public authorities in the event of a nuclear or radiological incident or accident is defined by **the Prime Ministerial circular of 2 January 2012** concerning the organisation of the Government response for the management of major emergencies, along with a range of texts concerning nuclear safety, radiation protection, public order and civil protection.

**Act of 13 August 2004** on the modernisation of civil protection provides for an updated inventory of risks, an overhaul of operational planning, the performance of exercises involving the population, informing and training the population, an operational watch and an alert system. Several Decrees implementing this Act, codified in Articles L 741-1 to L 741-32 of the Domestic Security Code, in particular concerning the civil protection response organisation plans (ORSEC) and off-site emergency plans (PPI), clarified it in 2005.

The **Act of 25 November 2021** aims to consolidate the French civil protection model. It notably confirms the importance of the local safeguard plan (PCS) at municipal or intermunicipal level in territorial management of emergencies, making it mandatory for any municipality exposed to a natural, industrial or nuclear risk. It also creates the obligation to hold an exercise to implement this plan at least every 5 years.

The **circular of 27 May 2009** defines the principles governing the respective responsibilities of a BNI licensee and of the State with regard to the distribution of iodine. This circular requires that the licensee finance the public information campaigns within the perimeter of the PPI and carry out permanent preventive distribution of the stable iodine tablets, free of charge, through the network of pharmacies. Outside the area covered by the PPI, stocks of tablets are created to cover the rest of the country. In this respect, the ministries responsible for health and for the interior decided to constitute the stocks of iodine tablets which are put in place and managed by the Santé Publique France (Public Health France agency). Each Prefect defines the modalities for distribution to the population in their *département*, relying in particular on the mayors for this. This arrangement is described in the circular dated 11 July 2011. Pursuant to this circular, the Prefects have drawn up plans to distribute iodine tablets in a radiological emergency situation, which may be the subject of exercises as part of the territorial implementation of the major nuclear or radiological emergency national response plan

The **circular of 18 February 2011** specifies national doctrine for the use of emergency response and care resources in the event of a terrorist act involving radioactive substances. These provisions, which also apply to a nuclear or radiological accident, aim to implement a unified nationwide methodology for the use of resources, in order to optimise efficiency. They are to be adapted to the specific situations encountered.

The "**Medical intervention in the case of a nuclear or radiological event" guide**, the drafting of which was coordinated by ASN, accompanies the circular of 2 May 2002 on the organisation of medical care in the event of a nuclear or radiological accident, bringing together all useful information for the medical respondents in charge of collecting and transporting the injured as well as for the hospital personnel providing treatment in the health care facilities.

### 16.1.2. Emergency and contingency plans

The "**Major Nuclear or Radiological Emergency" national response plan**, published in February 2014, describes the government's preparedness and enables radiological emergency situations of all types to be addressed. It supplements the existing local planning arrangements (PUI – on-site emergency plan and PPI – off-site emergency plan). It also includes the international nature of emergencies and the mutual assistance possibilities in the case of an event. This plan is based on 8 reference situations (uncertainty situation, accident in a facility with immediate and short-duration release, etc.), to be addressed by an overall response strategy. The provisions of this plan are implemented locally by means of the Off-Site Emergency Plans (PPI).

The purpose of the **on-site emergency plan** (**PUI**), drawn up by the licensee, is to bring the facility to a controlled state and to mitigate the consequences of the accident. It defines the organisational actions and the resources to be implemented on the site. It also includes the provisions for rapidly informing the public authorities. Pursuant to Article R.593-30 of the Environment Code, the PUI is one of the documents to be included in the file sent by the licensee to ASN for the commissioning of its facility.

The licensee's obligations in terms of preparedness for and management of emergency situations are set out in the "BNI Order". The ASN "emergency" resolution specifies the obligations of the licensees regarding preparedness for and management of emergency situations, along with the ASN requirements regarding the content of the PUI. This resolution also transposes certain reference levels established by the Western European Nuclear Regulators Association (WENRA) and takes account of the lessons learned from the Fukushima Daiichi accident (emergency management premises, means of communication, exercises simultaneously affecting several facilities). It requires that the emergency crew members take part in at least one simulation or exercise per year and specifies the information that the licensee must transmit to the authorities.

The **off-site emergency plan** (**PPI**) is drawn up by the Prefect of the *département* concerned, pursuant to Decree of 13 September 2005. The PPI specifies the initial population protection actions to be taken, the roles of the various services concerned, the systems for giving the alert, and the human and material resources liable to be engaged in order to protect the general public. The population protection measures notably include:

- sheltering and awaiting instructions: when alerted by a siren, the persons concerned take shelter at home or in a building - with all openings completely closed - and wait for instructions from the Prefect over the radio;
- taking stable iodine tablets;

- evacuation: the populations are then asked to prepare a bag, secure their home, leave it and go to the nearest assembly point;
- restrictions or a ban on the consumption or sale of foodstuffs.

The decision to implement these measures lies with the Prefect. However, the PPIs also comprise a "reflex" phase which involves the licensee immediately alerting the populations within a 2 km radius around the facility, requiring them to take shelter and await instructions.

For the emergency phase, reference values are defined in Article D. 1333-84 of the Public Health Code:

- an effective dose of 10 mSv for sheltering;
- an effective dose of 50 mSv for evacuation;
- an equivalent dose to the thyroid of 50 mSv for the administration of stable iodine.

The predicted doses are those that it is assumed will be received until releases into the environment are brought under control, generally calculated over a period of 24 hours. In the event of doubt concerning the duration of the releases, the duration adopted for the calculation does not exceed one week.

Furthermore, a reference value of 100 mSv received for the duration of the radiological emergency situation and comprising all exposure routes is defined in Article R. 1333-82 of the Public Health Code for application of the optimisation principle.

The PPIs currently make it possible to plan the public authorities' response in the first hours of the accident in order to protect the population living within a radius around the affected reactor which, until 2016, was 10 km and which has since then been raised to 20 km. The PPI also include preparation for an "immediate" evacuation within a 5 km radius and the implementation of consumption restriction measures as of the emergency phase. Extension of the PPI perimeter from 10 to 20 km is in line with international practices, notably the "HERCA-WENRA" approach, developed after the accident at the Fukushima Daiichi NPP.

The PPI falls within the framework of the ORSEC system, which describes the protection measures implemented in large-scale emergencies. Consequently, beyond the perimeter established by the PPI, the modular and progressive *département* or zone ORSEC plan applies in full. The "**ORSEC**" **system** (organisation of the civil protection response) is a *département* level programme to organise the response to a disaster. It allows rapid and efficient implementation of all the necessary means, under the authority of the Prefect. This system comprises general provisions applicable in all circumstances and provisions specific to certain particular risks or linked to the operation of specific facilities (off-site emergency plans in particular).

The **Local Safeguard Plan** (PCS) aims to clarify the emergency management actions at municipal level. Any municipality exposed to a risk (natural, industrial or nuclear) is required to produce a PCS and hold an exercise at least every 5 years.

### Focus 29 : The evolution of post-accident zoning as proposed by a pluralistic structure

The "post-accident" phase concerns the handling over a period of time of the consequences of long-term contamination of the environment by radioactive substances following a nuclear accident. It includes dealing with various consequences (economic, health, social), by their very nature complex, in the short, medium or even long term, with a view to restoring a situation considered to be acceptable.

The steering committee for management of the post-accident phase (Codirpa)[20] proposed in 2019 to the Government evolutions in the post-accident management strategy of the consequences of a nuclear accident to integrate the lessons of the Fukushima accident and the national emergency exercises

In 2020, the principles for modifying post-accident doctrine in France were approved by the Government. These will be implemented in the major nuclear or radiological emergency national response plan as well as in the future updates of the off-site emergency plans around the facilities.

The main change consists in simplifying the post-accident zoning which underpins the population protection measures:

- To protect the population from the risk of external exposure, the population evacuation perimeter (uninhabitable zone) is created, on the basis of an annual effective dose value of 20 mSv/year for the first year. The consumption and sale of foodstuffs produced locally is prohibited within this zone;
- To limit the exposure of the population to the risk of contamination by consumption :
  - a perimeter of non-consumption of locally produced fresh produce that extends beyond the evacuation perimeter is proposed. First of all, this perimeter would be defined from the largest of the population protection perimeters (sheltering, ingestion of iodine, etc.) determined during the emergency phase. It would then be refined using environmental contamination measurements and the available models. Beyond this perimeter, a consumption recommendations perimeter could be put in place, in which food from a variety of origins is recommended;
  - With regard to the sale of local produce, a territorial approach per agricultural production and livestock sector, based on the maximum allowable radioactive contamination levels defined by the European authorities for the sale of foodstuffs is adopted.

### 16.1.3. The national and local emergency situation stakeholders

In an emergency situation, the main parties involved and decision-makers are:

- the licensee of the affected nuclear facility, which deploys the response organisation and the resources defined in its on-site emergency plan (PUI);
- the Prefect of the *département* in which the facility is situated, who takes the necessary decisions to protect the population, the environment and the property threatened by the accident. He or she works within the context of the PPI and the civil protection response organisation plans (ORSEC). He/she keeps the population and the mayors informed;

[20] The Government tasked a pluralistic structure, the Steering committee for managing the post-accident phase of a nuclear accident (Codirpa), to propose, under ASN guidance, a national strategy for the management of the consequences of a nuclear accident.

- the mayor of the municipality, because of his local role, has an important part to play in planning ahead for and supporting the population protection measures;
- ASN, which oversees the licensee's actions in terms of nuclear safety and radiation protection. In an emergency situation, it is up to ASN to submit recommendations to the Government and the Prefect, incorporating the analysis carried out by IRSN. This analysis focuses on both the diagnosis of the situation (understanding the situation of the affected facility, consequences for humans and the environment) and the prognosis (evaluation of the possible developments, especially radioactive releases). This advice relates in particular to the public health protection measures to be implemented;
- IRSN, which also deploys the experts from its "mobile means for environmental analyses", in order to assist the public authorities with their decision-making. This implies deployment of resources in the field, but also the utilisation of monitoring networks and laboratories. The "mobile means for environmental analyses" provides technical coordination of environmental measurements, direct measurement of radioactivity or of samples taken from the environment and the examination of packages damaged during a radioactive materials transport accident. The "mobile means for medical analyses" enable internal contamination measurements to be carried out on people. Finally, the fixed laboratories carry out assessments of exposure of individuals (radio-toxicological analyses, whole-body radiation measurement examinations, dosimetry reconstruction), and analyse samples taken from the environment.

In the event of a major emergency requiring the coordination of numerous players, an **interministerial crisis committee** (**CIC**) is activated. Within the CIC, the relevant departments of the Ministries concerned, together with ASN, work together to advise the Government on the protective measures to be taken. They provide the information and advice to understand the state of the facility, the significance of the incident or accident, its possible developments, and the measures required to protect the general public and the environment.

Table 16.1 shows the positions of the public authorities (Government, ASN and technical experts) and the licensees in a radiological emergency situation. These players each operate in their respective fields of competence with regard to assessment, decision-making, action and communication, for which regular audio-conferences are held. The exchanges lead to decisions and orientations concerning the safety of the facility and the protection of the general public. Similarly, relations between the communication units and the spokespersons of the emergency centres ensure that the information given to the public and the media is consistent.

| | DECISION | EXPERT APPRAISAL | ACTION | COMMUNICATION |
|---|---|---|---|---|
| **Public authorities** | Government (CIC)<br>Prefect (COD) | - | Prefect (PCO)<br>Civil protection | Prefect (COD) |
| | ASN (Emergency Centre) and representative at Office of the Prefect | IRSN (CTC)<br>Météo France | IRSN<br>(mobile units) | ASN<br>IRSN |
| **Licensees** | National and/or local level | National and/or local level | Local level | National and/or local level |

*CIC: Interministerial Crisis Committee* *PCO: Operational command post*
*COD: Departmental Operations Centre* *CTC: Emergency Technical Centre*

*Table 16-1: Positions of the various players in a radiological emergency situation*

### 16.1.3.1. ASN's organisation for emergency situations

When a BNI's PUI is triggered, the licensee of this BNI activates the ASN alert system. This system allows rapid mobilisation of ASN staff to activate the various units in the emergency centre and carry out various local missions (support for the Prefect, on-site liaison, etc.), and the mobilisation of experts from IRSN's crisis centre. This system also sends the alert to the staff of the General Directorate for Civil protection and Emergency Management (DGSCGC), the Interministerial Emergency Management Operations Centre (COGIC), Météo-France and the ministerial operational monitoring and alert centre (CMVOA). For events outside BNIs (sources, transports, etc.), ASN has set up a toll-free number, accessible on the internet, and known to the nuclear activity licensees.

In January 2018, ASN set up its 24/7 on-call system. This system aims to reinforce the robustness of ASN's organisation enabling it to deal with alerts, events and emergencies within its fields of competence. The ASN on-call system team consists of 15 people from headquarters and regional divisions. Their role is to provide the first level of response to an emergency, to manage situations of low intensity and to activate the emergency centre if the situation warrants it.

The ASN emergency centre is organised around an emergency division and various specialist units (safety, protection of persons and the environment, communication, international relations, etc.). Indeed, it has a unit devoted to international relations in order to manage information exchanges with the European Commission, the Member States (WebECURIE), the IAEA (USIE) and the neighbouring states in the event of a transboundary accident.

The ASN emergency centre is closely linked to IRSN's crisis technical centre (CTC). IRSN's emergency preparedness is also based on a 24/7 on-call system. The IRSN experts in the CTC evaluate the situation and produce expert analysis for drafting of recommendations sent to the public authorities. The CTC also has a mobile unit capable of deploying measurement resources to the field.

The ASN emergency centre is connected to several independent telecommunication networks, providing direct or dedicated links, some of which are secure. It has IT equipment tailored to its functions, in particular for the transmission of technical information from IRSN (continuous environmental radioactivity monitoring).

The ASN emergency centre is regularly tested during national emergency exercises and is activated for actual incidents or accidents.

### 16.1.3.2. EDF's preparedness

The emergency organisation of the EDF nuclear fleet is designed to take account of emergency situations, in order to prevent all radioactive releases into the environment or, failing which, mitigate them.
It is based on two levels:

- the local level on each site under the supervision of the unit manager or his/her representative. It is structured into teams (or command posts - PC) covering the four broad areas necessary for emergency management (appraisal, decision, action and communication);
- the national emergency organisation (ONC), which supports the local level with the provision of specialists from the EDF head office departments.

It comprises human and material resources that can be mobilised 24/7, when called by an NPP.

***At local level***

On each of the NPPs in operation, about 70 persons can be mobilised within the hour:

- The operating team in charge of the affected reactor constitutes the local command post (PCL), under the responsibility of the shift operations supervisor;
- The local strategic management command post (PCD) is assisted by two expert teams:
    - the local emergency response team (ELC), in charge of analysing the state of the facility and predicting developments;
    - the controls command post (PCC), responsible for assessing the consequences of the accident on the population and the environment.

  These two teams inform the national technical teams (EDF and IRSN) and keep the local PCD regularly informed of events that could change the emergency management strategy;
- The resources command post (PCM) is responsible for all site intervention and logistics actions:
    - personnel protection and the management of assembly points;
    - management of telecommunications for all the PCs;
    - organisation of work and specific tasks on equipment;
    - logistical support to external emergency services and to emergency-response teams.

It is the responsibility of the director of the PCD to assess the significance of the event, based on predetermined criteria for triggering the PUI and determining its level.

***At national level***

The national emergency organisation must be operational in its Paris and Lyon premises within two hours. It mobilises about 50 people and alerts 300 others. It comprises a support unit from the reactor designer, Framatome.

The national strategic management command post (PCD-N) is directed by the DPN on-call manager. It coordinates the actions taken by EDF's emergency-response structure as a whole, advises the NPP management concerned by the event and provides information to the EDF Chair, to the public authorities and to ASN at the national level. It is supported by a national emergency technical team (ETC-N) which has two roles:
- provide the PCD-N with a diagnosis and prognosis of the situation of the site;
- propose opinions and recommendations to the site for management of the facility and an assessment of the environmental consequences.

EDF has also deployed the nuclear rapid intervention force (FARN), integrated into the EDF emergency organisation, which is capable of rapidly providing material and human aid to a site in difficulty, following the decision of the national emergency director (PCD-N). Since 1 January 2016, the FARN has been fully operational for the entire EDF NPP fleet.

It is based on four sites and has a national headquarters. It consists of professionals from the NPPs trained in emergency situations, who practice for 50% of their time. Its training programme comprises a minimum of five annual exercises, mobilising about a hundred people on the EDF nuclear NPP sites for one week, plus about ten command post exercises.

The FARN can therefore:
- intervene within 24h hours, in continuity and in support of the teams on the site concerned, where the access infrastructures could be partially destroyed;
- restore access to the site, in conjunction with the authorities;
- work independently for several days on a partially destroyed site (non-seismic tertiary buildings, for example);
- provide permanent liaison with the site management and teams.

### Focus 30 : Nuclear Rapid Intervention Force of EDF

EDF has set up a Nuclear Rapid Intervention Force (FARN) with material and human resources. The FARN is a national system capable of rapidly providing material and human aid to a site in an accident situation. All the installations have been modified so that the mobile emergency means brought in by the FARN can be connected.

Activation of the FARN is decided at national level on the basis of a situation analysis. The FARN comprises a national headquarters and four regional centres situated on the Bugey, Civaux, Dampierre and Paluel NPP sites.

The role of the FARN is to:

- intervene within 24 hours, without interruption and to take over from the operating teams that will have carried out the emergency measures for the site concerned whose access infrastructures may be partially destroyed;
- act independently for several days (which implies logistical support capability, notably for food and sleeping arrangements);
- deploy heavy protection or intervention means, unique to the EDF nuclear fleet, within a period of from 24 hours to a few days;
- ensure a permanent link with company management, NPP management and teams, and the local public authorities in order to manage and coordinate the interventions;
- prepare for continuation of the intervention beyond the first days of autonomy in the event of a long-duration emergency.

The regional centres have on-call intervention columns of 14 people with the various professional skills required (processes, intervention, logistics). These columns consist of specific EDF personnel prepared for emergency situations, notably through training (annual volume of training 33,000 h) and regular drills and exercises. The FARN uses methods for adapting to situations derived from the military and the civil protection's response units, so that it can act in a disorganised environment and take account of stress.

The FARN has transport and handling equipment, redundant telecommunication means and equipment for ensuring the resupply of water and electricity (pumps, compressors, electricity generating sets, etc.) so that it can intervene simultaneously on all the reactors of a given site. The equipment is stored in premises specific to each centre. Each column is capable of dealing with 2 reactors and can bring in the equipment necessary for this. The FARN has the human and material resources needed for simultaneous intervention on all the reactors of a given site (up to six reactors). Potential rear base locations are identified near the nuclear power plants.

At the end of 2021, 50 exercises were held on the nuclear sites, involving about a hundred people each time. The FARN was also involved in two real emergency situations as a result of extreme climatic hazards and provided:

- support for the crews dispatched to repair the electricity network on the island of Saint-Martin in the wake of hurricane IRMA in September/October 2017, with the installation of a construction camp for a month and a half;
- support for the EDF Hydraulic teams in October 2020 in the Tinée, Roya and Vésubie valleys for three weeks, in order to clear the hydraulic structures.

Following the accident at the Fukushima Daiichi NPP, two other major changes were defined to reinforce the robustness of emergency preparedness:

- the construction of local emergency centres (CCL) on each site, capable of withstanding extreme hazards, and designed to replace the existing emergency management premises, is scheduled by 2026. The Flamanville CCL has been in service since 2020. These CCLs provide the emergency crews with protection from external hazards and the possible presence of radioactivity on the site;
- changes to the PUI so that an emergency organisation can be set up, even partially at the local level, for the most severe hazards occurring on the site. In these cases, the operations supervisor is able, if necessary, to activate the organisations, with support from the national level as applicable, and with the help of dedicated telecommunications resources. The emergency preparedness organisation is thus made more adaptable by gradual local activation of the PUI (on-site emergency plan) and the distribution of tasks, in the event of site access difficulties. Work has thus begun on training the operating teams to deal with the unexpected, through situational exercises with the help of tools to share objectives, define priorities and allocate actions.

#### *16.1.3.3. CEA preparedness*

In the event of an emergency on a facility operated by CEA, the latter mobilises its emergency response organisation, on the one hand to manage the situation in the facility and on the other to ensure relations with the public authorities. This organisation includes a local level and a national level.

The site affected by the emergency (local level):

- manages the response inside the facility;
- ensures communication with the local media for the site affected by the emergency, in collaboration with the Prefecture;
- is responsible for relations with the Prefecture, ASN and the IRSN crisis technical centre.

The CEA administration (central level):

- directs CEA's response at national level;
- is responsible for communication with the national media;
- is responsible for relations with the public authorities at national level.

To fulfil their role, the local and central levels are assisted by the local (PCD-L) or national PCD-N) strategic management command posts.

- the PCD-L is under the responsibility of the director of the centre or his representative. It comprises a decision-making unit, a local technical emergency team (ETC-L), an operating team, an operational team, a communications unit and a press unit;
- the PCD-N is under the responsibility of the Chairman or his representative. It comprises a decision-making unit, a central emergency technical team (ETC-N), a communications unit and a press unit.

The communication and press units, in agreement with the PCD-L or the PCD-N, prepare press releases, answer external calls and manage interviews.

It is the responsibility of the director of the site or his representative to assess the significance of the event, based on predetermined criteria for triggering the PUI and determining its level.

### *16.1.3.4. Preparedness of the Institut Laue-Langevin (ILL)*

In the event of an emergency on the facility operated by the ILL, the latter mobilises its emergency response organisation, on the one hand to manage the situation in the facility and on the other to ensure relations with the public authorities.

ILL plays a role at local and national levels.

The site experiencing the emergency:

- manages the response inside the facility;
- ensures communication with the media by the site affected by the emergency, in collaboration with the Prefecture;
- is responsible for relations with the Prefecture, ASN and the IRSN crisis technical centre;
- is responsible for relations with the public authorities at national level.

To perform these duties, ILL relies on its strategic management command post, the PCD.

- the PCD is placed under the responsibility of the ILL Director and the Head of the Reactor division, or their representatives. It comprises a decision-making unit;
- the PCD calls on the services of an emergency technical team (ETC), a technical command post (PCT), a communications unit (communication delegate and media PCD). The ETC itself comprises a movements team (ETC Movement), an environment team (ETC Environment) and a radiation protection team (ETC RP).

The communication delegate, with the agreement of the PCD, drafts the press releases and handles interviews, while the PC Communication answers outside queries.

It is the responsibility of the Head of the Reactor Division or their representative to assess the significance of the event, based on predetermined criteria for triggering the PUI, and to determine its level.

The ILL is equipped with an emergency command post (PCS) which remains functional even in the event of the seismic, flooding or chemical accident hazards considered for definition of the "hardened safety core".

