

FRANCE

Convention on Nuclear Safety

Seventh National Report for the 2017 Review Meeting

August 2016

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List of figures

List of tables

A - INTRODUCTION

1. General remarks

1.1 Purpose