## 16.1.4. Training and exercises

***Local nuclear emergency exercises***

The provisions for maintaining the skill levels of the EDF staff, obtained through training and exercises, are defined in the site's on-site emergency plan, in compliance with the "Emergency" resolution. In accordance with these regulations, each site produces, updates and implements a multi-year programme and a calendar for the coming year of exercises. The emergency exercises held by the public authorities are included in this schedule. At least one emergency exercise is thus carried out every year in each facility.

Training and skills currency mainly involve emergency exercises organised regularly by CEA during the course of the year. These exercises use the local and national emergency units with the technical emergency teams and the command structure. Each team member takes part in several types of exercises depending on the facility or activity concerned.

Every year, the ILL carries out exercises, some of which include triggering of the PUI and one which was performed with the participation of the outside response forces (local response forces of CEA and/or the SDIS). The scenario writers and participants are chosen so as to ensure that all the emergency team members participate in turn.

***National nuclear emergency exercises***

Jointly with the General Secretariat for Defence and National Security (SGDSN), the DGSCGC and the ASND, ASN prepares the annual programme of national nuclear and radiological emergency exercises concerning BNIs and radioactive substances transport operations. This programme is announced to the Prefects by means of an interministerial instruction and takes account of the lessons learned from actual situations (national and international) and the exercises held the previous year.

In addition to the national exercises, the Prefects are asked to hold local exercises on the sites within their *départements*, in order to enhance preparedness for radiological emergency situations and more specifically test the time needed to deploy the players involved.

The exercises enable those involved to build on knowledge and experience in the management of emergency situations, in particular for the 300 or so persons mobilised in the field for each exercise. They enable the following to be performed:

- measure the degree of preparedness of each Prefect's office and the other stakeholders involved;
- ensure that the plans and procedures they contain for early alerting and notification of international organisations are kept up to date and are well-known to all the managers and responders;
- allow training of those liable to be involved;
- implement the various aspects of emergency preparedness, along with the procedures stipulated in the various plans and baseline requirements: national plan, interministerial requirements, contingency plans and local safeguard plans;
- contribute to informing the media and the populations;
- develop a pedagogical approach aimed at civil society, so that everyone can make a contribution to their own safety by adopting appropriate behaviour.

ASN is also heavily involved in the preparation and performance of other emergency exercises that have a nuclear safety component and are organised by other players such as:

- its counterparts in charge of nuclear security (defence and security high official – HFDS – at the Ministry for energy) or defence-related installations (ASND);
- international bodies (IAEA, European Commission, NEA);
- the Ministries (Health, Interior, etc.).

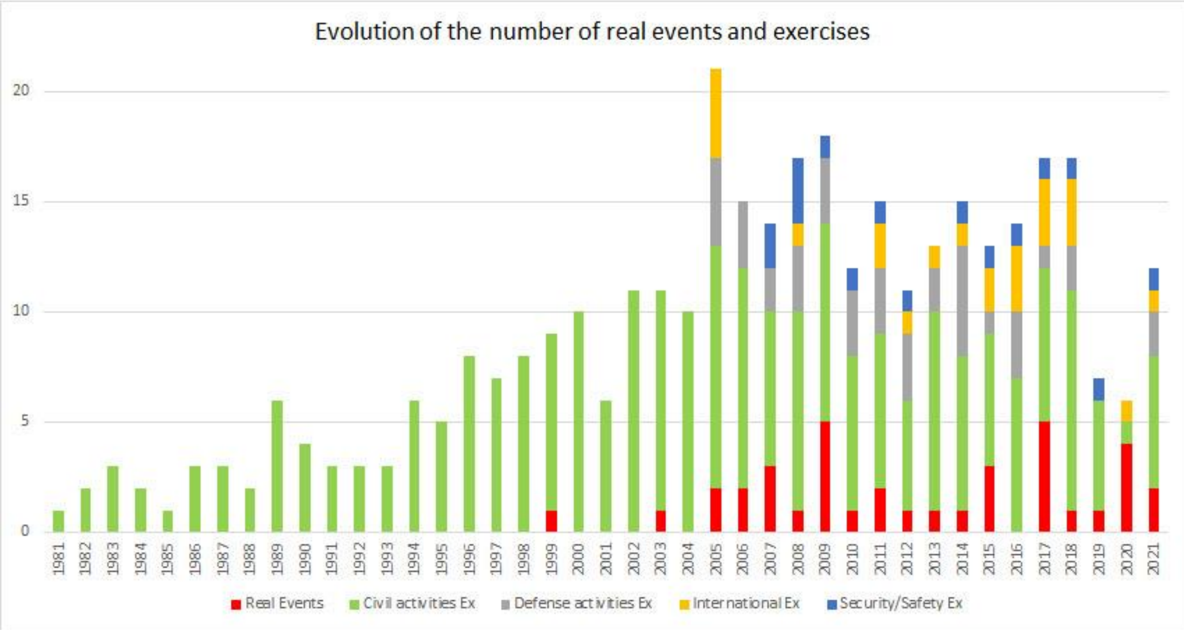



*Figure 16-1: Number of exercises and emergency situations*

Assessment meetings are organised immediately after each exercise in each emergency centre and then at ASN a few weeks after the exercise. ASN, along with the other players, endeavours to identify best practices and the areas for improvement brought to light during these exercises. Experience feedback debriefing meetings are also held to build on the lessons learned from actual situations which have occurred.

Every year, ASN also brings all the stakeholders together to learn the lessons from the exercises in order to improve the response organisation as a whole. These meetings enable the stakeholders to share their experience through a participative approach. They more specifically revealed the importance of having scenarios that were as realistic as possible, in real meteorological conditions and that were technically complex enough to be able to provide useful experience feedback.

The exercises brought the following to light:

- the need to increase the frequency of exercises comprising a simulation of the government's emergency organisation (CIC);
- the importance of communication in an emergency situation, in particular:
  - to inform the public and foreign authorities as rapidly as possible and avoid the spread of rumours liable to hamper good emergency management, in France and in other countries;
  - by announcing larger perimeters for restrictions on consumption and sale when these decisions are based on deposition simulations: these perimeters are then reduced when field measurements become available;
- the need to increase the number of exercises or drills simulating a transport accident, running both the field part and the decision-making centres part;
- the importance of providing the decision-makers with a clear view of the radiological consequences in the form of maps.

In 2020 and 2021, emergency exercises were able to test the resilience of nuclear emergency preparedness in the Covid19 epidemic context.

### *International exercises and cooperation*

ASN and its technical support organisation, IRSN, maintain international relations in order to discuss best practices observed during exercises held in other countries. From 2016 to 2021, ASN – sometimes accompanied by its technical support organisation, IRSN - therefore:

- took part in the INEX 5 international exercise in 2016, organised under the auspices of the NEA and one of the main goals of which was transboundary coordination of population protection measures;
- received foreign delegations as observers of exercises organised by France, more particularly during an exercise held in 2017 in the Cattenom NPP, in 2018 in the Fessenheim NPP and then in 2021 in the Gravelines NPP;
- in 2017, 2018 and 2019 took part as an observer of exercises organised abroad (Finland, Japan, United Kingdom, Taiwan);
- took part in the ConvEx exercises organised under the auspices of the IAEA, and ECUREX, under the auspices of the European Commission.

In addition, with regard to international assistance, ASN has set up a data bank listing all the national technical and human resources available in the event of an accident or radiological emergency and, since August 2008, has been one of the competent authorities which has registered their means of international assistance with the Response and Assistance Network (RANET).  ASN is involved in defining the strategy for international assistance needs and resources, and in the development of the RANET network.

## 16.2. Information of the public and neighbouring States

As shown in table 16.1, various stakeholders are involved in communication in a radiological emergency situation. Relations between the communication units and the spokespersons of the emergency centres ensure that the information given to the public and the media is consistent.

The licensee responsible for the nuclear activity that caused the radiological emergency immediately informs the competent authorities that the radiological emergency situation has occurred. The Prefect is responsible for informing the population and the mayors.  The role of ASN and IRSN is to assist with communication by the authorities, by providing explanatory information about the situation, putting the risks into perspective and reporting on the environmental radioactivity monitoring results.

ASN is involved in several ways in the dissemination of information to:

- the media and the public: ASN contributes to information of the media, the public and the stakeholders in different ways (press releases, press conferences); it is important for this to be done in close cooperation with the other entities that are required to communicate (Prefect, licensee at local and national levels, etc.);
- institutional players: ASN keeps the Government and the SGDSN informed, the latter being responsible for informing the President of the Republic and the Prime Minister;
- foreign nuclear safety regulators.

### *Informing the public*

French regulations (Article R741-26 of the Domestic Security Code and the Order of 5 January 2006 on public consultation regarding the off-site emergency plan for certain installations, Environment Code (Article R.125-11)) contain requirements for information of the public regarding the nature of the accident risks linked to the facilities, the envisaged consequences of the accidents, the planned measures and the required response in the event of an accident, notably with the production of brochures about the provisions contained in the PPI and their proactive distribution to the population.

The Mayor also plays a role in passing on information and heightening population awareness during the iodine tablet distribution campaigns.

### Focus 31 : Accompanying the population for a better understanding of nuclear risks and protection measures

In 2020, the Prime Minister gave the Codirpa a new mandate for the 2020-2024 period with a significant focus on accompanying the population, and the development of a culture of radiation protection. New work has already been initiated under this new mandate and resulted in several tangible advances, based on listening to and actively involving the players concerned:

- a document presenting a "questions and answers" relative to the health consequences of a nuclear accident, intended specially for health professionals : this document is the result of the collective work of a group of health professionals working near a nuclear power plant (doctors, hospital practitioners, nurses, pharmacists, veterinarians), who produced a set of more than 200 questions on the consequences of a nuclear accident, and a group of experts from institutional organizations or associations, who were responsible for writing the answers to these questions. This method ensures the relevance of the questions dealt with, the quality of the answers provided and favors a good appropriation by the actors concerned;
- a practical guide for the inhabitants of a region contaminated by a nuclear accident: it comprises 28 topical sheets containing good radiation protection practices, advice for everyday living and information on radioactivity, the environment and methods of measuring radioactivity. It is based on feedback from the Chernobyl and Fukushima accidents and on the concrete lessons learned by communities living in the contaminated territories of Belarus, Lapland and Japan;
- the preparation of instructions concerning the consumption of locally produced fresh foodstuffs (garden and orchard products, hunting, fishing and gathering products) whose radioactivity is not controlled: these instructions were debated with four panels of citizens living near nuclear power plants in order to assess the understanding of the proposed protective actions and their acceptability, which is crucial if they are to be applied. This is a first to test the understanding of the subjects, the relevance of the avenues of work, and to gather the opinions of the populations concerned.

This approach, which aims to anticipate the consequences of a major accident, is a means of developing a radiation protection culture among the stakeholders concerned (local authorities, public services, associations, general public, etc.).

***Transboundary coordination***

Given the potential repercussions of an accident on other countries, it is important that the information and response by the various countries concerned be as coordinated as possible. IAEA and the European Commission thus propose tools to the Member States for notification and assistance in the event of a radiological emergency. ASN made an active contribution to the production of these tools, more specifically the IAEA tool called USIE (Unified System for Information Exchange in Incidents and Emergencies), which is available in ASN's emergency centre and is tested on the occasion of each exercise.

France has signed the two international conventions on the early notification of a nuclear accident and on assistance in the event of a nuclear accident or radiological emergency, adopted by IAEA on 26 September 1986, and applies the Euratom decision of 14 December 1987 concerning community procedures for the rapid exchange of information in the event of a radiological emergency. ASN acts as the competent national authority under these two Conventions. As such, it collects and summarises information in order to send or receive the notifications and transmit the information required by these conventions to the international organisations (IAEA and European Union) and to the countries concerned by potential consequences on their territory, in particular the neighbouring countries, so that they can take the necessary population protection measures.

In 2014, the HERCA and WENRA associations adopted a joint approach aiming to improve cross-border coordination of protection measures during the first phase of a nuclear accident. The approach recommends:

- in normal situations, exchanges between countries to promote improved mutual familiarity with and understanding of their emergency response organisations;
- in emergency situations:
    - if the emergency organisations receive sufficient information to be able to function normally during the first hours of an emergency situation, attempts are made to align the population protection measures in neighbouring countries with those decided on by the country in which the accident occurred;
    - in a situation, even if highly improbable, which would require urgent measures to protect the population but in which very little information is available, predetermined "reflex" measures to be implemented by the country in which the accident occurred.

In order to implement these principles, a minimum coordinated level of preparation is necessary. HERCA and WENRA thus consider that in Europe:

- evacuation should be prepared for the local population living in a radius of up to 5 km around the NPPs, with sheltering and ingestion of stable iodine tablets for persons living in a radius of up to 20 km around the nuclear power plants;
- an overall strategy should be defined to ensure the capability, if necessary, of extending population evacuation up to a 20 km radius, and sheltering and ingestion of stable iodine tablets up to a 100 km radius.

***Bilateral relations***

ASN has bilateral relations in the field of emergency management with its European counterparts, notably with Germany, Belgium, Luxembourg and Switzerland. Within this context, delegations from Germany and Luxembourg were invited to observe a national exercise in the emergency centre in October 2017. In 2018, ASN also invited its German and Swiss counterparts to its emergency centre during a nuclear emergency exercise organised in the Fessenheim NPP, which aimed notably to test the alert and information chain for the departments, municipalities and border countries (Germany and Switzerland), activation of the emergency units, and decision-making. In 2019, Belgian observers also took part in an emergency exercise at ASN's emergency centre. This mutual observation practice was interrupted during the health crisis, but restarted in 2021 with the presence of a Swiss observer.

ASN staff were reciprocally invited to observe exercises for the response to a nuclear or radiological emergency abroad (see § 16.1.4).

***Multilateral relations***

ASN is taking part in the new IAEA committee (called EPReSC) for drafting of its safety standards for emergency situations and is collaborating with the NEA for the organisation of international emergency exercises (INEX 5 in 2016) and participation in the Working Party on Nuclear Emergency Matters (WPNEM).

At the European level, ASN is a participant in the “Emergencies” working group reporting to the HERCA Association. This group is tasked with proposing harmonised European measures to protect the general public, on the one hand in the event of an accident in Europe and, on the other, in the event of a more remote accident, in the light of the lessons learned from the Fukushima Daiichi NPP accident.

# Article 17 Siting

**ARTICLE 17 SITING**

***Each Contracting Party shall take the appropriate steps to ensure that the appropriate procedures are established and implemented with a view to:***

***i) evaluating all relevant site-related factors likely to affect the safety of a nuclear installation during its projected lifetime;***

***ii) evaluating the likely safety impact of a proposed nuclear installation on individuals, society and the environment;***

***iii) re-evaluating as necessary all relevant factors mentioned in sub-paragraphs (i) and (ii) so as to ensure the continued safety acceptability of the nuclear installation,***

***iv) consulting the Contracting Parties in the vicinity of a proposed nuclear installation, insofar as they are likely to be affected by that installation, and providing the necessary information to such Contracting Parties on request so that they can evaluate and make their own assessment of the likely safety impact of the nuclear installation on their own territory.***

## 17.1. Evaluation of site-related factors

### 17.1.1. The regulatory framework

The Environment Code specifies the different procedures in effect for the creation, commissioning, modification, shutdown and decommissioning of a BNI, which are reiterated in § 7.3 of this report. More specifically, the preliminary version of the safety analysis report is enclosed with the creation authorisation application.

The Environment Code (article R. 593-18) defines the content of the preliminary version of the safety report: the safety analysis report sets out, among other things, the hazards the BNI can present in the event of an accident, whether it is of a radiological nature or not. To this end, it describes the accidents that could occur, whether their cause originates on or off the site, and their consequences. The licensee takes particular account of the impact of the installations that could increase the risks of accident and their effects.

Article 3.1 of the BNI Order stipulates that *"application of the principle of defence in depth is based notably on appropriate siting, taking particular account of the risks of natural or industrial origin to which the installation is exposed"*.

Article 3.6 of the BNI Order specifies the external hazards to consider. The acceptable methods for characterising the site-related hazards are set out in Basic Safety Rules (RFS) or guides (see Appendix B), particularly concerning the site geology (RFS 1.3.c), the seismic conditions (RFS I.2.c5 and RFS 2001-01), the risks related to the industrial environment and communication routes (RFS 1.2.d), the risk of external flooding (Guide No. 13). More specifically:

- RFS 2001-01 recommends using a deterministic approach to define the seismic loads to consider in the safety case. This approach includes determining the maximum historically probable earthquake (MHPE), then defining the safe shutdown earthquake (SSE) by adding a further degree of intensity. The possibility of reaching safe shutdown conditions and maintaining them after an earthquake at least equivalent to the safe shutdown earthquake (SSE) is verified. Consequently, some systems, structures and components (SSCs) have seismic requirements ("seismic-classified" SSCs) in view of their role in safety;

- Guide No. 13 takes into account the lessons learned from the flooding of the Le Blayais site in 1999. It details the recommendations for assessing and quantifying the risks of external flooding of the BNIs and defining the appropriate means of protection to cope with this. The hazards to take into consideration are defined on the basis of an in-depth assessment of knowledge in the various areas concerned, especially hydrology and meteorology (eleven different hazards considered). It is based on deterministic methods, incorporating markups and combinations integrated into the hazards, taking account of an exceedance frequency not higher than $10^{-4}$ per year.

### 17.1.2. Measures taken at the reactor design stage

The risks associated with the site-related factors (seismicity, hydrology, meteorology, industrial environment and communication routes) are analysed in the studies relating to external hazards. The studies take into account the Basic Safety Rules (RFS) and guides concerned. They are reassessed at each periodic safety review and the chapters of the safety analysis report (SAR) are updated accordingly.

The SARs comprise a specific “site and environment” chapter, addressing the subjects concerning the characteristics of the sites. This chapter identifies the site-related factors that could affect the safety of the installation.

***Earthquakes***

<u>Nuclear power reactors</u>

The seismic risk is taken into account in the design of the installations and reassessed during the periodic safety reviews or further to certain events. EDF uses the deterministic methodology of RFS 2001-01 to define the seismic risk.

For the design of new reactors, EDF considers:

- a "seismic interaction" approach which is implemented in order to prevent an essential SSC from being damaged by equipment that is not seismic-classified in the event of an earthquake;
- loss of the off-site electrical power supplies further to an earthquake insofar as they are not designed to withstand the earthquake. This is to be considered in the safety case under the reference accidents;
- the SSE resistance requirements of the fire protection measures *(DPCI - Dispositions de Protection Contre l’Incendie):* fire sectorisation, fixed fire detection and extinguishing systems) contributing to nuclear safety.

In the event of major disruption to roads and engineered structures limiting access to the site after an earthquake, the emergency response organisation calls on the public authorities who, in addition to triggering the off-site emergency plan (PPI) if necessary, take specific measures so that the necessary personnel can access the site.

<u>Research reactors</u>

The seismic hazard of the Jules Horowitz Reactor (JHR) situated on the Cadarache site is defined in the Cadarache centre's general safety presentation. The CEA uses the deterministic methodology of RFS 2001-01 to define the seismic loads.

***External flooding***

Flooding is a risk that is taken into account in the design of the installations and reassessed during the periodic safety reviews or further to certain exceptional events (e.g. flooding of the Le Blayais site in 1999).

Nuclear power reactors

EDF has conducted a safety analysis for each site, drawing up a list of the SSCs necessary to reach and maintain a safe state. In order to guarantee the absence of water in the premises housing the SSCs to be protected in the event of flooding, EDF has adopted a two-step approach:

- comparison of the water height likely to be reached at the various possible water entry points;
- identification of the material and operating measures aimed at protecting the installation against these water inflows;
    - the material provisions concern the civil engineering, the specific equipment (electrical, instrumentation and control (I&C), mechanical, etc.);
    - The operating measures comprise:
        - alert systems in the event of a foreseeable hazard that could lead to flooding of the site;
        - agreements with organisations within or outside EDF;
        - specific operating rules in case of flooding;
        - local procedures.

Research reactors

The CEA has conducted the safety analysis of the JHR reactor, identifying the premises accommodating equipment or systems enabling the reactor to be placed and maintained in a safe state.

The installation elevation and design measures (including the drainage systems) are sufficient to exclude the possible consequences of water upwelling (rising groundwater table, rainfall, flooding of rivers or bodies of water, breach of engineered structures, tanks or pipes). Constructional measures have also been taken to limit the risks of water runoff on the site. They consist notably in providing downward gradients directed away from the buildings and installing a stormwater drainage network.

The Cadarache centre is equipped with a weather alert system.

***Climatic conditions***

Nuclear power reactors

From the outset, the design of the EDF reactors has included protection against plausible external hazards: these include protection against snow, wind, cold temperatures and heatwaves. These hazards are reassessed during the periodic safety reviews or following certain exceptional events.

The approach adopted aims to ensure:

- the resistance to snow and high winds of buildings and structures that contribute to safety;
- the resistance to snow and high winds of the equipment situated outside the building and also contributing to safety;
- the maintaining of satisfactory ambient conditions for systems whose failure could jeopardise fulfilment of the fundamental safety functions. The ventilation, heating and cooling systems are dimensioned for this.

The effects of snow and high winds are analysed in accordance with rules for constructions (NV65 or Eurocodes).

Research reactors

The CEA has taken into account the climatic conditions associated with extreme temperatures, wind and snow in the design of the JHR.

The civil engineering structures and the roofs are designed for the maximum reference loads defined for the Cadarache centre.

Physical provisions are put in place to maintain, in extreme temperature conditions, an acceptable ambient temperature in the premises accommodating SSCs that play a role in placing and maintaining the reactor in a safe state.

***Industrial environment and communication routes***

Nuclear power reactors

The risks due to the industrial environment and the communication routes are assessed in each site's safety analysis report, taking account of the local particularities (inventory of the installations, industries and types of goods transported in the neighbourhood); they are subject to a periodic review because they can change over time with respect to what existed when the NPP was designed and built.

The safety case is based on:

- a deterministic approach by ascertaining that the distance at which the physical phenomena have an impact is less than the distance separating the SSCs necessary to fulfil the safety functions from the source of the abovementioned physical phenomena;
- a probabilistic approach when the deterministic approach cannot exclude the risk; this consists in checking that the probability of unacceptable radioactive releases is sufficiently low (≤ about $10^{-7}$/reactor.year per family of hazards and $10^{-6}$/reactor.year for all external hazards caused by human activity – see RFS I.2.d).

Research reactors

The CEA has assessed the risks created by the environment (industry and communication routes) on the JHR facility by identifying the industrial installations outside and within the Cadarache site, the communication routes and the aerodromes or airports situated within a radius that could impact the JHR facility. This has led to the analysis of specific external hazards (off-site explosion, drifting of toxic or explosive clouds, emission of clouds or slicks of toxic substances or radiological hazard).

A probabilistic study of the risk of an aircraft crash on the "potential" targets of the JHR facility, based on the actual air traffic, enabled the characteristics of this hazard to be defined for the JHR reactor.

### 17.1.3. ASN oversight

During the examination of the creation authorisation application, ASN examines the natural or anthropogenic external hazards associated with the site, which are assessed on the basis of the latest available knowledge. This examination is similar to that carried out for the periodic safety reviews. ASN also ensures that in the design, the licensee includes either margins or possibilities of adapting the installation, given that the installation is intended to be operated for several decades.

## 17.2. Impact of the installation on individuals, society and environment

### 17.2.1. The regulatory framework

The Environment Code specifies the different procedures in effect for the creation, commissioning, modification, shutdown and decommissioning of a BNI, which are reiterated in § 7.3 of this report. In particular, the creation authorisation application is accompanied by an impact study.

The Environment Code (article R. 593-17) indicates the content of the impact assessment, which must more specifically present:

- the significant impacts that the installation project could have on the environment, distinguishing the different phases of construction and operation of the installation;
- the evaluation of public exposure to ionising radiation due to the installation, taking into account the irradiation caused directly by the installation and the transfers of radionuclides by the various vectors, including food chains.

### 17.2.2. Measures taken for the reactors

The impact study is one of the documents submitted by the licensee to ASN at the time of the creation authorisation application. This study is updated in the application for commissioning authorization. It includes a study of the radiological impact of its radioactive effluent discharges in the environment and public health, and a presentation of the measures taken to avoid, reduce and/or mitigate the effects of the facility.

### 17.2.3. ASN oversight

In the course of these procedures, ASN examines the impact assessment submitted by the licensee, particularly environmental discharges of liquid or gaseous radioactive effluents resulting from normal operation of the installation and the assessment of their impacts on man and the flora and fauna. ASN checks in particular that the licensee implements the best techniques available to avoid these discharges or, failing this, to reduce them as much as is reasonably practicable.

On completion of its examination, ASN issues requirements setting in particular the authorisation limits for environmental radioactive discharges associated with normal operation of the installation, the discharge conditions and the associated monitoring provisions (see § 15.3.2).

## 17.3. Re-evaluation of site-related factors

### 17.3.1. The regulatory framework

The Environment Code (Article L. 593-18) states that the licensee of a basic nuclear installation performs periodic safety reviews of its installation taking the best international practices into consideration. "*This review must allow [...] updating of the assessment of the risks or drawbacks presented by the installation [...], taking into account more specifically the state of the installation, the experience acquired during operation, the development of knowledge and of the rules applicable to similar installations*". Pursuant to this article, the external hazards must be reassessed as part of the ten-yearly periodic safety reviews, taking the development of knowledge into account and updating the SARs accordingly.

### 17.3.2. Measures taken for the reactors

***Periodic safety review***

The reassessments conducted during the successive periodic safety reviews, and notably the integration of operational experience feedback, the development of knowledge and the rules applicable to similar installations, may lead to reinforcement of protection of the installations against external hazards.

Nuclear power reactors

With regard to earthquakes, the periodic safety reviews provide the opportunity for an in-depth examination of compliance with the seismic requirements in force and a reassessment of the SSE in the light of the most recent data and the development of knowledge. If necessary, the reassessment of the seismic risk may lead to structural reinforcements or developments in earthquake engineering methods.

With regard to the climatic conditions, EDF conducts a climate watch in order to assess the possible changes in the hazards resulting from climate change and to ascertain that these changes are not likely to call into question the design of the installations with respect to climatic hazards. EDF has implemented a procedure in this respect, carried out with the same frequency as the publication of the reports of the Intergovernmental Panel on Climate Change (IPCC), defining:

- the climatic hazards whose development is conceivable or certain, which could lead to a reassessment of the baseline values;
- the criteria concerning climatic events that trigger an in-depth analysis (notion of major climatic event), in order to guarantee the conservative nature of the climatic hazards over the period between two safety reviews.

The CEA's research reactors

The reassessment studies conducted during the periodic safety reviews are based on experience feedback from important events occurring on the site, changes in regulations and in the state of knowledge.

The load levels can be revised, particularly the SSE and the climatic reference values. The extreme weather conditions and the seismic hazards have been reassessed for each site. The external hazards are also reassessed taking into account the development of the industrial environment and the communication routes.

Warning systems for predictable hazards, along with specific organisational and material prevention and protection measures, are implemented.

The HFR research reactor of the Laue-Lange Institute (ILL)

The external hazards studies are reassessed during the periodic safety reviews. The reassessments carried out by the ILL during the successive periodic safety reviews take into account the change in factors of the site environment. These factors comprise the weather, climatology, hydrogeology, geology, the industrial environment and communication routes, the population and the rural economy. The change in these factors is identified in a chapter of the safety analysis report which is updated on this occasion, and the safety case is updated if necessary, taking these updated factors into account.

With regard to earthquakes, the seismic loads considered by the ILL follow RFS 2001-01. The ILL considers the SSE as a load case for the dimensioning. It also takes into account combination of the earthquake with the internal initiating events and combination of the earthquake with other independent external hazards when the plausibility of such combinations cannot be ruled out. The SAR describes all the safety important components which have specified requirements relative to their ability to function during and after an earthquake, or their ability not to become a hazard for other equipment items in the event of an earthquake.

With regard to external flooding, the ILL has identified the flood scenarios and the scenarios for the breaching of hydroelectric dams situated upstream of the site. The scenario that leads to the greatest height of water on the site was then adopted, adding the effects of floating objects carried by the flood, such as the impact of a truck. This study concludes that all the reactor cooling and containment systems function passively and are not affected by a flood. To reduce the pressure of the water on the metal containment, rupture discs have been installed. In the event of a flood, the emergency management team can use the resources and the Command Post provided for extreme natural hazards, which are situated at a good height and remain operational in the a flood situation. Lastly, anti-floating devices have been installed on certain tanks whose integrity must be maintained in the reactor building.

The risks associated with the industrial environment and the communication routes are reassessed during the periodic safety reviews to take account of the development of road, rail and air traffic and the routing of energy via gas or oil pipelines. The evolution of the high-risk industries situated in the employment basin is also considered, especially the SEVESO-classified chemical industries in order to take into account the effects of toxic clouds or an explosion.

***Stress tests***

<u>Nuclear power reactors</u>

As part of the stress tests, EDF has reviewed the margins on the resistance of the SSCs necessary to place and maintain the installation in a safe state during extreme hazards (earthquake and flooding in particular).

As regards <u>the earthquake-related assessments:</u>

- EDF has carried out the seismic inspection of a representative sample of the equipment needed to manage the reactor in the event of total loss of off-site and on-site power supplies, whether seismic-classified or not, for all the reactor fleet in service. These on-site inspections have ascertained that the analysed equipment items can fulfil their functions in view of international post-earthquake operational experience feedback;
- EDF has defined extreme seismic hazard levels (SND – "Séisme Noyau Dur" or "hardened safety core earthquake") for all the sites in operation in accordance with the ASN requirement;
- EDF has defined a "Hardened Safety Core" for its installations, consisting of new and existing SSCs which must withstand hazards beyond the NPP design-basis in situations of total loss of heatsink and total loss of electrical power supplies. In particular, to meet the ASN requirements, EDF has deployed an additional electrical power supply resource, an ultimate backup diesel generator set (DUS) dimensioned for the SND, which can supply the Hardened Safety Core systems and components in the event of total loss of the off-site and on-site electrical power supplies of one of the site reactors (failure on start-up or connection of the reactor diesel generator sets which constitute the emergency power sources).

As regards the <u>flood-related assessments:</u>

- For all the sites EDF has defined beyond-design-basis hazards that cover all the phenomena that can lead to or contribute to an extreme external flood, and has assessed the associated water level taking into account the site's existing means of protection. These studies have led to the deployment of additional measures on the sites that needed them;

- EDF has defined extreme scenarios taking into account the external floods induced by the SND (destruction of water retention structures that could constitute potential sources of flooding). EDF has assessed the risk of submersion of the nuclear island platform. In accordance with the ASN requirements, additional protections have been deployed on the sites;
- Measures aiming to cope with isolation of the site in the event of flooding have been implemented on the sites potentially at risk.

Research reactors

As part of the stress tests, the CEA has assessed the robustness of the research reactors beyond the safety baseline requirements, particularly for earthquake and flood situations.

As part of the stress tests, the ILL has defined extreme natural hazard levels for earthquakes, flooding and climatic conditions (tornados). A 20,000-year return period has been considered for the extreme earthquake (SND) and the breach of the four hydroelectric dams situated upstream the site has been combined with the extreme earthquake, with a submersion wave and floating objects.

These studies have led to the implementation of a "hardened safety core" of redundant physical measures on two trains (see Focus 19 in § 14.1.2.2), allowing control of the safety functions in these situations (control of reactivity, control of cooling, control of containment) and the management of a crisis, also taking account of the effects induced by the hazard on the industrial environment and the communication routes. The Emergency Command Post installed further to the stress tests is robust to all these hazards.

### 17.3.3. ASN oversight

As part of the periodic safety reviews, ASN examines the natural or anthropogenic external hazards associated with the site, which are assessed on the basis of the latest knowledge available.

Further to the stress tests, ASN resolutions have set requirements relative to:

- the definition of the "hardened safety core" earthquake (SND), to be taken into account for the hardened safety core SSCs, defined by a response spectrum which must:
  - encompass the site's safe shutdown earthquake (SSE), increased by 50%;
  - encompass the probabilistic site spectra with a return period of 20,000 years;
  - take into account the specific site effects in its definition, particularly the nature of the soil.
- protection of the installations against flooding beyond the baseline requirements. This requirement more specifically concerns raising of the protection volume to protect against total loss of the heat sink or electrical power supplies in beyond design-basis scenarios (beyond design-basis rainfall, flooding induced by the failure of on-site equipment due to an earthquake, etc.);
- the risks created, in the extreme situations studied in the stress tests, by the facilities situated near the nuclear power plants.

## 17.4. Consultation with other Contracting Parties likely to be affected by the installation

The principle of consultation of States concerned by a project is internationally enshrined by both the European Directive 2011/92/EU of 13/12/11 concerning the assessment of the impact of certain public and private projects on the environment, and the Espoo convention. In French law, this principle is implemented in the Environment Code.

If a project is likely to have significant impacts on the environment of another State (member of the European Union or party to the Convention of 25 February 1991 on the assessment of the environmental impact in a transboundary context signed in Espoo, Finland), the government, as part of the BNI creation authorisation procedure, notifies this State of the public inquiry opening order and sends it a copy of the investigation file. The authorities of the foreign State are given a deadline to express the State's intention to participate in the public inquiry, which cannot begin until this deadline has expired (Article R. 122-10 of the Environment Code).

The States concerned are therefore consulted during the public inquiry.

Pursuant to article 37 of the treaty instituting the European Atomic Energy Community and of the Environment Code, the creation authorisation for a facility likely to discharge radioactive effluents into the environment can only be granted after consulting the European Commission.

# Article 18 Design and construction

**ARTICLE 18 DESIGN AND CONSTRUCTION**

***Each Contracting Part takes appropriate measures to ensure that:***

***i) the design and construction of a nuclear installation provides for several reliable levels and methods of protection (defence in depth) against the release of radioactive materials, with a view to preventing the occurrence of accidents and to mitigate their radiological consequences should they occur;***

***ii) the technologies used in the design and construction of a nuclear installation are proven by experience or qualified by testing or analyses;***

***iii) the design of a nuclear installation allows for reliable, stable and easily manageable operation, with specific consideration given to human factors and the man-machine interface.***

## 18.1. Implementation of defence in depth

### 18.1.1. The regulatory framework

The BNI Order (Article 3.1) requires application of the principle of defence in depth. Thus, when designing BNIs, this leads to the implementation of successive defence levels (intrinsic characteristics, material provisions and procedures), intended to prevent incidents and accidents and, should prevention fail, to mitigate their consequences.

For the design of the EPR reactor, three main improvement targets with respect to the preceding reactors have been set. They figure in the technical directives for the design and construction of the next-generation pressurised water nuclear reactors:

- reduce the number of incidents with the aim of reducing the possibilities of accident situations arising further to such events;
- significantly reduce the probability of core melt: the technical directives stipulate in this respect that "*improving defence in depth [...] should lead to an overall core melt frequency of less than* $10^{-5}$ *per reactor-year, taking uncertainties and all types of failures and hazards into account*". Consideration of all initiating events that could lead to core melt is a new approach compared with that for previous reactors;
- significantly reduce the radioactive discharges that could result from all conceivable accident situations, including core melt accidents. The technical directives stipulate in this respect that:
  - "*for accident situations without core melt, there shall be no necessity of protective measures for people living in the vicinity of the damaged plant (no evacuation, no sheltering)*";
  - "*Low pressure core melt sequences have to be dealt with so that the associated maximum conceivable releases would necessitate only very limited protective measures in area and in time for the public. This would be expressed by no permanent relocation, no need for emergency evacuation outside the immediate vicinity of the plant, limited sheltering, no long term restrictions in consumption of food*";
  - "*Accident situations with core melt which would lead to large early releases have to be "practically eliminated»: if they cannot be considered as physically impossible, design provisions have to be taken to design them out. This objective applies notably to high pressure core melt sequences.*"

Defined in 2000, these safety objectives are those of Principle No.1 of the Vienna Declaration on Nuclear Safety.

Produced jointly with IRSN, the ASN Guide No. 22 contains recommendations with regard to safety for the design of pressurised water reactors. Although this guide applies primarily to the design of new-generation PWRs, its recommendations may also be used as a reference when seeking improvements to be made to reactors in service, for example during their periodic safety reviews, in accordance with Article L. 593-18 of the Environment Code and Articles 8b and 8d introduced by European Council Directive 2014/87/Euratom of 8 July 2014.

The guide focuses essentially on the prevention of radiological incidents and accidents and the mitigation of their consequences. It details the general design objectives and principles and makes recommendations to meet regulatory requirements. The recommendations focus in particular on defence in depth and the nuclear safety case.

ASN Guide No. 22 thus constitutes a reference in France for the design of new reactors and a tool for presenting French nuclear safety practices on the international stage. It updates the technical directives adopted by ASN in 2000. The safety objectives are similar to those set out in the technical directives and correspond to those of principle No.1 of the Vienna Declaration on Nuclear Safety.

### 18.1.2. Measures taken for the reactors

In its present form, the principle of defence in depth is based on the implementation of five successive and sufficiently independent levels of defence, of which the first four are the licensee's responsibility:

1. the first level aims to prevent operating anomalies and system failures through the quality of design and manufacturing;
2. the second level consists in detecting incidents and taking steps that will firstly prevent them from leading to an accident, and secondly restore a situation of normal operation or, failing this, place and maintain the facility within the authorised operating range;
3. the purpose of the third level is to control accidents that could not be avoided or, failing this, prevent the situation from worsening by regaining control of the facility in order to reach a safe condition and maintain it;
4. the fourth level consists in managing accident situations that could not be controlled so as to mitigate the consequences, notably for persons and the environment;
5. the fifth level of defence in depth, which targets emergency management by the public authorities, aims at mitigating the radiological consequences of radioactive releases that could result from accident conditions.

***EPR reactor***

The safety of the EPR reactor is based on the abovementioned levels and retaining at the design stage:

- severe accidents (integrating in particular a corium spreading and cooling area if necessary);
- improvement in the resistance of the installation to external hazards: it has been in particular decided to consider the aviation risk independently of the probability of occurrence of the event, by basing protection of the installation jointly on the principle of geographical separation and the existence of a physical barrier called "APC (airplane crash) shell". The roof and external walls of the buildings that could contain nuclear fuel (Reactor and Fuel Buildings), the main control room, the reactor secondary control room and two of the four divisions of the Safeguard Auxiliary Building (BAS) are thus covered by a thick shell. Protection against the effects of this external hazard is supplemented by adequate geographical separation from the

other two divisions of the BAS, from the rooms housing the isolation valves of the SG main steam and feedwater pipes (grouped in two circuits of two loops), the diesel generator buildings of the four divisions grouped in two pairs and the premises of the pumping station housing two of the four cooling system trains (SEC, SRU, CFI);

- improvement in the resistance of the installation to external hazards: the designing of buildings with structural divisions (BAS, diesel generator set buildings, etc.) aimed to limit the consequences of internal hazards, when relevant, within the division concerned (reduction of interconnections between divisions by means of isolation or decoupling);
- multiple failures that could lead to core melt: additional safeguard systems have been designed and installed to prevent core melt during these sequences;
- application of the principle of defence in depth to the Fuel Building (see § 18.3.2.1).

Implementation of the principle of defence in depth at the design stage has been presented in the preliminary safety analysis report submitted to ASN to support the reactor creation authorisation application. It is then substantiated in the commissioning authorisation file.

The reactors currently in operation were designed following an older defence in depth approach based on three levels. The current approach with five levels has been applied during the periodic safety reviews.

***JHR Reactor***

The design of the JHR reactor is based on the defence in depth concept. Under the fourth level of defence in depth, the JHR reactor considers severe accidents at the design stage. The design-basis accident considered for the installation is the BORAX-type explosive reactivity accident. Vents with appropriate filters are planned for in the design to mitigate the consequences of a severe accident.

Furthermore, the installation has specific design provisions to take into account the external hazards risk. For this, the installation incorporates a system of aseismic bearing pads, accelerometers triggering a complete fast emergency shutdown, a specific airplane crash-resistant design of the reactor building and its nuclear auxiliary building, as well as provisions for protection against the effects of a tornado or lightning.

Furthermore, the stress tests studied situations resulting from extreme natural phenomena (earthquake, flooding and their combination) or total loss of the electrical power supplies and the heatsink: the modifications resulting from these stress tests are presented in § 18.3.

### 18.1.3. ASN oversight

***EPR reactor***

As part of its oversight duty, ASN examines the detailed design of the reactor, and in particular the provisions associated with application of the principle of defence in depth. These provisions were described in the preliminary safety analysis report submitted to support the creation authorisation application for this installation, then detailed and substantiated in the safety analysis report submitted to support the commissioning authorisation application. Sections § 14.1.3 and 19.1.3 present the ASN's review of the reactor detailed design.

***JHR reactor***

During the examination of the creation authorisation application for the JHR reactor, ASN examined the provisions associated with implementation of the defence in depth principle. ASN checks in particular that, in the manufacturing and production phases, the licensee uses the materials, standards and design codes applicable for the first level of defence in depth.

## 18.2. Incorporation of proven technologies

### 18.2.1. The regulatory framework

The BNI Order (Article 2.5.1) requires the qualification of protection important components (PIC) to be proportionate to the risks: it aims in particular to guarantee their ability to fulfil their functions in the situations in which they are needed. Appropriate design, construction, tests, inspection and maintenance provisions must be implemented to enable this qualification to be maintained over time.

Nuclear pressure equipment (NPE) is subject to both the BNI regulation and another specific regulation. On this account, NPE is obliged to comply with essential safety requirements set by the regulations and verified during a conformity assessment. These requirements concern in particular the design and manufacture of the equipment and the materials used. They imply in particular that the materials have appropriate characteristics for the expected loads. The conformity of these characteristics can be demonstrated by referring to harmonised standards or by performing assessments or specific tests. Likewise, the manufacturing methods and techniques must be appropriate and guarantee fault-free results. To ensure this, some processes, such as welding and non-destructive testing, and the operators performing them, must be qualified.

Lastly, for certain components which risk having heterogeneous characteristics, all the material production operations and the manufacturing operations must be subject to "technical qualification". The purpose of this qualification is to ensure that the component characteristics ultimately meet the specifications in all respects. This problem concerns, for example, large equipment items (e.g. a reactor vessel head), because their size makes them particularly vulnerable to metallurgical defects such as carbon segregation, which weaken their mechanical characteristics.

### 18.2.2. Measures taken for the reactors

Design codes are used for the classified equipment. The nuclear industry produces detailed rules concerning the state of the art and good industrial practices, which it brings together in "design codes". These codes (RCC - *Règles de Conception et de Construction* – Design and Construction Rules) have been drawn up for the design, manufacture and commissioning of electrical equipment, civil engineering structures, mechanical equipment and fuel assemblies of NPPs. These industrial codes are drafted by AFCEN, the French association for rules on design, construction and in-service monitoring of nuclear steam supply systems, which comprises 60 French and international industrial firms, including EDF, Framatome and the CEA.

The manufacturer of a nuclear pressure equipment item is responsible for its compliance with the applicable safety requirements to guarantee the absence of failure throughout its operating life. These requirements are defined by a European Directive concerning pressure equipment (PE) and are supplemented by requirements specific to nuclear pressure equipment, which also take into account their importance for the safety of the installation. The manufacturer defines and applies the rules that enable it to prove compliance with these requirements. These rules are given in the design and construction code for these equipment items (RCC-M) published by AFCEN.

The RCC-M code includes in particular a method for controlling the risk of heterogeneity: the manufacturer must identify the parameters that can influence the risk of heterogeneity resulting from the operation in question, check their effects through a test programme on a dedicated part, then check these parameters on the production parts through an acceptance test programme.

### Focus 32 : in-service ability of the EPR pressure vessel

On 7 April 2015, ASN released information concerning an anomaly in the composition of the steel in the centre of the Flamanville 3 EPR pressure vessel closure head and bottom head. This anomaly is linked to the presence of a high carbon concentration which results in mechanical properties that are not as good as expected.

Framatome, in collaboration with EDF, has launched a test programme to assess the mechanical properties xx. The results show that the mechanical properties of the material are sufficient to prevent the risk of fast fracture, given the loads applied and postulating the existence of the most unfavourable flaw. Following its examination, ASN considered that this anomaly is not such as to compromise the serviceability of the EPR reactor pressure vessel bottom head and closure head, provided that specific inspections are carried out during operation of the installation to ensure that no flaws appear.

Furthermore, on 13 July 2018, Framatome submitted a commissioning[21] and operation authorisation application for the Flamanville EPR reactor pressure vessel. ASN verified compliance with the technical and regulatory requirements other than those concerning the chemical composition of the steel of the reactor vessel closure and bottom heads. On the basis of the conclusions of this review, ASN authorised the commissioning and operation of the Flamanville EPR reactor pressure vessel on 9 October 2018, subject to the performance of a test programme to monitor thermal ageing, plus specific inspections during operation of the facility. As the current state of knowledge does not enable the feasibility of these inspections to be confirmed for the vessel closure head, ASN set a service life limit for it.

With regard to safety, qualification is the demonstration that a safety important component is capable of fulfilling its functions under the conditions (temperature, pressure, humidity, irradiation, earthquake, etc.) to which it is likely to be subjected.

An item of equipment can be qualified by either testing or analyses (studies), or a combination of the two:

- qualification by testing consists in subjecting a "model" item of equipment to loads representative of the normal and accident operating conditions it must be capable of withstanding; the test programme is broken down into successive test sequences that aim to represent the loads to which the equipment is likely to be subjected. This method, for example, is the one used most often for electrical equipment. It is also used for other equipment, such as valves;
- qualification by analysis can be performed:
    - either by analogy with an item of equipment already qualified by tests, on the basis of predetermined rules (similar technology and dimensions, etc.); this method is used in particular for valves and pumps;

[21] Commissioning of the reactor pressure vessel is to be distinguished from commissioning of the installation.

- or by calculation with a simulation model representative of the equipment and qualified method or calculation codes; this method is used in particular to substantiate the mechanical design;
- or by operating experience, when the conditions experienced have been at least as severe as those the equipment must be able to "withstand".

A safety classification approach is applied for safety important equipment. This approach allows appropriate requirements to be defined in terms of design, manufacture, qualification, operation and in-service monitoring, proportionate to their importance for safety. Equipment items can be classified under the prevention of incidents and accidents, the mitigation of their consequences or protection against hazards, and according to their type (mechanical, electrical, etc.).

***EPR reactor***

The qualification approach described above was applied to the EPR. Several equipment items were nevertheless subject to specific approaches:

- for the instrumentation and control (I&C), a specific approach was adopted for its design in order to provide the appropriate substantiations. It is based on control of the different steps of the industrial process, namely the specification of the design requirements, the design process, production and integration (assembly of the various system components), each of which include verifications; a final independent validation step constitutes an additional precaution. This approach is supplemented by functional diversification which enables hypothetical faults in design or in the execution of certain functions to be compensated by means of other functions using physical signals or different processing methods;
- for the reactor vessel, a specific qualification process has been adopted. Test pieces made from the same material as the reactor vessel are irradiated in areas near the core and subjected to mechanical tests at different stages of the installation life with the aim of predicting the behaviour of the vessel material (particularly in terms of the transition threshold for ductile-fragile mechanical behaviour);
- for the EPR core catcher, its qualification for the accident conditions of situations with core melt was largely based on European experimental programmes such as those associated with the COMAS[22], CSC[23] and ECOSTAR[24] projects.

For the EPR reactor, the safety classification approach for the equipment and systems is based on the importance of the safety function they fulfil and their importance as a containment barrier depending on the releases, within the installation and into the environment, that could result from their failure.

[22] the COMAS tests are large-scale corium cooling tests performed by Framatome.

[23] the CSC (Corium Spreading and Coolability) tests are qualification tests of the concept of a corium collector and spreader, and of the "COMET 581 concept" of reflooding from the bottom.

[24] the ECOSTAR (Ex-Vessel Core Melt Stabilization Research) project includes the studies relative to the study of the physical-chemical phenomena that occur during spreading and the study of the effectiveness of reflooding a spread corium by adding water via the top or bottom).

***JHR reactor***

The qualification approach applies to the equipment items which are divided into two categories according to their nature and their purpose:

- for all the active safety-classified equipment, the conventional approach of qualification by testing or analyses as described in § 18.2.2 has been applied;
- for the passive equipment, the qualification approach consists in checking their resistance to the accident conditions, particularly the loads to which they are subjected.

Combinations of the abovementioned methods have frequently been used for the JHR equipment items as they make very wide use of technologies already used in other French BNIs.

Alongside this, several equipment items have undergone specific approaches:

- a fuel element qualification programme has been deployed to cover the fabrication process, behaviour when irradiated, hydraulic behaviour and validation of the locking and handling system,
- a qualification programme for the aluminium alloy material used in certain components of the reactor block aims to qualify the forging routes and the welding process to implement and to assess the behaviour of the material and its welds when subject to irradiation,
- a qualification programme for the absorbent cluster control mechanisms has validated the general design (early qualification phase), the main technological choices (functional validation tests on mock-ups) and all the expected performance levels (qualification on test loop),
- a specific test programme is underway to test the reduction of the effects of the fluid-structure interaction associated with a vibration risk for all the reactor pile block structures, given the expected high speeds of hydraulic flow in the pile block internal structures,
- the qualification programme for the aseismic bearing pads addresses four areas: manufacture and characterisation, possibility of replacing these pads, proof of durability and validation of the monitoring plan.

### 18.2.3. ASN oversight

#### *18.2.3.1. Equipment other than nuclear pressure equipment*

For the reactor components or equipment items, ASN's examination focuses on:

- the design, dimensioning and manufacturing requirements for the components/equipment, in view of the importance of their role in the safety case. ASN's examination focused in particular on the safety classification approach which serves to identify and differentiate the main applicable requirements, including the applicable standards or industrial codes to be used;
- qualification for accident conditions, which aims to verify that the equipment items used in the management of incidents and accidents fulfil their functions under the corresponding environmental conditions (temperature, relative humidity, radiation, etc.). ASN has devoted particular attention to the qualification of equipment for severe accident conditions.

#### *18.2.3.2. Nuclear pressure equipment (NPE)*

ASN assesses the regulatory compliance of the NPE most important for safety, referred to as “level N1”, which corresponds primarily to the reactor pressure vessel, the SGs, the pressuriser, the reactor coolant pumps, the piping – especially that of the main primary and secondary systems, and the safety valves. ASN can be assisted in this task by an approved organisation. This organisation is then mandated by ASN to perform some of the inspections on the level N1 equipment.

The oversight by ASN and the approved organisations is carried out at the different stages of design and manufacture of the NPE items. It involves an examination of the technical documentation of each equipment item and inspections in the workshops of the manufacturers, as well as at their suppliers and subcontractors.

The ASN-approved organisations assess the regulatory compliance of the level N2 and N3 NPE items. These organisations are called upon directly by the manufacturer. The activity of these organisations is regularly inspected and audited by ASN.

ASN assesses the conformity of the NPE items of the main primary and secondary systems. In this context, ASN ensures oversight of manufacture of the NPE items that will be part of the primary and secondary systems of the nuclear steam supply system. In addition to this oversight, ASN and the approved organisations examine the technical documentation and the monitoring of the NPE assembly operations that are carried out on the site. The conformity of the equipment intended for the Flamanville EPR is also assessed in the light of operating experience feedback from the assembly and testing operations performed on other EPR-type reactors such as those of Taishan (China) or Olkiluoto (Finland). If the checks are satisfactory with respect to the regulatory requirements, ASN issues the NPE certificates of conformity.

ASN also conducts inspections of EDF and its manufacturer Framatome concerning assembly of the NSSS and preparation of the hydrostatic tests, as well as inspections of the inspection organisations or entities mandated by ASN to monitor these activities. These inspection organisations and entities have themselves conducted several thousand inspections over the last few years.

### Focus 33 : Repair of the welds of the main secondary systems of the EPR

At the beginning of 2017, EDF informed ASN of design deviations and anomalies having occurred during welding of the main steam pipes (VVP system) for the Flamanville EPR reactor. These anomalies concerned firstly mechanical properties (impact strength) lower than those stipulated in the break preclusion baseline requirements applicable to these pipes, and secondly the presence of defects detected late (during the non-destructive test performed on the welds during the pre-service inspection of the equipment). ASN had considered as of 2018 that preference should be given to repairing all the welds.

For information, the principle of application of a break preclusion approach consists in not examining the consequences of the break of a pipe in the nuclear safety case because such a break is rendered extremely improbable with a high level of confidence. Application of this approach must lead to a reinforcement of the first two levels of defence in depth: it is therefore underpinned by particularly stringent measures in terms of the design, manufacture and in-service monitoring of these pipes.

EDF wanted to keep these welds, which are situated in the reactor containment penetrations and are subject to a break preclusion approach, in their present condition by applying a test programme and reinforced in-service monitoring. After examining the EDF file and consulting its Advisory Committee for nuclear pressure equipment, ASN considered that the nature and the particularly high number of the deviations which had occurred during design and manufacture represented a major obstacle to keeping these welds as-is. In June 2019, ASN requested that the welds be repaired before the commissioning of the reactor.

Since then, EDF has been working hard to repair the welds on the secondary circuits of the Flamanville EPR. Indeed, due to the deviations observed, about a hundred secondary circuit welds required repair. EDF defined specific mock-ups and carried out tests to qualify the repair processes. ASN has stepped up its oversight of these work sites to ensure the quality of the new welds.



## 18.3. Design choices

### 18.3.1. The regulatory framework

The BNI Order (Article 3.1.II) requires "*a cautious design approach, integrating design margins and wherever necessary introducing adequate redundancy, diversification and physical separation of the protection important components that fulfil functions necessary for the nuclear safety case*".

The BNI Order (Article 3.2) requires that "*the safety case [be] carried out in accordance with a cautious deterministic approach, [integrating] the technical, organisational and human dimensions*. ».

The BNI Order (Article 3.9) requires that it be shown that "*accidents likely to lead to significant releases of hazardous materials or to dangerous effects off-site with kinetics that would not permit the timely implementation of the necessary measures to protect the population are physically impossible or, if this physical impossibility cannot be demonstrated, that the provisions implemented on or for the installation make such accidents extremely unlikely with a high degree of confidence.*"

ASN Guide No. 22, developed with IRSN, contains recommendations for the design of pressurized water reactors. The guide deals mainly with the prevention of radiological incidents and accidents and the mitigation of their consequences. It specifies the objectives and general design principles and makes recommendations to meet regulatory requirements.

In this guide, ASN also defines the conditions for using human actions in the safety case accident studies. These conditions thus set the minimum time to consider, from the time an event is detected, to allow for the performance of a human action in the control room (30 minutes) or on site but outside the control room (1 hour) and requires proof of the feasibility of the human actions thus valued.

### 18.3.2. Measures taken for the reactors

#### *18.3.2.1. Measures taken at the design stage*

***EPR reactor***

Some of the EPR design choices result from the safety targets set for the 3rd-generation reactors, notably reduction of the probability of core melt situations and significant reduction of the radioactive releases that can result from core melt situations. More specifically, regarding these latter situations:

- the system for ultimate removal of heat from the reactor building (EVU) enables the pressure in the containment to be limited in all accident situations;
- the corium catcher is designed to collect the corium, cool it and stabilise it. These measures prevent basemat melt-through. In the longer term, the reactor building ultimate heat removal system (EVU) enables the residual heat to be removed from the corium;
- the injection of sodium into the IRWST (In-containment Refuelling Water Storage Tank) aims to limit radioactive releases within the containment. This produces a basic pH in the IRWST, thereby limiting the production of volatile molecular and organic iodine which is poorly filterable. The sodium is injected by the EVU system in the event of a severe accident.

Other design choices stem from the objectives assigned to the 3rd level of defence in depth for the management of events affecting the Fuel Building, notably:

- the design of two main cooling trains for the fuel storage pool (PTR), each equipped with two 100% pumps;
- installation of the "3rd PTR cooling train";
- water make-up in the storage pool  by fire protection system (JAC – JPI systems);
- isolation of the valves at the bottom of the fuel storage pool and fuel reactor pool compartments and isolation of the suction valves of the cooling trains (PTR) to limit water inventory losses from the pool;
- the electrical interconnections to ensure resupply of pumps of the main cooling trains (PTR).

Moreover, technical choices made at the design stage have enabled the human factor to be better taken into account in the future operation of the Flamanville EPR reactor. More specifically, certain technical choices limit the maintenance activity peaks during reactor outages by making maintenance possible when the reactor is in operation, such as:

- the design of the safeguard systems (SRU, EVU, SBO diesel generator sets) with two redundant trains enables their preventive maintenance to be performed when the reactor is at power;
- the preventive maintenance of one of the two main cooling trains of spent fuel in the storage pool (PTR) can be carried out when the reactor is at power, with the backup of the "3rd diversified" PTR train;
- electrical power can be supplied to the three PTR trains via a dedicated electrical interconnection when the switchboards are cut off during the reactor outages.

The scheduled maintenance operations during outages have been reviewed to improve the work conditions for the personnel. To give an example, the diameters of the steam generator secondary and primary access hatches have been increased compared with the N4 plant series to facilitate entry of the operators and the inspection equipment.

EDF has also adopted certain technical choices for the I&C systems and the man-machine interface:

- the digital technology used jointly for the instrumentation, the conventional I&C and the safety-classified I&C offers advantages in terms of physical diversification between the protection controller and the process controller of the plant, but also in terms of man-machine interface with a computerised interface (the Process Information and Control System - PICS) and a conventional interface (the Safety Information and Control System - SICS);
- separate I&C functions have been designed for normal operation and for incident and accident prevention; they cover:
  - the monitoring functions, which are the functions used for reactor operation in all situations;
  - the operator aid functions, which significantly help the operator for the operation of the reactor;
  - the LCO functions, which are implemented to avoid prolonged operation beyond the limiting conditions of operation (LCO) considered in the safety case;
  - the limiting functions, which are the automatic correction functions before the reactor protection functions are activated;
- the allocation of tasks between the operators and the technical systems, particularly through the automatic control choices, has been defined so as to make optimal use the operator's capabilities. For example, the workload during accident situation has been limited for the secondary system cooling activity by putting in place an automatic cooling function. These automatic control choices have been made while also ensuring that the operators are able, if necessary, to take over operation in manual mode.

Test campaigns have been carried out on a simulator to assess the available operational means, alarms management, organisation of the operating team in incident and accident situations, and the man-machine interface. Further to these tests, recommendations were issued to improve the design specifications for the operational means and the organisation.

***JHR Reactor***

The integration of operational experience feedback from similar installations has led to design choices such as:

- the creation of a leak recovery zone which can collect leaks at the singular points of the reactor building containment;
- the installation of underwater air lock doors to exclude loss of containment in the event of an accidental drop in the water level of the pools;
- the choice of a main primary system in which the deactivation tank is replaced by a purification/filtration system ensuring the continuous treatment of the primary fluid downstream of the main heat exchangers;
- the overpressurisation of the secondary system in comparison with the main primary system, with monitoring of the secondary system pressure in order to reduce the risk of it becoming contaminated in the event of a primary/secondary leak;
- provisions in the design for the prevention and mitigation of the consequences of hazards (internal fire, projectile emission, extreme climatic conditions, external flooding and earthquake).

Furthermore, for the fourth level of defence in depth, provisions are made as from the design stage to mitigate the consequences of a BORAX-type explosive reactivity accident.

Human and Organisational Factors (HOF) have been integrated from the start of the JHR design project with the establishing of Human Factors Integration Plans (HFIPs) which take into account the HOF requirements as of the definition phase and continue through the development and production phases up to testing.

The lessons learned from HOF feedback have led to the following decisions:

- design work stations integrating an ergonomic approach: activities to perform, available means and equipment;
- set up a work organisation that takes into account the specific role of the operators, in normal, incident and accident operating situations;
- specify from the start of design the role given to humans in the operational control of the installation and the organisation of the operating teams (management of reactor and interfacing with the management of experiments);
- give the operators adequate man-machine interfaces that enable them to get a proper representation of the situation (means for the operator and surveillance);
- separate geographically and as distinctly as possible the interventions of different natures in the reactor building (Reactor Operation Compartment and Experimental Devices Operation Compartment, etc.) and identify the potential interactions between these activities to deduce complementary design and/or operating measures from them.

Emphasis has been placed in particular on the centralisation of information fed back to the JHR control room and the backup control room. The design of the operator consoles in the control room has integrated the data centralisation needs, the selection of data to display and the control systems to assign to the operators based on their functions and activity (organisation of information and method of presentation).

#### *18.3.2.2. Provisions made further to the stress tests*

***EPR reactor***

As part of the stress tests, for the management of Station Blackout (SBO)[25] situations and loss of heat sink for a period exceeding 24h, EDF has defined the following provisions for the EPR reactor:

- the possibility of providing ultimate water make-up for the steam generator feedwater tanks (ASG tanks) and the fuel storage pool by mobile means and the installation of additional connection points at the disposal of the FARN (see Focus 30 in § 16.3.1.2);
- the possibility of extending the autonomy of the ultimate backup diesel-generator sets by a mobile means for feeding fuel by gravity from the main generator set tanks.

Other provisions have been made to increase the EPR robustness:

- extension of the duration of electrical supply for essential functions by deploying additional fixed or mobile electrical power sources;
- means of restarting the I&C dedicated to severe accidents in the event of failure to recover an electrical power source within 12 hours following the initiating event;

[25] The SBO situation corresponds to the combined loss of off-site electrical sources (electricity grid) and "conventional" on-site back-up electrical sources (four main electricity generator sets). In this situation, two ultimate back-up diesel generator sets are available to supply the required equipments.

- addition of a mobile and independent water make-up device (motor-driven pump) in the reactor building.

A new local emergency management centre (CCL), withstanding extreme hazard levels, has been built on the Flamanville site. The CCL will enable the emergency response teams to carry out long-term management of a major crisis such as that encountered during the Fukushima Daiichi NPP accident, particularly where several reactors are affected simultaneously.

***JHR Reactor***

As part of the stress tests, modifications constituting the "hardened safety core" were defined to increase the robustness of the installation. They concern in particular the creation of:

- a building housing the "hardened safety core" electrical power supply and its distribution;
- a cooling and water make-up system for the reactor building pools;
- a water make-up system for the pools of the nuclear auxiliary building.

The structures, systems and components constituting the "hardened safety core" are designed to withstand the extreme hazards.

### 18.3.3. ASN oversight

***EPR reactor***

ASN has particularly examined the design choices. ASN has also requested the opinions of its advisory committees of experts on various themes, such as:

- safety classification,
- accident studies,
- safety systems design,
- fuel storage and handling,
- protection against the effects of internal and external hazards,
- probabilistic safety assessments,
- severe accidents and their radiological consequences.

The adequacy between the means for the reactor operation and the organisation of the operating team has also been examined, allowing a review of the man-machine interface design and the feasibility of the actions for which the operating team is responsible.

A number of specific points relative to the design of certain equipment items (pressuriser valves, recirculation function filtration system) or the safety case (integration of operational experience feedback from the EPRs in service) are still being examined.

In addition to this, ASN has examined the EPR stress tests further to which it has issued a resolution containing specific requirements for the EPR reactor (see § 14).

ASN has also carried out inspections in the engineering departments responsible for the detailed design studies or for monitoring the subcontracted design studies.

ASN considers that the Flamanville EPR reactor, by virtue of its design, presents a significantly improved level of safety compared with the reactors currently in service, in particular through reinforced protection against external hazards and more effective means of mitigating the consequences of accidents with core melt.

### *JHR Reactor*

ASN's examination of the creation authorisation application focused more specifically on the design of the installation's civil engineering, particularly with respect to hazards (fire, combined off-site or on-site hazards), the classification and qualification approach, the reactor containment, the operating situations and severe accidents, notably the BORAX accident, and their radiological consequences.

# Article 19 Operation

**ARTICLE 19 OPERATION**

*Each Contracting Part shall take appropriate steps to ensure that:*

*i) the initial authorisation to operate a nuclear installation is based on an appropriate safety analysis and a commissioning programme demonstrating that the installation, as built, is consistent with design and safety requirements;*

*ii) the operating limits and conditions derived from the safety analysis, tests and operating experience are defined and revised as necessary to delimit the safe operating range;*

*iii) operation, maintenance, inspection and testing of a nuclear installation are conducted in accordance with approved procedures;*

*iv) procedures are established to respond to anticipated operating incidents and to accidents;*

*v) the necessary engineering and technical support in all safety-related fields is available throughout the lifetime of a nuclear installation;*

*VI) incidents significant to safety are notified to the regulatory body in a timely manner by the holder of the corresponding licence;*

*vii) programmes to collect and analyse operating experience data are established, the results obtained and the conclusions drawn are acted upon and that existing mechanisms are used to share important experience with international bodies and with other operating organisations and regulatory bodies;*

*viii) the production of radioactive waste resulting from the operation of a nuclear installation is as low as possible for the process concerned, both in activity and in volume, and that conditioning and disposal are taken into consideration in any necessary treatment and storage operations for spent fuel and waste resulting directly from operation and situated on the same site as the nuclear installation.*

## 19.1. Initial authorisation

### 19.1.1. The regulatory framework

The Environment Code specifies that commissioning corresponds to the first use of radioactive materials in the installation (Article R. 593-29).

The Environment Code details the content of the commissioning authorisation application file submitted to ASN by the licensee (Article R. 593-30):

- the safety analysis report (SAR);
- the general operating rules (GOR)[26];
- the on-site emergency plan (PUI);
- the decommissioning plan;
- the updated installation impact study;
- the updated risk study.

[26] The general operating rules (GOR) cover the operation of the reactors. They are drafted by the licensee and are the operational implementation of the hypotheses and conclusions of the safety assessments constituting the nuclear safety case.

The Environment Code indicates that ASN authorises commissioning of the installation after having verified that it "*complies with the objectives and rules defined by the regulations*" (Article R. 593-33).

The Environment Code indicates that before performing or completing the authorisation procedure, partial commissioning may be authorised by ASN resolution for a limited period in the following cases (Article R. 593- 35):

- for the performance of specific operating tests requiring the introduction of radioactive materials into the installation;
- for the introduction of nuclear fuel into the perimeter of the reactor before the first loading of fuel into this reactor.

### 19.1.2. Measures implemented by the licensees

***Nuclear power reactors***

EDF submitted a commissioning authorisation application for Flamanville 3 in 2015, accompanied by the file specified in § 19.1.1. EDF has updated this file several times since then.

On site, the operating teams are set up well in advance and are trained to develop the personnel skills required for the installation and to disseminate the safety culture.

Startup tests are carried out to verify that all the protection important components function correctly and to declare that the components concerned are available. These tests are carried out in addition to the appropriate inspections and tests carried in the factory or on specific installations. They represent a transition step towards normal operation of the various systems constituting the reactor. They comprise:

- pre-operational tests, which include:
  - the preliminary tests and initial startup tests of the equipment items and functions, which do not involve interaction between the primary system or the auxiliary systems and the secondary systems;
  - the cold and hot functional tests of the primary and secondary systems before loading the fuel;
- "first startup" tests (operational tests): fuel loading, pre-critical tests, tests at different power levels with performance checks.

During the startup test periods, an organisation is put in place to enable the stakeholders to fully exercise their roles and responsibilities:

#### Focus 34 : Preparatory work for the operation of the EPR Flamanville

The operating unit based at Flamanville 3 conducts the operational preparedness work on the EPR reactor for its final commissioning.

The baseline operating requirements specific to each activity (for example: monitoring the installations, maintenance quality control) have been put in place. The same goes for the joint safety baseline requirements necessary for performance of the activities (for example: risk analyses, work reliability-enhancement practices, prevention of the risk of introduction of foreign materials into the systems).

An independent safety organisation is in place. It has an independent focus on the way in which the role of operator is exercised at each management level of the Flamanville 3 "operational" organisation and ensures that nuclear safety predominates in the activities performed, by exercising an independent verification, analysis and advisory support role.

Development of the personnel safety culture is based on three pillars:

- the development of skills;
- self-diagnosis and self-assessment, and the resulting improvement actions (for example: in the light of the WANO questionnaire and image feedback from the IAEA, WANO and the EDF Nuclear Inspectorate) implemented by the personnel and the managers with regard to the requirements for safety and safety management;
- regular communication with the teams and information to them about safety and quality (for example through the weekly safety reports of the FIS (independent safety organisation), messages on safety fundamentals put across at team meetings and operational meetings, weekly presentation of the FIS verifications to the management team).

In October 2020, ASN authorised partial commissioning of the installation to allow interim storage of the fresh fuel assemblies and the primary source clusters in the fuel building. The fresh fuel assemblies necessary for the first reactor fuel loading are currently stored in the fuel building pool. Within the partial commissioning bounds, the installation is already operated in accordance with modalities similar to those applicable for final commissioning, such as the application of adapted GORs, the performance and confrontation of daily safety assessments by the Operations Supervisors and the FIS Safety Engineers. The emergency response organisation of the On-Site Emergency Plan (PUI) common to the three reactors of the Flamanville site is also operational at the local emergency management centre (CCL)).

EDF has taken into account the recommendations and suggestions issued by the IAEA's Pre-OSART mission (2019) and operational experience feedback (OEF) from the other EPR licensees (Olkiluoto and Taishan) and international OEF from the sites in startup phase (IAEA, WANO). These have been integrated in the steps to finalise operational preparedness with a view to final commissioning, that is to say:

- the installations are available, reliable and operable with the expected performance level;
- the skills are ready for operation;
- the data and the operating procedures are ready;
- the target organisations are defined, in place and efficient;
- the EDF national engineering services are ready;
- the baselines of the EDF Nuclear Production Division (DPN - Direction du Parc Nucléaire) are deployed;
- the spare parts are available;
- the industrial partners are under contract;
- the On-site Emergency Resources (MLC – Moyens Locaux de Crise), the special tools and the Specific Systems and Resources (DMP - Dispositifs et Moyens Particuliers) are available;
- the General Operating Rules (GORs) are stabilised, usable and mastered by the licensees;
- the safety culture is firmly rooted in the operating personnel.

The "pre-startup WANO" mission is planned for autumn 2022.

***Research reactors***

The startup tests of the JHR reactor will comprise several phases: the manufacturers' tests, (end-of-assembly verifications, final adjustment equipment/systems, operation of the circuits), followed by the integration tests (operation of several interfacing systems), and lastly the overall tests (before loading the core, after loading the core and after the first divergence at low power and at maximum power).

Three stakeholders are involved in the tests:

- the suppliers, who perform tests for the design of the equipment and systems,
- the JHR project Tests Division, which defines the logic of the tests, draws up the programmes, schedules and coordinates the integration and overall tests,
- the JHR Operations Department, responsible for the operation of the installation, which will more specifically be in charge of training and licensing the operating teams.

### 19.1.3. ASN oversight

***EPR reactor***

Oversight of the Flamanville EPR comprises the inspection of the activities carried out on site and in the factory, and the examination of the installation commissioning authorisation application file.

ASN thus ensures the oversight of the EPR reactor construction. Moreover, ASN conducts inspections on execution activities, which encompass site preparation after the creation authorisation decree, manufacture, construction, qualification, assembly and testing of structures, systems and components, both on the construction site and on the manufacturers' premises, particularly for the manufacture of the NPE (see § 18.2.3). The purpose of these inspections, conducted proportionately to the potential risks, is to:

- verify the quality of execution of the equipment manufacturing activities, of construction of the installation, of radiation protection and environmental protection;
- ascertain that the startup tests programme is satisfactory, that the tests are correctly implemented and that the results comply with requirements;
- ensure that the feedback from the construction and startup tests phase is integrated in continuous improvement process of the licensee's Integrated Management System (IMS);
- ensure that the licensee takes the necessary steps to duly prepare the teams that will be in charge of operating the installation after commissioning.

| Year | Inspections performed | Main themes |
|---|---|---|
| **2016** | 26 | Preparation for and performance of the start-up tests, mechanical assemblies, preparation for operation, nuclear pressure equipment and performance of hydrostatic tests, safety management and human and organisational factors, emergency response organisation and resources. |
| **2017** | 26 | Startup tests, electrical and mechanical assemblies, preparation for operation, notably in the field of radiation protection, preparation for reactor partial commissioning, in-service monitoring of PE and NPE, protection of the environment. |

| Year | Inspections performed | Main themes |
|---|---|---|
| **2018** | 24 | Startup tests, in-service monitoring of PE and NPE, mechanical assemblies, monitoring of radiographic inspections, preparation for operation, control of fire risk, non-destructive tests (NDT) at completion of manufacturing, repair work on main SG feedwater lines |
| **2019** | 21 | Startup tests, analysis of startup test results, defining and implementation of a complementary inspections programme as part of the EPR reactor equipment quality review, preparation for operation, strategy for the preservation, maintenance and testing of equipment and structures, processing deviations, equipment qualification, protection of the environment |
| **2020** | 27 | Startup tests and analysis of their results, preparation and performance of the first weld repairs on the main steamlines, preparation for partial commissioning (arrival of fuel assemblies), development of the reactor protection system software, production and management of the documentation for incident and accident situations, protection of the environment |
| **2021** | 29 | Startup tests and analysis of their results, preparation and performance of the first weld repairs on the main steamlines, operation of the fuel building, protection of the environment, preparation of the licensee |

*Table 19-2: Inspections performed on the Flamanville 3 reactor construction site and in factories since 2016*

ASN is examining the reactor commissioning authorisation application, with the assistance of IRSN. ASN has in particular obtained the opinions of its advisory committees of experts on various themes of the safety analysis report, such as:

- safety classification,
- accident studies,
- safety systems design,
- the safety case for fuel handling and storage,
- protection against the effects of internal and external hazards,
- probabilistic safety assessment,
- severe accidents and their radiological consequences.

The examination aims firstly to check that the conclusions of the previous technical examinations are duly taken into account, secondly to check on the prevention and limitation of the risks and drawbacks created by operation of the installation. This examination takes into account the actual state of the installation, including in particular the known deviations and the results of the startup tests.

A number of specific points relative to the design of certain equipment items (pressuriser valves, recirculation function filtration system) or the safety case (integration of operational experience feedback from the EPRs in service) are still being examined.

In addition to this, ASN has examined the EPR stress tests further to which it has issued a resolution containing specific requirements for the EPR reactor (see § 14).

ASN considers that the Flamanville EPR reactor, by virtue of its design, presents a significantly improved level of safety compared with the reactors currently in service, in particular through reinforced protection against external hazards and more effective means of mitigating the consequences of accidents with core melt.

ASN assesses the regulatory compliance of the NPE most important for safety, referred to as "level N1", which corresponds primarily to the reactor pressure vessel, the SGs, the pressuriser, the reactor coolant pumps, the piping – especially that of the main primary and secondary systems, and the safety valves.

The oversight by ASN and the approved organisations is carried out at the different stages of design and manufacture of the NPE items. It involves an examination of the technical documentation of each equipment item and inspections in the workshops of the manufacturers, as well as at their suppliers and subcontractors.

ASN is also examining the other regulatory documents submitted by EDF with the commissioning authorisation application.

In parallel with this examination, ASN develops an inspection programme relative to performance of the startup tests and preparation of the documentation and the operating teams.

***JHR reactor***

The oversight of the JHR reactor includes inspection of the activities performed on site. ASN's on-site inspections focus mainly on the performance of the construction work and the licensee's monitoring of outside contractors. Furthermore, on the basis of the quarterly project progress report, ASN identifies the activities or particular points to integrate in its inspections.

In addition to this, ASN has examined the JHR reactor stress tests. On completion of this examination, ASN issued a resolution containing specific requirements.

ASN inspects the CEA's new organisation put in place in March 2020 for the JHR project (setting up of an integrated team: project owner / project manager), in particular skills management. ASN also examines that new organisation to maintain its skills in the operation of a research reactor.

## 19.2. Operational limits and conditions

### 19.2.1. The regulatory framework

The Environment Code specifies the content of the files to be submitted for the commissioning authorisation application of a basic nuclear installation (Article R. 593-30). This file contains, among other things, the safety analysis report (SAR) and the general operating rules (GOR).

One section of the GORs indicates the BNI operating conditions and limits; this section is called "operating technical specifications".

In application of the "noteworthy modifications" resolution, ASN is notified of any significant change in the GORs: it is subject to ASN authorisation before being implemented if it has a significant impact on the safety of the installation.

### 19.2.2. Measures taken for nuclear power reactors

The technical operating specifications (STE), which constitute chapter III of the general operating rules of the EDF reactors, define the normal operating conditions based on the design and sizing hypotheses and require the systems necessary to maintain the safety functions, in particular the integrity of the radioactive substance containment barriers and the monitoring of these functions in the event of an incident or accident. They also stipulate the action to take in the event of temporary failure of a required system or if a limit is exceeded, situations which constitute degraded mode operation.

The STEs evolve to integrate the lessons learned from their application and the modifications made to the reactors. The licensee can amend them temporarily on an ad hoc basis, for example to carry out an operation in conditions that differ from those initially considered in the nuclear safety case. In such cases the licensee must demonstrate the relevance of this temporary modification and define adequate compensatory measures to control the associated risks.

The unavailability of any item involved in a required safety function or any crossing of a normal operating limit constitutes an event. For each operating range, the STEs define the action to take following an event: fallback state, fallback (initiation) time or repair time. Fallback state is a reactor state in which the safety functions are ensured over the long term. Transition from the initial operating range to fallback state is made by applying normal operating procedures.

### 19.2.3. Measures taken for research reactors

The operation of research reactors is based on the GORs. These basic documents are supplemented by a set of procedures and instructions managed by the relevant services which ensure that all operations are carried out in compliance with the applicable rules, with which outside contractors must also comply. The licensee must ensure that the contractors comply with these rules.

The experimental devices have their own safety baseline requirements which include the interfaces with the reactor in terms of safety (e.g. reactor shutdown in response to a device alarm).

### 19.2.4. ASN oversight

ASN examines the acceptability of the permanent noteworthy changes to the BNI operating limits and conditions subject to its authorisation. These changes can stem from operational experience feedback or changes made to the safety case. They are sometimes related to physical modifications to the reactors.

ASN is sometimes also required to examine licensee applications for authorisation of temporary modifications to the operating limits and conditions in order to manage any unforeseen event.

During its inspections, ASN checks that the licensee complies with the operating limits and conditions and, if applicable, the compensatory measures associated with the temporary modifications. It also checks the consistency between the modifications made to the facilities and the normal operating documents, such as operational control instructions, the alarm sheets, the operating limits and conditions and the training of the persons responsible for applying them.

## 19.3. Procedures for operation, maintenance, inspection and testing

### 19.3.1. The regulatory framework

The BNI Order (Article 2.5.1) stipulates that measures for analyses, construction, testing, inspection and maintenance must be taken to guarantee the ability of the SSCs to fulfil their assigned functions. These provisions are supplemented for certain equipment items, notably the NPE for which in-service monitoring requirements are defined.

### 19.3.2. Measures taken for nuclear power reactors

The periodic tests of the SSCs are described in chapter IX of the GORs. This chapter indicates the necessary tests to ensure the availability of the equipment items and their ability to fulfil their functions as provided for in the safety case. The test programmes are updated when the facility undergoes changes, particularly during the periodic safety reviews.

EDF has a maintenance policy for the nuclear fleet in operation that is structured to enhance the reliability of the equipment and systems, in order to guarantee throughout the installation's life cycle that they are capable of fulfilling their assigned functions with respect to the loads and ambient conditions that can prevail in the situations for which they are required.

The elementary equipment and systems that must have basic maintenance programmes are identified from the key issues concerning the nuclear fleet (safety, radiation protection, environment, regulation, assets, availability, costs, occupational safety). The basic maintenance programmes specify the nature and frequency of the preventive maintenance activities. They are subject to a continuous improvement process based on operational experience feedback from the SSCs. The preventive maintenance activities are planned on a schedule that takes into account their conditions of performance (reactor in operation or during periodic outage, for example) and their frequency. They are scheduled in compliance with the conditions provided for in the GORs. The maintenance activities that concern the protection important components (PIC) are subject to the following requirements:

- preparation of the maintenance work, including the preparation of a file drafted, checked and approved by qualified personnel,
- performance of the maintenance work using appropriate human and material resources,
- requalification after the maintenance work, which consists in checking operation of the equipment or system to ensure that the required design-basis performance is maintained or restored further to the work,
- putting back into operation after the maintenance work when equipment availability is demonstrated further to requalification,
- detecting and processing deviations: any deviation with respect to a defined requirement is identified, undergoes a formal analysis, curative actions and, if applicable, corrective and preventive actions,
- production of a work report to turn the experience feedback to good account.

### 19.3.3. Measures taken for research reactors

***The HFR reactor of the Laue Langevin Institute (ILL)***

The ILL's IMS defines a documentation structure and clear documentation management rules in relation to the protection of interests. The operational documents (operation, maintenance, periodic inspections and tests) form part of this documentation. They are obligatorily drawn up or verified by the personnel directly concerned by the activities or installations covered by the document. The applicable versions of these documents are accessible to everyone in read mode via dedicated computerised directories.

For each PIC, a maintenance plan is established to ensure the long-term durability of the originally defined and verified equipment requirements and functionalities. The aim of the periodic tests and inspections of the PICs is to verify that they effectively maintain these requirements and functionalities over time. These tests and inspections and their frequency are specified in GOR No. 5. The control process for these tests and inspections is described in a specific process of the IMS.

***The CEA's Cabri reactor***

The PICs are subject to periodic inspections and tests to check they are functioning in compliance with the requirements defined in the safety case and to ensure their availability. The nature and frequency of the inspections and tests are described in the GORs. Satisfactory performance of these inspections and tests, at the planned frequency, makes it possible to state that the items concerned are available and fulfil their required safety function.

Furthermore, some safety important equipment items are subject to preventive maintenance which takes into account both the manufacturer's maintenance specifications and operational experience feedback from these equipment items. The aim of these preventive maintenance campaigns is to reduce risks of failures of these items and maintain them in a fit state to fulfil their function with the required performance levels. This preventive maintenance is carried out periodically in accordance with validated procedures and accompanied by a risk assessment if the intervention could affect safety.

### 19.3.4. ASN oversight

ASN checks that the periodic tests of safety important equipment items do effectively check their proper functioning and level of performance. It carries out this verification when examining the reactor commissioning authorisation application, and when applications for authorisation to modify the GORs are made. During inspections, it also verifies that these periodic tests are carried out in accordance with the test programmes stipulated in the GORs.

Maintenance is also subject to regular checks by ASN during its inspections. In 2021 and 2022, ASN carried out inspections dedicated to maintenance on the majority of the NPPs in order to assess the deployment of the changes in maintenance policy initiated by EDF as from 2016. As part of its oversight function, ASN also conducts an annual examination of operational experience feedback from the reactors which may lead it to ask EDF to make changes to its maintenance programmes.

NPE items undergo regular inspections to check that the licensee carries out the required in-service monitoring operations. Furthermore, the 10-yearly hydrostatic tests of PWR primary and secondary systems required by the regulations are carried out in the presence of ASN, which issues a requalification report before the reactor is put back into service. The relevance of the in-service monitoring programmes is moreover reassessed under the supervision of ASN during the periodic safety reviews in the light of operational experience feedback.

## 19.4. Procedures for responding to operational occurrences and accidents

### 19.4.1. The regulatory framework

The Environment Code specifies the content of the files to be submitted for the commissioning authorisation of a basic nuclear installation (Article R. 593-30). This file contains, among other things, the safety analysis report (SAR) and the general operating rules (GOR). One section of the GORs details the strategies and reactor operating rules for an incident or accident situation.

After commissioning, ASN is informed of the noteworthy modifications to these rules, the most significant of which are subject to ASN authorisation.

### 19.4.2. Measures taken for nuclear power reactors

Parameters representative of the state of reactor operation are monitored continuously by automatic systems and by the operators.

If predefined criteria representative of an incident or accident situation are exceeded, the operators are required to proceed with application of the "safety guidance document" (DOS), either in application of the operating technical specifications (STE), or directly following the actuation of specific alarms in the control room (particularly in the event of triggering of automatic reactor protection systems).

The DOS enables the operators to diagnose the situation and guides them to the relevant incident or accident operating rule, depending on the parameters affected and the current reactor operating range (under power, in shutdown state, primary system closed or open, etc.).

The operating rules in incident and accident situations is based on the "state-based approach" (*Approche Par Etat* or "APE" in French), which leads to the application of strategies developed according to the identified physical state of the nuclear steam supply system (NSSS) irrespective of the events that led to this state. The priority aim of state-based approach is to prevent the risk of core melt.

In the hypothetical event of core melt occurring, the priority would then be to secure the containment. The operational strategy in this case is supported by the Severe Accident Management Guidelines (SAMG) which are designed for the management of new and complex phenomena in severely degraded situations.

The decision to apply the SAMG, which marks the abandonment of the state-based approach procedures, is taken on criteria concerning the core outlet temperature and the dose rate in the reactor containment.

### 19.4.3. Measures taken for research reactors

***For the CEA reactors (Cabri and JHR)***

The analysis of the alarms and operating parameters measured on these installations and transmitted to the control room can lead the operators to apply incident or accident operating procedures. These procedures describe the operational control applicable in such situations, the objectives being to bring the reactor to and maintain it in a safe condition and to mitigate the consequences of the incident or accident.

The operating rules applicable in incident and accident situations are described in the general operating rules (GOR).

The operation of incident and accident situations is carried out from the control room unless the accident situation has made it unavailable (fire, for example). In this case, accident management is transferred to a rack situated in a backup room. These backup control racks are used in the emergency exercises.

The management of severe accidents, particularly further to loss of core cooling, calls upon specific procedures.

***For the HFR high flux reactor (ILL),*** the GORs define the general actions to carry out in the event of an incident or accident.

The particular instruction "Organisation in PUI activation situation" describes the action to take out of normal operating situations, and the conditions for switching to accident mode organization. This document allows the transition from normal or incident operation to an emergency situation defined in the PUI. The criteria for triggering the PUI are indicated in it, as are the particular instructions that must be applied according to the situation.

### 19.4.4. ASN oversight

#### *19.4.4.1. Nuclear power reactors*

ASN examines the incident or accident operating rules as part of its examination of the reactor's commissioning or if they have undergone modifications that are subject to ASN authorisation. ASN regularly checks the processes to produce and validate the incident or accident operating rules and instructions, their relevance and how they are implemented.

To do this, ASN can run a situational exercise for the installation's operating teams to check the methods of applying the above-mentioned rules and managing the specific equipment used in accident operating situations (see Focus 11 in § 7.4).

#### *19.4.4.2. Research reactors*

Through its inspections and during exercises, ASN checks the operating teams' management of the incident and accident situation procedures.

When any modification is made to the installation, ASN also checks that the licensee has assessed the impact of the modification on the operating procedures.

## 19.5. Engineering and technical support

### 19.5.1. The regulatory framework

The Environment Code and the BNI Order contain several provisions concerning engineering and technical support, in particular:

- to obtain the creation authorisation for a BNI, the licensee must "*have the technical capabilities enabling it to conduct its project in compliance with the [protected] interests* » (Environment Code, Article L. 593-7);
- to ensure the control of the activities under its responsibility when BNI creation is authorised, the licensee must:
  - "*have, either in-house or through its subsidiaries, the technical skills guaranteeing the understanding and embracing of the abovementioned activities*" (BNI Order, Article 2.1.1);
  - "*have sufficient in-house technical capabilities to take any decision and implement any protective measures that prove necessary (for example in the event of a deviation or accident)*" (BNI Order, Article 2.1.1);
  - limit, as much as possible, the number of subcontracting levels; the performance of services or work important for the protection of interests cannot be entrusted by a service provider of the operator to subcontractors beyond second-tier level (Article R. 593-13 of the Environment Code).

Furthermore, "*the licensee cannot entrust the operational responsibility and control of operation of a [BNI] to an outside contractor* (Article R. 593-13 of the Environment Code).

### 19.5.2. Measures taken for nuclear power reactors

EDF has its own national engineering centres with appropriate design, construction and operating skills to support the NPPs.

Maintaining design integrity throughout the life of a nuclear reactor is the subject of INSAG 19. Thus, to guarantee the design integrity, EDF has put in place the "Design Authority" and "Responsible Designers". This is because after the initial design, numerous changes take place during the life of the installation, due to operational experience feedback, changes in safety requirements, economic reasons (e.g. extension of the operating cycles), ageing, etc. The understanding of the design as a whole, the interaction between the systems and with the operating rules must be maintained over the long term in order to preserve safety when changes are made.

The subcontracted operations, maintenance in particular, are subject to contracts and monitoring, as required by the regulations. EDF puts in place the necessary provisions to control the risks associated with the subcontracted activities and updates them regularly. The preparation of reactor outages has thus been reinforced, more particularly to guarantee the availability of human and material resources.

### 19.5.3. Measures taken for research reactors

At each CEA centre, technical support units bring together skills in the different fields involved in operating the facilities. The technical support for the CEA's facilities is provided in particular by the DSSN and services which intervene in their areas of competence. These services provide the facilities with the assistance of specialists in diverse technical areas such as seismic risks, paraseismic engineering, fire, criticality, chemical risks, pressure equipment, structural mechanics, thermomechanics, instrumentation and I&C, containment-ventilation, measurements, impact assessments (environmental and adverse effects) and the HOFs. These technical support units establish contracts with the outside contractors called upon by the facilities for maintenance of the equipment items. These technical support units are different from the nuclear safety support units.

The ILL has several project engineers capable of managing projects from start to finish and a design office for installation design. Furthermore, the ILL staff includes specialists in mechanical design, neutronics, criticality, electrotechnology, electronics, instrumentation and I&C. These specialists assist the project teams and safety engineers either directly or through the monitoring of service providers.

### 19.5.4. ASN oversight

ASN carries out inspections in the head office departments of the nuclear reactor licensees, the workshops or design offices of the subcontractors, the construction sites, and the plants or workshops manufacturing safety important components.

ASN checks the conditions surrounding the preparation (schedule, required resources, etc.) and performance of the subcontracted activities (relations with the licensee, monitoring by the licensee, etc.). It also checks that the workers have the necessary means (tools, operating documentation, etc.) to perform their tasks, in particular when these means are made available by the licensee.

## 19.6. Reporting of incidents significant to safety

### 19.6.1. The regulatory framework

The Environment Code requires basic nuclear installation licensees to notify ASN without delay of any accidents or incidents that occur due to operation of that installation which could significantly prejudice the protected interests (Article L. 591-5).

The BNI Order (Article 2.6.4) details the information to be provided in the notification: characterisation of the event, description and chronology of the event, actual and potential consequences, measures already taken or envisaged to address the event provisionally or definitively.

The BNI Order (Article 2.6.5) requires the notification to be supplemented within two months by a report indicating the conclusions the licensee has drawn from the analysis of the event and the measures it is taking to improve safety or radiation protection and to prevent recurrence of the event.

ASN has published guides which describe the principles and criteria for reporting significant events.

### 19.6.2. Measures taken for nuclear reactors

Detection of events (deviations, anomalies, incidents, etc.) by the licensee and the implementation of corrective measures decided on after analysis play a fundamental role in accident prevention.

Prioritising the anomalies should enable the most important ones to be addressed first. The regulations have defined a category of anomalies called "significant events".

The criteria for reporting significant events to the public authorities take account of:

- the actual or potential consequences of these events on the workers, the general public, patients or the environment;
- the main technical, human or organisational causes of these events.

This reporting process is part of an approach to continuously improve safety and radiation protection. It enables other licensees to benefit from the lessons learned from the event.

The number of significant events (excluding generic events) reported by EDF from 2016 to 2021 and rated on the INES scale (excluding those rated level 0) is shown in Table 19.3. The examination of the breakdown of the number of ESS's (including ESS's not rated on the INES scale) by reporting criterion shows that slightly over half of them stem from failure to comply with the operating technical specifications (STEs) (52% of events reported under criterion 3, noncompliance with STEs).

| INES level | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|
| **1** | 57 | 65 | 74 | 83 | 83 | 78 |
| **2** | 0 | 4 | 0 | 2 | 0 | 0 |

*Table 19-3: Evolution of the number of significant events rated on the INES scale in the EDF nuclear power plants between 2016 and 2021 (excluding generic events)*

Furthermore, several similar events or events resulting from common causes have affected several nuclear reactors. They are grouped under the term generic safety significant events (see Table 19.4).

| INES level | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|
| **1** | 2 | 2 | 5 | 3 | 8 | 1 |
| **2** | 0 | 2 | 0 | 2 | 0 | 0 |

*Table 19-4: Evolution of the number of generic safety significant events rated on the INES scale in the EDF nuclear power plants between 2016 and 2021*

Just one significant event occurred on the CEA reactors over the 2016-2021 period: an ESS rated level 1 on the INES scale was reported on 1 October 2018 on the EOLE-MINERVE reactor. It concerned the shipping of a radioactive material transport package presenting, with respect to its model, two deviations which were only detected after transportation.

Two level-1 events occurred on the ILL's HFR reactor over the 2016-2021 period:

- in May 2017, temporary blockage of a fuel element when lowering it under water from its handling cask,
- in March 2019, the raising of a gate in the spent fuel element storage channel using a sling of insufficient capacity.

### 19.6.3. ASN oversight

ASN examines all the reported significant events.

ASN analyses the initial notification to check the implementation of immediate corrective measures, to decide whether to conduct an on-site inspection to analyse the event in depth, and to prepare for informing the public if necessary.

ASN analyses the report submitted by the license and checks that the licensee has analysed the event pertinently, has taken appropriate steps to remedy the situation and prevent it from recurring, and has circulated the conclusions of the event analysis. The events having the greatest potential implications are subject to an in-depth analysis to check that the licensee has effectively identified all the root causes of the event and that all appropriate measures have been taken to prevent its recurrence and, if necessary, ASN requests further actions. If this analysis reveals information that warrants international dissemination, it is subsequently published in the IAEA and NEA's database. Furthermore, to guarantee rapid dissemination of the information, ASN endeavours to inform its foreign counterparts as quickly as possible when a significant event occurs in France by using the international organisations and the bilateral or multilateral agreements and conventions to which it is party.

Lastly, during its inspections ASN examines compliance with the rules regarding the detection and reporting of significant events. ASN checks the licensees' organisation for analysing events, the methodology employed and the depth of the analyses carried out to ensure that the underlying causes (organisational and human) of events are looked for and, lastly, the development and implementation of the follow-ups to the analyses, whether in the short, medium or long term.

ASN also conducts an annual review of the observable event trends in order to identify weak signals or subjects to examine in greater depth.

## 19.7. Operational experience feedback

### 19.7.1. The regulatory framework

The BNI order (Articles 2.4.1 and 2.7) requires the licensee to implement an integrated management system that includes provisions enabling it to identify and process the significant events, and to gather and use the experience feedback from the operation of its facility or other facilities, whether similar or not, in France or abroad, or resulting from research and development.

### 19.7.2. Measures taken for nuclear power reactors

The continuous improvement in performance in the areas of safety, security, radiation protection, environmental protection and production is based on a systematic process of turning acquired experience to good account. The use of OEF consists in drawing the lessons from the past to improve the future. EDF's operating experience today represents more than 2,000 reactor-years.

The EDF events-related OEF process is organised around the following phases:

- the events collection, selection, weighing-up and codification phase,
- the analysis phase, including the definition of curative, corrective and preventive actions when necessary. For the most significant events, EDF uses a method of in-depth events analysis drawn from international standards,
- the phase of implementation of the defined corrective or preventive actions, integrating the oversight of implementation and verification of their effectiveness,
- the phase of sharing OEF with the work teams.

This system is in place in all the EDF NPPs and nationally. This system is subject to annual efficiency assessment reviews.

The perimeter of the EDF OEF loop includes, in addition to the events resulting from the operation of its own reactors, the analysis of events recorded in the IAEA and WANO databases, a selection of the events having occurred on reactors of foreign licensees with which EDF has cooperation agreements (EPRI, ESKOM, CGNPC, EDF Energy in particular) and an annual review of the events occurring in other industries (ARIA database of the Ministry of Ecological Transition).

Lastly, through its participation in various committees and international organisations, EDF shares OEF on good practices and internationals standards, and in the area of nuclear R&D.

EDF takes into account the recommendations and suggestions resulting from the Peer Review missions of WANO (four EDF sites per year), OSART (one site per year) and the "follow-up" missions.

### Focus 35 : Share of information on the OEF from Taishan 1 operation

EDF takes into account the OEF from Taishan 1 to improve the safety of operation of its future EPR installation.

In particular, licencees and regulators of both countries shared information following the increase in water activity in the primary circuit of the Taishan 1 reactor during its second operating cycle, which led to its early shutdown.

Investigations carried out on the discharged fuel revealed damage to fuel assemblies.

ASN has asked EDF to draw on the experience of this event before the start-up of the Flamanville EPR reactor. Cooperation has been set up between French manufacturer and operator and the Chinese licencee to share their analyses. NNSA and ASN have also held regular exchanges on this event.

In June 2022, EDF submitted a file describing the conclusions of its analysis and the measures it plans to take on the Flamanville EPR reactor. In particular, EDF plans to reinforce the structure of the assemblies to prevent damage to the fuel. ASN will take a position on EDF's proposals as part of the examination of the reactor's commissioning, scheduled for 2023.

### 19.7.3. Measures taken for research reactors

The collection and analysis of operational experience at the CEA takes place at three levels:

- at installation level, the installation manager is responsible for analysing any anomalies and events that occur;
- at the centres level, where taking OEF into account consists more specifically in organising and promoting exchanges between the facilities and between the centres. On this account, an OEF leader is appointed in the safety unit that performs the checks on behalf of the director of each centre;
- at the CEA's general management level, it is the role of the DSSN to make sure that the various units consult one another, and to ensure the integration of OEF and the exchange of best practices. The DSSN also draws up an assessment of the significant events and defines the lines of progress. The OEF is also integrated in the documents (circulars and recommendations, directives, technical data sheets) that the DSSN is responsible for producing.

At the ILL, the OEF process is described in the IMS. The process coordinator collects the information from the ILL's activities based in particular on the analyses of anomalies, the operating reports and the audit results. At least once a year the process coordinator also selects the relevant information concerning other French and foreign nuclear installations, through the ASN and IRSN websites in particular.

After analysing this information, a report is drawn up and shared with the personnel concerned depending on the nature and importance of the OEF, either by circulation of the report or via a presentation and discussion meeting. These reports are accessible to everyone on the documentation data base of the IMS.

### 19.7.4. ASN oversight

During its inspections in the nuclear reactors and the EDF head office departments, ASN checks the licensee's organisation and the steps taken to learn the technical and organisational lessons from operational experience feedback.

ASN regularly examines the OEF from the reactors and OEF concerning fuel behaviour. The conclusions of the expert assessments carried out in this context are submitted to the Advisory Committee for Nuclear Reactors to obtain its opinion.

ASN also endeavours to disseminate experience feedback from French nuclear installations during bilateral or multilateral discussions with its counterparts within other safety organisations. ASN and IRSN also participate in various discussion forums within the IAEA, the NEA and the European Union. For example, ASN is a member of NEA working groups: the *Working Group on Operating Experience* (WGOE) addressing reactors in operation, and the *Working Group on the Regulation of New Reactors* (WGRNR) which focuses more specifically on experience feedback from the construction of new reactors.

## 19.8. Management of spent fuel and radioactive waste on the site

### 19.8.1. The regulatory framework

European Directive 2011/70/Euratom of 19 July 2011 establishes a community framework for the responsible and safe management of spent fuel and radioactive waste. It applies to the management of spent fuel and the management of radioactive waste, from production to disposal. Like the directive of 25 June 2009, it calls for each Member State to set up a coherent and appropriate national framework and sets various requirements for the States, the regulators and the licensees. The content of this directive has been transposed in France, more specifically through the Environment Code and its provisions relative to waste and the waste act. The policy regarding nuclear waste is detailed in the Joint Convention report.

The Environment Code stipulates that a national radioactive materials and waste management plan provides an overview of the existing methods of radioactive waste management and the technical solutions adopted, lists the foreseeable needs for storage or disposal facilities and specifies their required capacities and the storage durations (Article L. 542-1-2). The national plan and the decree establishing the requirements pursue the objective of reducing the quantity and harmfulness of radioactive waste, in particular by reprocessing spent fuels and treating and packaging the radioactive waste. The licensees are responsible for the high-level and intermediate-level long-lived waste resulting from spent fuel reprocessing in the Orano Cycle La Hague plant (Article . 542-1 of the Environment Code).

The BNI Order defines the requirements relating to waste management, and in particular:

- the licensee shall define, as from the design stage, measures to prevent and reduce, particularly at source, the production and the harmfulness of the waste produced in its installation (Article 6.1);
- the establishing of a waste zoning plan delimiting the areas of potential nuclear waste production within the BNI. In this context, the licensee defines the characteristics of the waste storage areas according to the type of waste (Article 6.3);
- the requirements associated with packaging of the packages. Producers of radioactive waste are asked to package their waste taking into consideration the requirements associated with their subsequent management, and more particularly their acceptance at the disposal facilities (Article 6.7).

The ASN "packaging" resolution specifies the requirements regarding waste packaging for disposal and the conditions of acceptance of waste packages in the disposal facilities.

### 19.8.2. Measures taken for nuclear power reactors

***Spent fuel management***

EDF uses two types of nuclear fuel in the pressurised water reactors:

- uranium oxide (UO2) based fuels enriched to a maximum of 4.5% of uranium-235,
- fuels consisting of a mixture of depleted uranium oxide and plutonium oxide (MOX).

After a period of about three to five years, the spent fuel is removed from the reactor to cool down in a spent fuel storage pool, first on the NPP site, then in the Orano reprocessing plant at La Hague.

***Radioactive waste management***

The arrangements of managing the waste resulting directly from operation of the reactors include: "waste zoning", collection, sorting, characterisation, treatment/packaging, storage and shipping.

Collection is a sensitive waste management phase in the nuclear facilities. The waste is collected selectively, either directly by the process or by personnel on the sites (sorting at source).

The radioactive waste resulting from the operation of PWRs is essentially very low, low or intermediate level short-lived waste.

The intermediate level waste is conditioned in concrete containers. This waste is sent to the Aube repository (CSA) for disposal.

The solid low-level waste is:

- either compacted on site in 200-litre metal drums and sent directly to the CSA repository to be further compacted and disposed of definitively after concreting in 450-litre drums;
- or compacted in 200-litre plastic drums and sent to the CENTRACO plant of Cyclife France for incineration. The residual ash and clinkers from incineration are conditioned in 400-litre thick metal drums and definitively disposed of at the CSA repository;

The very low level waste, which essentially comprises metal waste and rubble, is shipped to Cires (Industrial centre for grouping, storage and disposal), a dedicated repository situated in Morvilliers, also managed by Andra and which entered service in 2003.

### 19.8.3. Measures taken for research reactors

***Waste management***

The majority of the waste produced by the operation of the research reactors (CEA and ILL) is routed to the disposal facilities managed by ANDRA.

***Spent fuel management***

The spent fuel from the research reactors is transferred to the La Hague plant. The last spent fuel elements from the Osiris and Isis reactors, and the last four spent cores of the Orphée reactor were transferred to La Hague in 2021.

### 19.8.4. ASN oversight

With regard to radioactive waste management, ASN's oversight aims at verifying on the one hand correct application of the waste management regulations on the production sites (for example with respect to waste zoning, packaging or the controls performed by the licensee), and on the other hand the safety of the facilities dedicated to radioactive waste management (waste treatment, packaging, storage and disposal facilities).

During its inspections, ASN examines the organisation and measures taken by the sites in terms of waste management, from sorting through to packaging, and spent fuel management. It also check the operation of the waste storage and treatment areas.

# APPENDIX A – List and location of nuclear reactors in France

## A.1 Location of the nuclear reactors

The 56 nuclear power reactors in operation as at 05-08-2022 are distributed over French territory as shown in the following map. In addition, two research reactors are in operation: the HFR of ILL in Grenoble (East) and the Cabri reactor of CEA/Cadarache (South).

Besides, one nuclear power reactor (EPR) is under construction in Flamanville, and one research reactor is under construction (JHR) in the South of France at CEA/Cadarache.

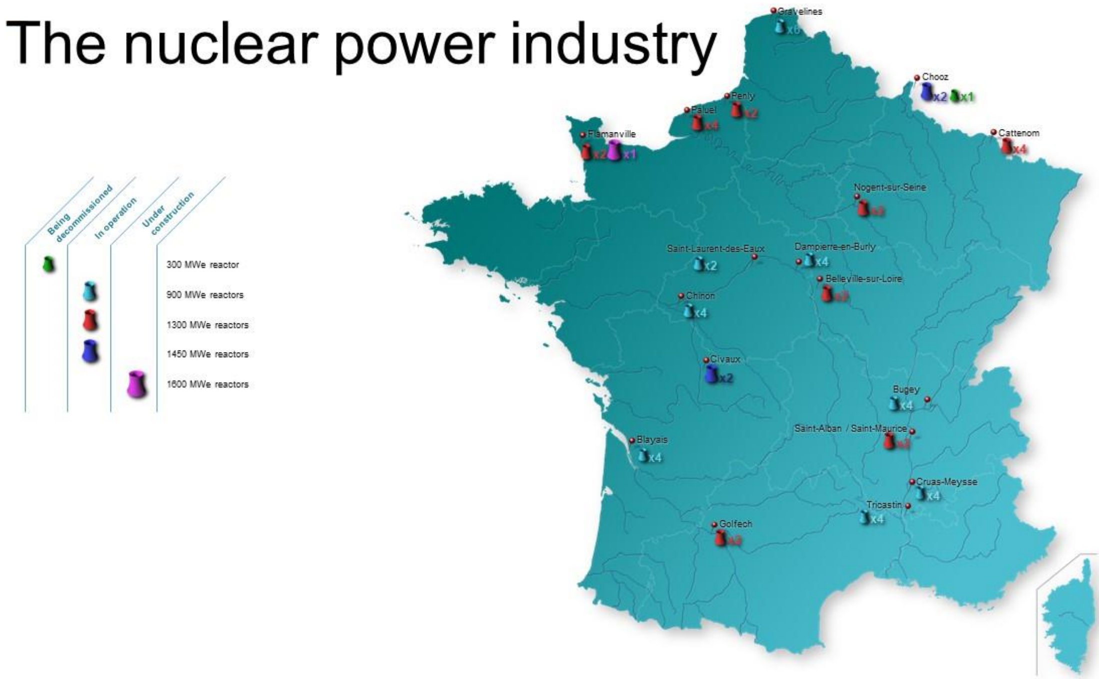



*Figure A-1: Map of France showing the 18 sites of the nuclear power reactors in operation*

## A.2 List of nuclear power reactors

| NAME AND LOCATION OF THE FACILITY | Type of facility |
|---|---|
| BUGEY NPP (reactors 2, 3, 4 and 5)<br>01980 Loyettes | 2 PWR reactors CP0 900 MWe<br>2 PWR reactors CP1 900 MWe |
| DAMPIERRE-EN-BURLY NPP (reactors 1,2,3 and 4)<br>45570 Ouzouer-sur-Loire | 4 PWR reactors CP1 900 MWe |
| LE BLAYAIS NPP (reactors 1,2,3 and 4)<br>33820 Saint-Ciers-sur-Gironde | 4 PWR reactors CP1 900 MWe |
| TRICASTIN NPP (reactors 1,2,3 and 4)<br>26130 Saint-Paul-Trois-Châteaux | 4 PWR reactors CP1 900 MWe |
| GRAVELINES NPP (reactors 1,2,3,4,5 and 6)<br>59820 Gravelines | 6 PWR reactors CP1 900 MWe |
| ST-LAURENT-DES-EAUX NPP (reactors B1 and B2)<br>41220 La Ferté-St-Cyr | 2 PWR reactors CP2 900 MWe |
| PALUEL NPP (reactors 1,2,3 and 4)<br>76450 Cany-Barville | 4 PWR reactors P4 1300 MWe |
| CHINON NPP (reactors B1, B2, B3 and B4)<br>37420 Avoine | 4 PWR reactors CP2 900 MWe |
| FLAMANVILLE NPP (reactors 1,2 and 3)<br>50830 Flamanville | 2 PWR reactors P4 1300 MWe<br>1 PWR reactor EPR 1600 MWe |
| CRUAS NPP (reactors 1,2,3 and 4)<br>07350 Cruas | 4 PWR reactors CP2 900 MWe |
| SAINT-ALBAN NPP (reactors 1 and 2)<br>38550 Le Péage-de-Roussillon | 2 PWR reactors P4 1300 MWe |
| CATTENOM NPP (reactors 1,2,3 and 4)<br>57570 Cattenom | 4 PWR reactors P'4 1300 MWe |
| BELLEVILLE-SUR-LOIRE NPP (reactors 1 and 2)<br>18240 Léré | 2 PWR reactors P'4 1300 MWe |
| NOGENT-SUR-SEINE NPP (reactors 1 and 2)<br>10400 Nogent-sur-Seine | 2 PWR reactors P'4 1300 MWe |
| GOLFECH NPP (reactors 1 and 2)<br>82400 Golfech | 2 PWR reactors P'4 1300 MWe |
| PENLY NPP (reactors 1 and 2)<br>76370 Neuville-lès-Dieppe | 2 PWR reactors P'4 1300 MWe |
| CHOOZ B NPP (reactors 1 and 2)<br>08600 Givet | 2 PWR reactors N4 1450 MWe |
| CIVAUX NPP (reactors 1 and 2)<br>BP 1 86320 Civaux | 2 PWR reactors N4 1450 MWe |

*Table A-1: Nuclear power reactors in operation and under construction as at 05-08-2022 (licensee EDF)*

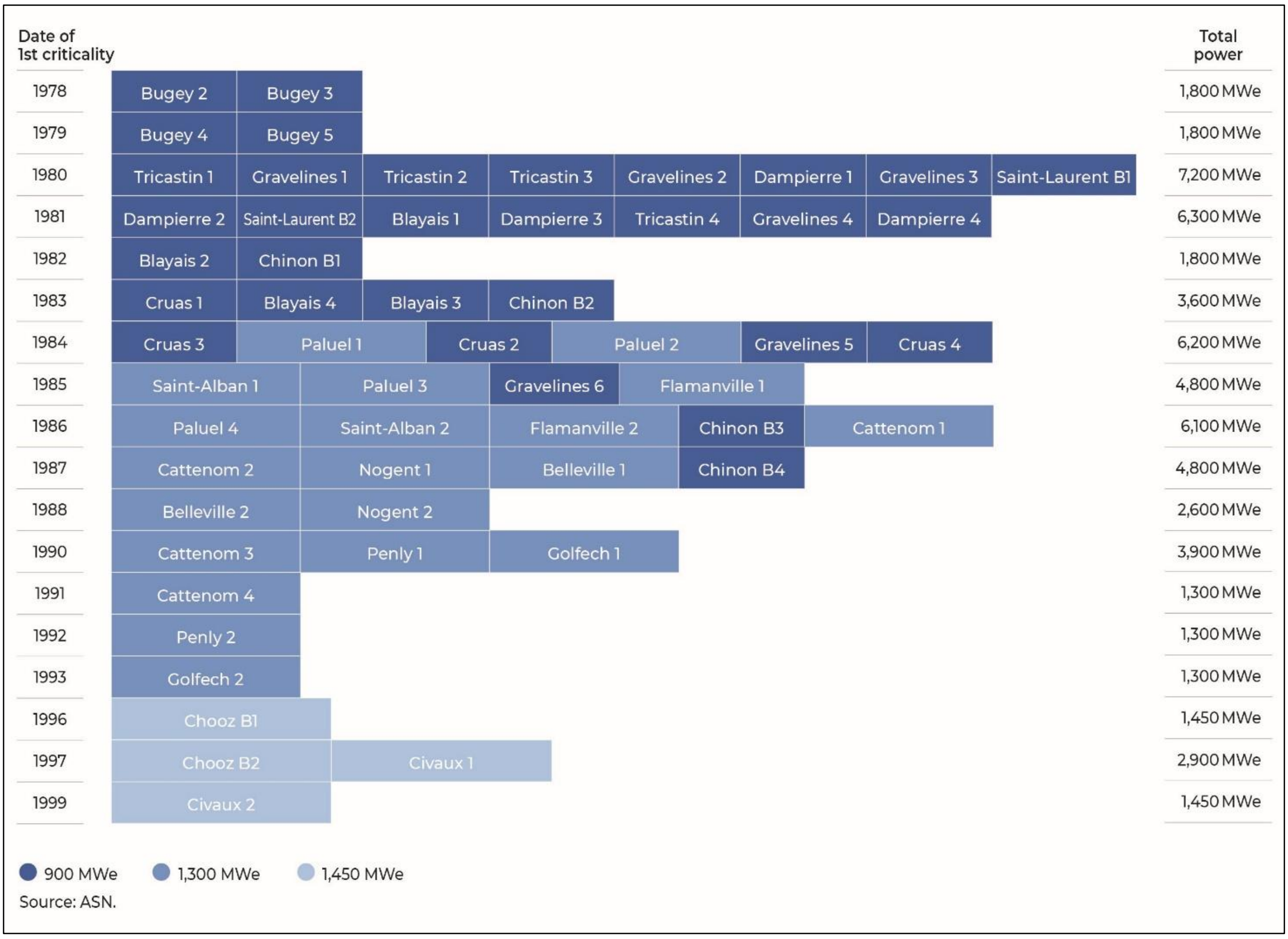



*Figure A-2 : Chronology of the first criticality of French nuclear power reactors in operation*

## A.3 Research reactors in operation and under construction

| NAME AND LOCATION OF THE FACILITY | Licensee | Type of facility and thermal power |
|---|---|---|
| Cabri (Cadarache)<br>13115 Saint-Paul-lez-Durance | CEA | Research reactor<br>25 MW-th |
| High Flux Reactor (HFR)<br>38041 Grenoble Cedex | Institut Max von Laue Paul Langevin (ILL) | Research reactor<br>57 MW-th |
| JULES HOROWITZ (JHR) (Cadarache)<br>13115 Saint-Paul-lez Durance Cedex | CEA | Research reactor<br>100 MW-th |

*Table A-2: Research reactors[27] in operation and under construction*

[27] Research reactors that are permanently shut down, being dismantled or decommissioned - outside the scope of the Convention - are not included in this list.

## A.4 List of nuclear reactors permanently shut down since August 2016

| NAME AND LOCATION OF THE FACILITY | Licensee | Type of facility (date of permanent shut down) |
|---|---|---|
| ORPHEE (Saclay)<br>91191 Gif-sur-Yvette Cedex | CEA | Research reactor<br>(November 2019) |
| ISIS (Saclay)<br>91191 Gif-sur-Yvette Cedex | CEA | Research reactor<br>(March 2019) |
| MASURCA (Cadarache)<br>13115 Saint-Paul-lez-Durance | CEA | Research reactor<br>(December 2018) |
| EOLE (Cadarache)<br>13115 Saint-Paul-lez-Durance | CEA | Research reactor<br>(December 2017) |
| MINERVE (Cadarache)<br>13115 Saint-Paul-lez-Durance | CEA | Research reactor<br>(December 2017) |
| Fessenheim NPP | EDF | 2 PWR 900 MWe reactors<br>(February and June 2020) |

# APPENDIX B – Main legislative and regulatory texts as at end of 2021

## B.1 Codes, acts and regulations

- Environment Code:
    - Book I – Part II – Chapter V (Articles L. 125-10 to L.125-40); Provisions specific to nuclear activities;
    - Book V – Part IV – Chapter II (Articles L. 542-1 to L.542-14); Provisions specific to the sustainable management of radioactive materials and waste.
    - Book V – Part IX (Articles L. 591-1 to L.59-7-46). Nuclear security and basic nuclear installations.
- Public Health Code: Articles L 1333-1 et seq. and R.1333-1 et seq., relative to the general protection of individuals against the hazards of ionising radiation.
- Labour Code: Articles 4451-1 et seq. and R.4451-1 et seq., relative to the protection of workers against the hazards of ionising radiation.
- Planning Act 2006-739 of 28 June 2006 relative to the Sustainable Management of Radioactive Materials and Waste (Articles 3 and 4).
- Act No. 2015-992 of 17 August 2015 relative to Energy Transition for Green Growth (LTECV).
- Act No. 2017-55 of 20 January 2017 on the general status of independent administrative authorities and independent public authorities.
- Decree No. 2005-1158 of 13 September 2005 relative off-site emergency plans concerning certain fixed structures or installations and taken in application of article 15 of the law No. 2004-811 of 13 August 2004 relative to the modernization of civil security.
- Decree 2018-437 of 4 June 2018 relative to the protection of workers against the hazards of ionising radiation (articles 7 to 11: transitional provisions).
- Decree 2019-190 of 14 March 2019 codifying the provisions applicable to basic nuclear installations, the transport of radioactive substances and transparency in the nuclear field (articles 4, 8 to 11 : transitional provisions).
- Order of 1 September 2003 defining the methods for calculating effective doses and equivalent doses resulting from the exposure of individuals to ionising radiation.
- Order of 5 January 2006 on public consultation on the draft off-site emergency plan for certain installations, pursuant to Article R. 741-26 of the Domestic Security Code.
- Order of 7 February 2012 setting the general rules concerning basic nuclear installations.
- Order of 10 November 1999 relative to the monitoring of operation of the main primary system and the main secondary systems of nuclear pressurized water reactors.
- Order of 30 December 2015 relative to nuclear pressure equipment.
- Order of 20 November 2017 relative to the in-service monitoring of pressure equipment and simple pressure vessels.
- Ordinance No. 2016-128 of 10 February 2016 on the transposition, for the legislative part, of the Directive of 8 July 2014.
- Ordinance No. 2016-1060 of 3 August, 2016 modifying the rules applicable to environmental assessment.
- Ordinance No. 2016-128 of 10 February 2016 extending the range of oversight exercised by the ASN to suppliers, service providers or subcontractors of licensees, including for activities carried out outside BNIs.

## B.2 ASN resolutions

Resolution 2010-DC-0179 of 13 April 2010. Hearings of licensees and CLIs before adoption of opinions or resolutions.

Resolution 2013-DC-0360 of 16 July 2013. Control of detrimental effects and impact on the environment.

Resolution 2014-DC-0417 of 28 January 2014. Control of fire risks.

Resolution 2014-DC-0444 of 15 July 2014. PWR shutdowns and restarts.

Resolution 2014-DC-0462 of 7 October 2014. Control of the criticality risk in BNIs.

Resolution 2015-DC-0508 of 21 April 2015. Study of waste management and the inventory of waste produced in the BNIs.

Resolution 2015-DC-0532 of 17 November 2015. BNIs safety report.

Resolution 2016-DC-0578 of 6 December 2016. Prevention of risks resulting from the dispersal of pathogenic micro-organisms (legionella and amoeba) by PWR secondary system cooling installations.

Resolution 2017-DC-0587 of 23 March 2017. Conditioning of radioactive waste and the conditions of acceptance of the radioactive waste packages in the disposal basic nuclear installations.

Resolution 2017-DC-0588 of 6 April 2017. Conditions for water intake and consumption, discharge of effluents and monitoring of the environment around PWR reactors.

Resolution 2017-DC-0592 of 13 June 2017. Obligations on BNI licensees in terms of preparedness for and management of emergency situations and the content of the on-site emergency plan.

Resolution 2017-DC-0616 of 30 November 2017. Noteworthy modifications to basic nuclear installations.

Resolution 2020-DC-0688 of 24 March 2020. Qualification of organisations tasked with the inspection of nuclear pressure equipment.

## B.3 Basic safety rules and guides

### B.3.1 Rules relative to PWRs

| | |
|---|---|
| **RFS 2002-1** | Basic safety rule 2002-1 concerning the development and utilisation of probabilistic safety assessments for pressurised water nuclear reactors. |
| **RFS-I.2.a.** | Integration of risks related to airplane crashes. |
| **RFS-I.2.b.** | Integration of risks of projectile release following fragmentation of the turbine generator sets. |
| **RFS-I.2.d.** | Integration of risks related to the industrial environment and communication routes. |
| **RFS-I.3.a.** | Use of the single failure criterion in safety analyses. |
| **RFS-I.3.b.** | Seismic instrumentation. |
| **RFS-I.3.c.** | Geological and geotechnical site studies; determination of soil characteristics and study of soil behaviour. |
| **RFS-II.2.2.a.** | Design of containment spray system; revision 1. |
| **RFS-II.3.8.** | Construction and operation of the main secondary system. |
| **RFS-II.4.1.a** | Software for safety-classified electrical systems. |
| **RFS-IV.I.a.** | Classification of mechanical equipment, electrical systems, structures and civil engineering works. |
| **RFS-IV.2.a.** | Requirements to be considered in the design of safety-classified mechanical equipment carrying or containing a fluid under pressure and classified level 2 and 3. |
| **RFS-IV.2.b.** | Requirements to be considered in the design, qualification, implementation and operation of electrical equipment included in safety-classified electrical systems. |
| **RFS-V.I.a.** | Determination of the activity released outside the fuel to be considered in accident safety studies. |
| **RFS-V.I.b.** | Meteorological measurement means. |
| **RFS-V.2.b.** | General rules applicable to civil engineering works. |
| **RFS-V.2.c.** | General rules applicable to the production of mechanical equipment. |
| **RFS-V.2.d.** | General rules applicable to the production of electrical equipment. |
| **RFS-V.2.e.** | General rules applicable to the production of fuel assemblies. |
| **RFS-V.2.g.** | Seismic calculations for civil engineering works. |
| **RFS-V.2.h.** | General rules applicable to the construction of civil engineering works. |
| **RFS-V.2.j.** | General rules relative to fire protection. |

### B.3.2 Other Basic safety rules

| | |
|---|---|
| **RFS 2001-01** | Determination of seismic risk for the safety of the facilities (Revision of RFS-I.2.c and RFS-I.1.c – 16 May 2001). |
| **RULE SIN C-12308/86 (RR1)** | Cleaning systems equipping nuclear research reactor ventilation systems (4 August 1986). |
| **RULE SIN A-4212/83** | Relative to meteorological measurement means (12 August 1983). |
| **RULE SIN C-12670/9-1 (RR2)** | Protection against the fire risk in nuclear research reactors (1 July 1991). |

### B.3.3 Guides relative to BNIs

**The ASN guides (in force as at June 2022) concerning the subject of the report**

| | |
|---|---|
| Guide to the declaration procedure of significant events related to basic nuclear installations. | |
| ASN guide 2/01 of 26 May 2006 on the inclusion of the seismic risk when designing civil works for basic nuclear installations other than radioactive waste long-term disposal facilities. | |
| General orientation safety guide for the siting of a low-level, long-lived waste disposal facility. | |
| No. 3 | Recommendations for writing annual public information reports concerning basic nuclear installations. |
| No. 6 | Final Shutdown, Decommissioning and Delicensing of Basic Nuclear Installations in France. |
| No. 8 | Conformity assessment of nuclear pressure equipment. |
| No. 10 | Local involvement of CLIs in the 3rd ten-yearly outage inspections of the 900 MWe reactors. |
| No. 12 | Notification and codification of criteria related to significant safety, radiation protection or environmental events applicable to BNIs and to radioactive material transport operations. |
| No. 13 | Protection of BNIs against external flooding. |
| No. 14 | Acceptable complete clean-out methodologies in BNIs in France. |
| No. 15 | Control of Activities in the Vicinity of Basic Nuclear Installations. |
| No. 19 | Application of the Order of 12/12/2005 relating to nuclear pressure equipment. |
| No. 21 | Processing of non-compliance with a requirement defined for an element important for protection (EIP). |
| No. 22 | Design of pressurised water reactors. |
| No. 23 | Drafting and modification of the waste zoning plan for basic nuclear installations. |
| No. 25 | Drafting of an ASN regulation or an ASN guide. |
| No. 28 | Qualification of scientific computing tools used in the nuclear safety case. |
| No. 30 | Policy for the management of risks and detrimental effects of nuclear installations and the licensees' integrated management system. |

# APPENDIX C – Organisation of nuclear reactor licensees

## C.1 EDF organisation for nuclear reactors

The EDF Group, one of the world's top ten energy companies, is a limited company (EDF S.A.) with a board of directors, which is active along the entire electricity value chain. It is present in all areas of the electricity industry: nuclear, renewables and fossil energy productions, transport, distribution, marketing, energy efficiency and management services, as well as energy trading. In France, Électricité de France S.A. is the main electricity production company and is today the only one to operate nuclear power reactors.

The EDF group's nuclear organisation is mainly built around two departments (see Figure C-1

- the **Nuclear and Thermal Fleet Department** (**DPNT**),
- the **Engineering and New Nuclear Projects Department** (**DIPNN**).

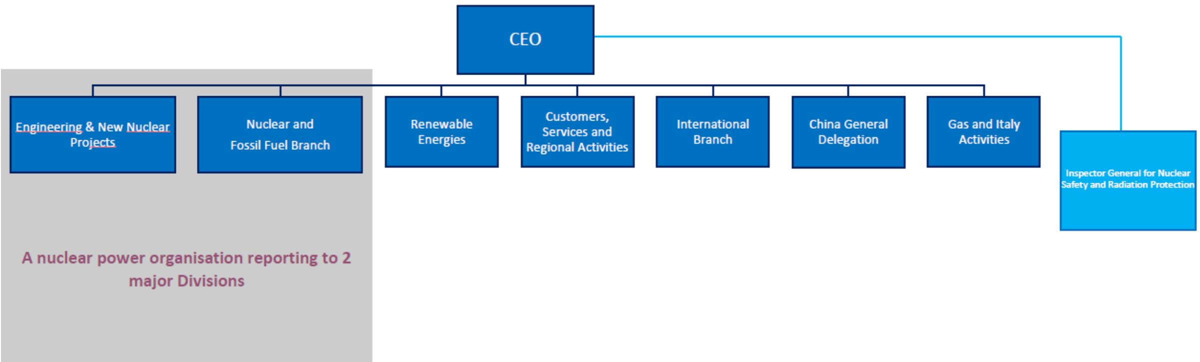



*Figure C-1: Organisation of the EDF SA Group*

These two departments are responsible for the design and construction of new reactors (in France, the Flamanville 3 EPR), for maintaining the safety of the nuclear fleet in operation at the highest level and for ensuring the success of the work to renovate and to continue the operation of the existing fleet in complete safety, for developing an industrial sector for nuclear dismantling and management of radioactive waste, for reinforcing the performance and innovation of nuclear engineering, at the service of new construction projects, of the major overhaul programme, or of dismantling projects.

With regard to operation of the nuclear reactors, the **DPNT** includes in particular:

- the Nuclear Power Operations Division (DPN), with all the sites in operation (NPPs: Nuclear Power Plants), the National Operational Engineering Unit (UNIE) and the Operational Technical Unit (UTO);
- The Nuclear Fleet, Dismantling and Environment Division (DIPDE);
- The Nuclear Fuel Division (DCN);
- the "Major Overhaul" Programme Department (DPGC);
- the Dismantling and Waste Projects Department (DP2D).

With regard to engineering and new nuclear projects in France, the **DIPNN** more specifically includes:

- two Project Departments: Flamanville 3 project department and EPR 2 project department;

- four Operational Departments: Projects Support and Digital Transformation Department (DSPTN), Industrial Department (DI), Technical Department (DT) and Development Department (DD);
- two Engineering Departments: the national electricity generating equipment centre (CNEPE) and EDVANCE (subsidiary reporting to the DIPNN).

With these units of expertise, which also support the fleet in service, the DIPNN is at the centre of the challenges facing the nuclear sector.

### C.1.1 Principles of nuclear safety and radiation protection responsibilities within EDF S.A.

EDF S.A. is the named holder of the creation authorisation decrees for its BNIs and has responsibility as nuclear licensee.

Nuclear safety and radiation protection are applicable to all BNIs operated by EDF SA, as well as to radioactive substance transports from and to them. This concerns all persons working in or finding themselves in a BNI in whatsoever capacity. In this respect, the EDF Group has defined and implemented a policy reaffirming:

- **the priority given to the protection of the interests** mentioned in Article L. 593-1 of the Environment Code (public health and safety, protection of nature and the environment), primarily by preventing accidents and mitigating their consequences in accordance with the demands of nuclear safety;
- and the **constant search for improvements in the measures taken** to protect these interests.

As nuclear licensee, EDF S.A.'s operational **responsibilities in terms of nuclear safety and radiation protection are delegated to three levels:**

- **the Chairman of EDF S.A,**
- **the national entities:** in charge of BNI construction and operation projects and the design of BNI modifications,
- **the nuclear production sites.**

Each of these levels of delegation and competence is **in charge of developing a management system** which contributes to the **rules of nuclear safety and radiation protection** in the organisation and operation of its entity and, more generally, to the **protection of the interests** identified by the Environment Code. It thus guarantees the **priority granted to the protection of the above-mentioned interests**.

§ C.1.2.1 to § C.1.2.4 of this appendix summarise the responsibilities of these 3 levels.

In addition to this **management line** given responsibility for nuclear safety and radiation protection, each level of the company calls on the services of an **Independent Safety Organisation** (FIS) providing an **independent view** of how the nuclear licensee performs its duties. The FIS ensures that priority is given to nuclear safety by exercising a **role of verification and advice** for the management.

Each level in the company organises the integration of the FIS into the *ad hoc* bodies, so that this independent view can be provided at the appropriate level. At each level of the company, the FIS reports to the manager of the level concerned.

In the event of any serious breach of the nuclear safety rules, the FIS is duty bound to sound the alert which may, if necessary, be sent to the next higher management level.

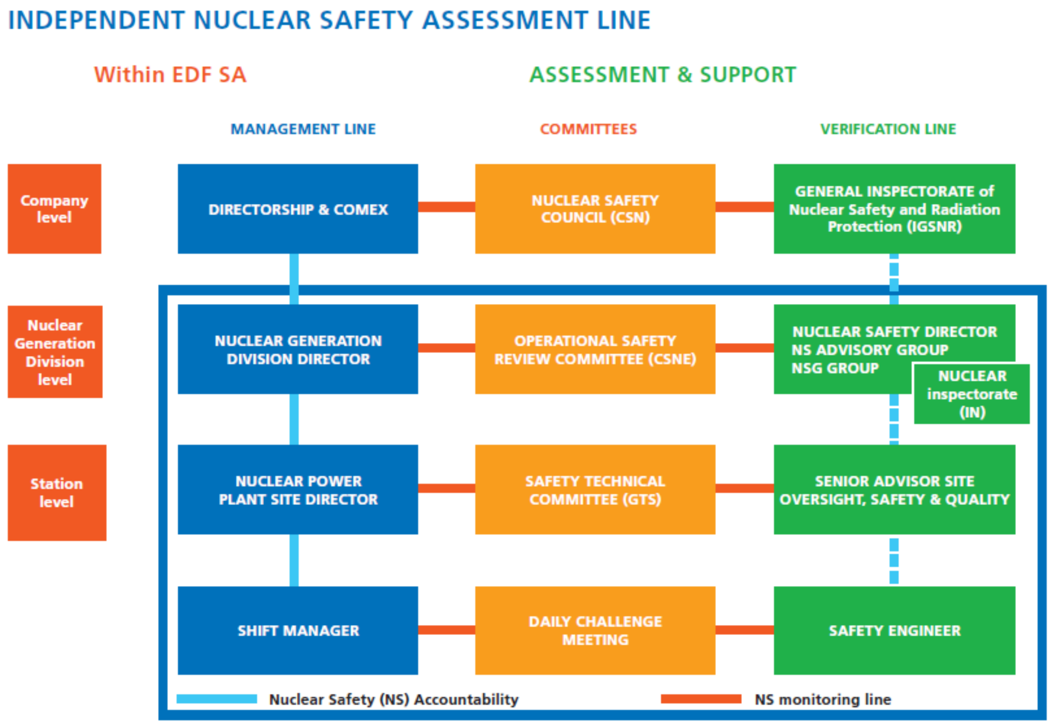



*Figure C-2: The Independent Safety Team (FIS)*

### C.1.2 Assignment of responsibilities for nuclear safety and radiation protection within EDF S.A.

In its capacity as nuclear licensee, **the EDF S.A. legal person is represented by the following natural persons**:

#### *C.1.2.1 At EDF SA Chairman level*

Under the delegation of powers granted to his or her by the Board of Directors, the **CEO** has all the powers needed for EDF S.A. to exercise its capacity as nuclear licensee. He or she in particular determine the strategic orientations regarding nuclear safety and set the general principles of organisation and resources allowing the correct performance of EDF S.A.'s responsibility as nuclear licensee, with the assistance of the Group Executive Director in charge of nuclear and thermal production and the Group Executive Director in charge of engineering and new nuclear projects

He or she chairs the **Nuclear Safety Council** and ensures the consistency of the main orientations and actions of the different sectors of the company that may affect nuclear safety and radiation protection, including in areas such as purchasing of goods and services, implementation of training programmes, research and development.

In order to define and implement these strategic orientations as organisational principles, the EDF SA CEO relies on the following within the EDF Group executive committee:

- for BNIs under construction (Flamanville 3), on the **Group Executive Director in charge of Engineering and New Nuclear Projects**, to whom he or she delegates the powers necessary for exercising the function of nuclear licensee, as of the submission of the creation authorisation application and up to transfer of responsibility for them to the entity in charge of operation,

- for the BNIs in operation[28] on the **Group Executive Director in charge of the Nuclear and Thermal NPP flee,** to whom he or she delegates the powers necessary for exercising the function of nuclear licensee, as of their transfer.

**The two Group Executive Directors** are the guarantors that nuclear safety and radiation protection are taken into account within their respective perimeters (BNIs under construction / BNIs in operation respectively), within the EDF Group executive committee.

They are responsible for drawing up the general organisational principles such as to ensure correct performance of the function of nuclear licensee by EDF S.A. on the BNIs within their perimeter (design-construction projects / reactors in operation respectively) and implement these principles within these BNIs. They ensure the consistency of the main orientations and actions of the different sectors of EDF SA that may affect nuclear safety and radiation protection. They more specifically aim to guarantee that priority is given to nuclear safety in the investments and asset selections decided on by the Chairman. They ensure that the design and construction of BNIs throughout their lifecycle comply with the applicable nuclear safety requirements. They are the points of contact for the nuclear safety regulator (ASN)

**The Inspector General for Nuclear Safety and Radiation Protection** ensures that nuclear safety and radiation protection concerns are properly taken into account for the company's nuclear facilities and reports to the **CEO** in this respect

### *C.1.2.2 Within the entities in charge of "new nuclear "projects*

Under the powers delegated to him or her by the Group Executive Director in charge of Engineering and New Nuclear Projects, the **Flamanville 3 Project Director** is the representative of the EDF SA nuclear licensee for this BNI in its entirety. Following the partial commissioning for fuel delivery, this representation is delegated on the perimeter of the partial commissioning to the Director of the Flamanville 3 Nuclear Power Plant.

He or she takes all the steps needed for EDF S.A. to exercise its capacity as a nuclear licensee. He or she ensures that priority is given to protection of the abovementioned interests, first of all through **design, construction and commissioning** (up to transfer of responsibility to the entity in charge of operations), aiming to **prevent accidents and mitigate their consequences** in terms of nuclear safety.

**The Group Executive Director in charge of Engineering and New Nuclear Projects** acts as Backer for nuclear safety and radiation protection in the Flamanville 3 BNI. **The project owner is the Flamanville 3 Project entity.** In this respect, the **Flamanville 3 Project Director** guarantees that the design of the facilities and their construction within the BNI perimeter and their subsequent modifications throughout the project are compliant with the baseline safety requirements in force. In so doing, he or she calls on the expertise of the engineering centres reporting to the New Nuclear Projects Engineering Department (DIPNN).

On behalf of the Group Executive Director in charge of the Nuclear and Thermal Fleet and the Executive Director in charge of Engineering and New Nuclear Projects, the **Technical Department** (**DT**) of the DIPNN has the role of ensuring the **control and implementation of the technical baseline requirements for the new nuclear projects and for the existing NPP fleet.** It is assisted by the Industrial Department (DI) to ensure involvement by the industrial sector in drawing up these baseline requirements.

[28] The licensee's responsibility is transferred in two stages: within a perimeter limited to the equipment needed for storage of the new fuel assemblies in the pool at arrival of the first fuel element in the BNI (partial commissioning), and then on the entire BNI when the first assembly is loaded into the vessel (commissioning).

### *C.1.2.3 Within the entities in charge of BNI operation and BNI design and modification at EDF SA:*

The following are concerned: the Nuclear Operations Division, the **Nuclear Fleet**, **Dismantling and Environment Division** (**DIPDE**);

Under the powers delegated to him or her by the Group Executive Director in charge of the Nuclear and Thermal Fleet and under their authority, the **DPN Director** is the representative of the EDF S.A nuclear licensee for all the facilities in operation.

He or she take all the steps needed for EDF S.A. to perform its duties as nuclear licensee. He or she develops a management system which contributes to compliance with the rules of nuclear safety and radiation protection in the organisation and operation of their entity and, more generally, to the protection of the interests identified by the Environment Code. In this respect, he or she ensures that **priority is given to protection of the abovementioned interests and its constant improvement**, principally by **preventing accidents and mitigating their consequences in terms of nuclear safety**. He or she aims to ensure the development of continuous improvement and the adoption of best practices, including those identified internationally.

The principles of this management system are applied on the sites in operation, under the responsibility of the **Unit Directors** (**NPP**).

For the BNIs he or she operates, the DPN Director carries out the duties of nuclear licensee throughout the lifetime of these BNIs. He or she may be required to make a final ruling on the decisions taken within the nuclear sector of EDF S.A. with regard to the BNIs for which they are responsible. This responsibility is exercised more particularly within the bodies comprising cross-participation by the entities of the sector.

The **Group Executive Director in charge of the Nuclear and Thermal Fleet** acts as Backer for nuclear safety and radiation protection for the BNIs in operation within his or her perimeter.

**The Project Manager is the Nuclear Operation Division for the BNIs in operation**.

The Group Executive Director in charge of the Nuclear and Thermal fleet appoints the **Fleet Engineering**, **Dismantling and Environment Division** (**DIPDE**) as the **Design Authority** for BNIs in operation, on behalf of the Backer and Project Owner. In this respect, the **Director of the DIPDE** guarantees that the design status of the facilities within this perimeter and their modifications throughout their lifecycle are in conformity with the baseline safety requirements in force.

For this purpose, the **Design Authority** draws on the expertise of the engineering centres appointed as **Responsible Designers**, whether reporting to the Nuclear and Thermal Fleet Department (DPNT) or the New Nuclear Project Engineering Department (DIPNN).

The **Nuclear Fuels Division is Project Manager for activities related to the nuclear fuel cycle**, as well as **Project Manager for the removal of radioactive waste**.

On behalf of the Group Executive Director in charge of the Nuclear and Thermal Fleet and the Executive Director in charge of Engineering and New Nuclear Projects, the **Technical Department** (**DT**) of the DIPNN has the role of ensuring the **control and implementation of the technical baseline requirements for the new nuclear projects and for the existing NPP fleet**. It is assisted by the Industrial Department (DI) to ensure involvement by the industrial sector in drawing up these baseline requirements.

#### *C.1.2.4 On the nuclear sites:*

The **Flamanville 3 Development Director is the representative of the nuclear licensee, EDF S.A.,** under delegation from the Flamanville 3 Project Director.

The **Directors of the nuclear power plants are the representatives of the nuclear licensee, EDF S.A.,** for those facilities for which they have been delegated responsibility by the Director of the DPN.

More specifically, these unit directors take all steps needed for the exercise of this responsibility, in all the phases of the process for which the company is responsible, they:

- draw up and implement a protection of interests policy;
- propose and implement the principles of organisation and operation that ensure compliance with nuclear safety and radiation protection rules, as well as the effective exercise of the responsibilities of EDF S.A. as nuclear licensee;
- rely on a management system and ensure verification of compliance with the requirements through appropriate internal monitoring. In this respect, each NPP Development Director (or site director) ensures that priority is given to Safety when categorising the issues being addressed. They aim to ensure the development of continuous improvement and the adoption of best practices, including those identified internationally;
- report the information relating to nuclear safety and radiation protection to the Director of the Flamanville 3 Project / Director of the DPN, for the BNIs in operation. They are the points of contact for the national and local competent authorities in the area of nuclear safety and radiation protection for the aspects specific to the installations under their responsibility.

## C.2 Organisation of CEA

A new general organisation was set up at CEA in January 2016.

In January 2018, the nuclear protection and safety division and the central security division were merged into the Nuclear Security and Safety Division (DSSN).

On April 1, 2019, an Audit, Risk and Internal Control Department (DARCI) was created with the aim of enabling the CEA to have an overall view of risks and to take them into account in their entirety and regardless of their nature.

In February 2020, the Nuclear Energy Directorate (DEN) was restructured into a new Directorate of Energies (DES) dedicated to low-carbon energies, integrating nuclear and renewable energies with a particular focus on solar production and hydrogen.

Since 2020, the Directions of the CEA civilian centres have been attached to the Directorate General, in the same way as the operational and functional Directorates.

In this organization, in terms of safety, which includes nuclear security, there are three levels of delegation of responsibilities:

- the Chairman, head of the CEA and, as such, the nuclear licensee of the reactors;
- the Directors of the centres, local representatives of the Chairman, more specifically with regard to his or her duty as nuclear licensee;
- the Facility Managers, responsible for ensuring compliance with the regulations and internal rules applicable to their facility at all times.

To guarantee that the safety objectives are duly taken into consideration for the through-life support of the reactors, the Director of of Energies (DES) signs an annual safety objectives contract (COS) with the Chairman, formally setting out the objectives. Execution of this COS is monitored by the Nuclear Safety and Security Department on behalf of the Chairman.

## C.3 ILL organisation

The Laue-Langevin Institute (ILL) was founded in January 1967 by Germany, France and the United Kingdom, in order to obtain a very intense neutron source entirely dedicated to civil fundamental research. It is managed by these three founding countries ("the associated"), in partnership with its 11 scientific member states (Spain, Italy, Switzerland, Austria, Czech Republic, Slovenia, Slovakia, Poland, Belgium, Sweden and Denmark). It operates a high flux neutron reactor entirely dedicated to scientific research.

The Institute is currently organised into four divisions.

The director and the four division heads make up the ILL Management Board.

The Radiation Protection Safety and Environment Department (SRSE) and the Quality Safety Risk Cell (CQSR) report directly to the Director of ILL.

As regards management of the INB and the installations defined in the safety report, the director delegates his responsibility as licensee to the head of the reactor division. For the protection of interests, the latter relies on a safety cell that is directly attached to him. As head of the BNI, the head of the reactor division is ultimately responsible for deciding on the safety of the operating conditions of the reactor, the instruments and the experimental devices.

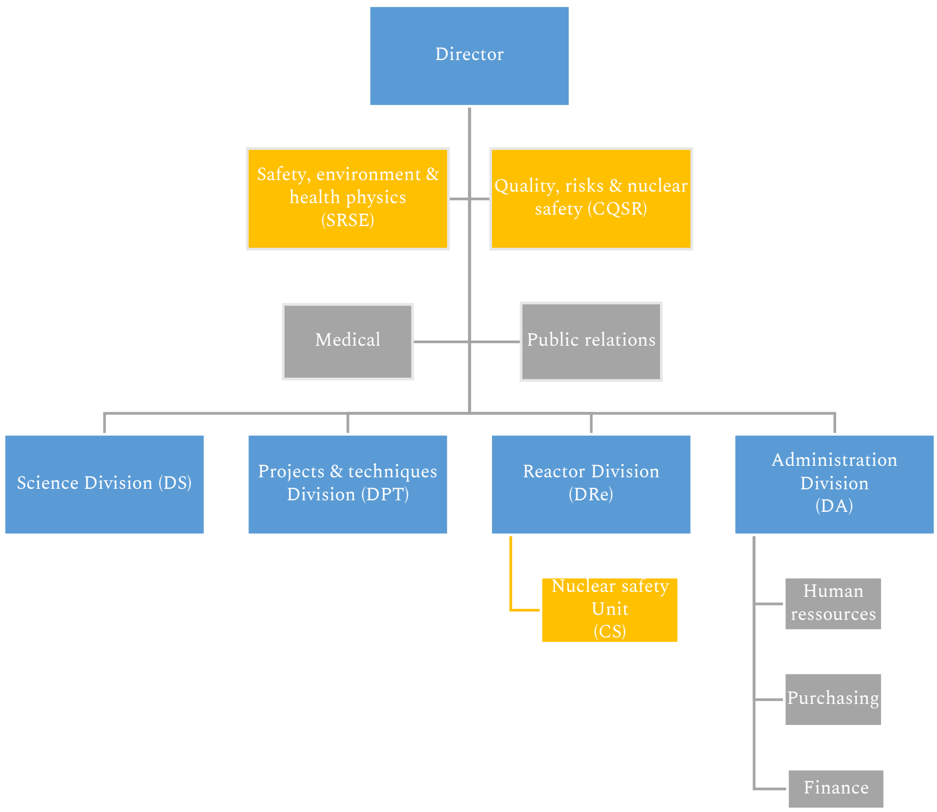



*Figure C-3 : Organisation of ILL*

# APPENDIX D - Environmental monitoring

| Environment monitored or type of monitoring | Nuclear power plant |
|---|---|
| Air at ground level | • 4 stations continuously sampling atmospheric dust on fixed filter with daily measurements of total β activity ($β_G$). γ spectrometry if $β_G$ > 2 mBq/m$^3$<br>• for each of the stations, γ spectrometry on the monthly grouping of daily filters<br>• 1 continuous sampling station under the prevailing winds with weekly measurement of tritium ($^3H$) |
| Ambient radiation | • 4 monitors at a distance of 1 km with continuous measurement and recording<br>• 10 monitors with continuous measurement at the site limits (monthly readings)<br>• 4 monitors at a distance of 5 km with continuous measurement |
| Rain | • 1 station under the prevailing wind (continuous sampling) with measurement of $β_G$ and $^3H$ on bi-monthly mixture |
| Environment receiving liquid discharges | • Sampling in the river and upstream at mid-discharge, for each discharge (riverside NPP), or sampling after dilution in cooling water and bi-monthly sampling at sea (coastal NPP): measurement of $β_G$, potassium (K) and $^3H$<br>• Continuous sampling of $^3H$ (daily average mixture)<br>• Annual sampling in the aquatic sediments, fauna and flora, with measurement of $^3H$, $^{14}C$ and γ spectrometry |
| Groundwaters | • 5 sampling points (monthly check) with $β_G$, K and $^3H$ measurement |
| Soil | • 1 annual sample of the surface layer of the soil with γ spectrometry |
| Plants | • 2 grass sampling points (monthly check) γ spectrometry. Periodic measurements of $^3H$, carbon 14 ($^{14}C$) and total carbon<br>• Annual campaign on the main agricultural crops with measurement of $^3H$, $^{14}C$ and total carbon, plus γ spectrometry |
| Milk | • 2 sampling points (monthly check) with γ spectrometry and annual measurement of $^{14}C$ and $^3H$ |

*Table D.1: Nature of environmental monitoring around the NPPs*

# APPENDIX E – Management of Covid-19

EDF has a major role in the French economy because of its electricity production mission. During the Covid crisis, EDF had to adapt its organisation to ensure its public service mission and the continuity of nuclear production.

**The implementation of a specific crisis organisation**

A specific EDF steering organisation was set up to manage the situation linked to Covid 19 and the associated uncertainties with two objectives: to protect the personnel and contractors on EDF sites and to ensure the continuity of public service and of the electricity production of the nuclear installations safely.

Inspired by the nuclear industry's crisis organisations, EDF DPN has set up a dedicated national crisis unit with specialised units, notably concerning:

- healthcare organisation,
- management of technical issues,
- relations with the nuclear safety authority (ASN),
- relations with service providers,
- human resources: this allows to implement specific arrangements on the sites, such as maintaining voluntary work at home and setting up team rotations to be able to rely on reserve teams if one team was more affected than another.

A prospective unit has also been set up: this is a first. This unit, similar to what the army usually sets up, i.e. a "heads-up" management unit, works with scenario-based reasoning to anticipate and constantly draw lessons, with the capacity to rapidly formulate recommendations to contribute to decision-making in different areas, for example to protect workers, maintain security and ensure the continuity of nuclear energy production.

The communication played a very important role. The dialogue has always been transparent and responsible: EDF has always adopted a 'straight talk' approach with the employees, constantly adapting to the means available. From a very practical point of view, it was necessary to adapt the installations, particularly concerning the changing rooms and canteens, in order to avoid concentration zones by organising controls at the entrances and exits. All these issues were addressed with the health of employees and their confidence in the company as a priority.

The main resilience factors identified were:

- the flexibility and adaptability of the national organisation and the sites, which have reconfigured to manage the crisis, to monitor and anticipate potential developments, to reorganise the operating teams, site and crisis protection, etc.;
- the implementation of protocols and working procedures related to the occupational health department, human resources and communication;
- the rapid development of communication means to facilitate passing on information at the peak of the crisis;
- the flexibility and mobilisation to ensure the logistics (in terms of masks, hand sanitiser gel, etc.);
- the skills of the actors in terms of expertise in crisis management, knowledge and awareness of risks, as well as the ability to prioritise activities. Staff involvment has also played a key role in the success;
- the collective skills allowing all staff to rally together, to coordinate to find solutions, etc.;

- the management skills that promote the development of social dynamics and managerial practices that facilitate collective operation and decision-making;
- an organisation that combines centralisation of strategic decisions with decentralisation of operational decisions, and has put itself "at the service" of the actual work of the personnel.

**Lessons learned from this crisis**

A nuclear power plant is not like any other installation. Nuclear safety is of prime importance and must always be ensured, even in a degraded situation like the one during this crisis. The safety results were maintained or even improved. The number of events has decreased. This is not a coincidence but the result, among other things, of the implementation of a management charter, drawn up jointly and shared by all the nuclear sites. Because of the Covid 19 epidemic, the latitude for the rescheduling of activities was significantly reduced, but the resilience of the organisation facilitated the adaptation to the situation.

A weekly safety update was organised with WANO and the IAEA, which also allowed sharing of practices between operators (Chinese, German, English, Spanish and other European plants).

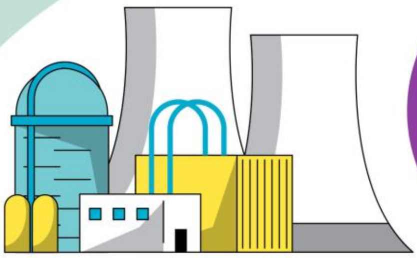
Priority was always given to the safety of the installations, especially in a complex context with strict sanitary measures necessary to protect the workers. It was important to remain humble in the face of this virus, and to maintain constant vigilance and adaptation to avoid any infection in the workplace. The entire staff acquired a healthcare culture in addition to the radiological culture.

The staff involvment played a key role in the successful management of this crisis, which leads to go even further in the process of changing management methods. The development of collaborative communication tools must also be continued in order to ensure the sharing and transmission of information in real time, adapted to crisis management.

The importance of having a specific foresight team is one of the major lessons learned, and this can be adapted to other sensitive crisis issues such as cyber attacks or exceptional climatic events.

## Focus 36: An unprecedented stress test on the organisation of nuclear safety and radiation protection

The measures taken during the health emergency period severely affected nuclear activities. The licensees of the Basic Nuclear Installations (BNIs) activated their activity continuity plan and adapted their organisation in order to maintain the level of safety in the installations and guarantee compliance with the regulatory requirements. The medical nuclear players also had to deal with an unprecedented health situation. During this period, ASN adapted its oversight methods, notably by developing remote-inspections for certain subjects.



The licensees and activity managers demonstrated **a good level of adaptability**

### Satisfactory management of the health crisis

- **Maintaining the required level of safety**
- **Implementing an activity continuity plan**

**Organisational adaptability:** continued preparation of the files required by ASN, by means of remote-working, efficient measures to ensure the permanent availability of qualified operating personnel on the sites.

**Operational adaptability:** continued performance of the priority activities considered to be essential (monitoring, safety checks), postponement or cancellation of non-essential activities, satisfactory compliance with the applicable requirements regarding nuclear safety and radiation protection, etc.

# APPENDIX F - Bibliography

## F.1 Documents


/1/ Convention on Nuclear Safety (CNS), September 1994.

/2/ Guidelines regarding National Reports under the Convention on Nuclear Safety, IAEA - INFCIRC/572/Rev.6, January 2018.

/3/ Convention on Nuclear Safety – National Report for the Second Extraordinary Meeting

/4/ Annual reports from the Nuclear Safety Authority (ASN). http://www.asn.fr/Informer/Publications/Rapports-de-l-ASN

/5/ EDF – The Inspector General's Report on Nuclear Safety and Radiation Protection

/6/ CEA – Annual reports on nuclear safety and radiation protection http://www.cea.fr/Pages/surete-securite/priorite-securite-surete.aspx

/7/ ILL - Annual reports. https://www.ill.eu/fr/a-propos-de-ill/documentation/annual-report/

/8/ IRSN – Report on the radiological state of the French environment from 2018 to 2020: https://www.irsn.fr/FR/expertise/rapports_expertise/Documents/environnement/IRSN-ENV_Bilan-Radiologique-France-2018-2020.pdf

/9/ French national report on the state of implementation of the Joint Convention obligations, October 2020. https://www.french-nuclear-safety.fr/content/download/172883/file/France%E2%80%99s%20seventh%20national%20Report%20on%20compliance%20with%20the%20joint%20convention.pdf


## F.2 Websites

The abovementioned documents, or at least the key points of their content, as well as other relevant information concerning the subject of this report are available on the Internet. The following sites may in particular be consulted:

- Légifrance: www.legifrance.fr
- ASN: www.asn.fr
- IRSN: www.irsn.fr
- SFRO: www.sfro.org
- CEA: www.cea.fr
- EDF: www.edf.fr
- ILL: www.ill.fr
- Andra: www.Andra.fr
- IAEA: www.iaea.org
- French national network of environmental radioactivity monitoring (RNM): www.mesure-radioactivite.fr

# APPENDIX G – List of main abbreviations

| | |
|---|---|
| **AFCEN** | French association for rules on design, construction and in service monitoring of nuclear steam supply systems |
| **ANCCLI** | National Association of Local Information Committees and Commissions |
| **ANDRA** | French national radioactive waste management agency |
| **ASG** | Steam generators feedwater system |
| **ASN** | Autorité de Sûreté Nucléaire (French nuclear safety authority) |
| **BNI** | Basic nuclear installation |
| **CEA** | French Alternative Energies and Atomic Energy Commission |
| **CFSI** | Counterfeit, Fraudulent and Suspect Items (IAEA definition) |
| **CIRES** | (ANDRA) Industrial centre for collection/grouping, storage and disposal |
| **CLI** | Local Information Committee |
| **CNS** | Convention on Nuclear Safety |
| **CODIRPA** | Steering committee for managing the post-accident phase of a nuclear accident or radiological emergency situation |
| **CQSR** | Quality, safety, risks unit (ILL) |
| **CSA** | (ANDRA) Aube waste disposal facility |
| **CSPRT** | French High Council for Technological Risk Prevention |
| **DAC** | Creation authorisation decree |
| **DCN** | (EDF) Nuclear Fuel Division |
| **DES** | (CEA) Energy Division |
| **DGSCGC** | General Directorate for Civil Security/protection and Emergency Management |
| **DIPNN** | Engineering and New Nuclear Project Division (EDF) |
| **DOS** | Safety options dossier |
| **DPN** | (EDF) Nuclear Operation Division |
| **DPNT** | (EDF) Nuclear and Thermal Production Division |
| **DSSN** | (CEA) Nuclear Security and Safety Division |
| **DUS** | Ultimate backup diesel generator set |
| **ECOT** | (EDF) Plant unit conformity examination programme |
| **ECURIE** | European Community Urgent Radiological Information Exchange |
| **EDF** | Électricité de France |
| **ELC** | Local emergency team |
| **ENSREG** | European Nuclear Safety Regulators Group |
| **EPR** | European Pressurised Reactor |
| **EPRI** | Electric Power Research Institute |
| **ESS** | Events Significant for Safety |
| **ETC-N** | (EDF) national emergency technical support team |
| **EVU** | Heat removal system |

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| **FARN** | Nuclear rapid intervention force |
| **FIS** | Independent Safety Organisation (EDF) |
| **FRAMATOME** | Formerly AREVA-NP, NSSS maker |
| **GOR** | General operating rules |
| **GPEC** | Forward planning of employes and skills |
| **GPE** | Advisory Committee of experts |
| **GPR** | Advisory Committee of Experts for Nuclear Reactors |
| **HCTISN** | High Committee for Transparency and Information on Nuclear Security |
| **HERCA** | Head of the European Radiological Protection Competent Authorities |
| **HFR** | (Laue-Langevin Institute) High-flux reactor |
| **IAEA** | International Atomic Energy Agency |
| **ICPE** | Installations classified for protection of the environment |
| **ICRP** | International Commission on Radiological Protection |
| **IGN** | (CEA) General and nuclear inspectorate |
| **ILL** | Laue-Langevin Institute |
| **IMS** | Integrated safety Management System |
| **INES** | International Nuclear Event Scale |
| **INSAG** | (IAEA) International Nuclear Safety Group |
| **IRRS** | Integrated Regulatory Review Service |
| **IRSN** | French Institute for Radiation Protection and Nuclear Safety |
| **ITER** | International Thermonuclear Experimental Reactor |
| **JHR** | Jules Horowitz Reactor |
| **MEP** | Multi-year energy programme |
| **MPS** | Main Primary System |
| **MSNR** | Nuclear Safety and Radiation Protection Mission |
| **MSS** | Main Secondary System |
| **NEA** | Nuclear Energy Agency (OECD) |
| **NPE** | Nuclear Pressure Equipment |
| **NPP** | Nuclear Power Plant |
| **NSSS** | Nuclear steam supply system |
| **OEF** | Operating experience feedback |
| **OHF** | Organisational and Human Factors |
| **OPECST** | Parliamentary Office for the Evaluation of Scientific and Technical Choices |
| **ORANO** | Formerly AREVA-NC, fuel cycle company |
| **ORSEC (plan)** | Disaster and emergency response organisation (plan) |
| **OSART** | Operational Safety Review Team |
| **PCC** | (EDF) controls command post |
| **PCD** | Strategic management command post |
| **PCD-L** | (CEA) Local strategic management command post |

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| **PCD-N** | (EDF) National emergency director |
| **PCL** | (EDF) Local command post |
| **PCM** | (EDF) Resources command post |
| **PIA** | Protection Important Activity |
| **PIC** | Protection Important Component |
| **PNGMDR** | National radioactive materials and waste management plan |
| **PPI** | Off-site emergency plan |
| **PSA** | Probabilistic safety assessment |
| **PSR** | Periodic safety review |
| **PUI** | On-site emergency plan |
| **PWR** | Pressurised water reactor |
| **QSE (System)** | (CEA/DES) Integrated Management System "Quality, health, security, safety, environment" |
| **RANET** | (IAEA) Response and Assistance Network |
| **RCC** | Design and construction rules |
| **RCCA** | Rod Cluster Control Assembly |
| **RFS** | Basic safety rules |
| **RIC** | Incore instrumentation Room |
| **RIS** | Safety injection system |
| **RNM** | French national environmental radioactivity monitoring network |
| **SAMG** | Severe Accident Management Guidelines |
| **SG** | Steam Generator |
| **SGDSN:** | General Secretariat for Defence and Civil Protection |
| **SISERI** | Ionising radiation exposure monitoring information system |
| **SMR** | Small Modular Reactor |
| **SOH** | (EDF) approach to take account of Socio-Organisational and Human aspects |
| **SSE** | Safe Shutdown Earthquake |
| **SSC** | Systems, structures and components |
| **STE** | Operating Technical Specifications |
| **TPR** | Topical Peer Review (EU) |
| **TSN Act** | Transparency and Nuclear Safety Act |
| **UNIE** | (EDF) Operation Engineering Unit |
| **USIE** | Unified System for information Exchange in Incidents and Emergencies |
| **WANO** | World Association of Nuclear Operators |
| **WENRA** | European Nuclear Regulators' Association |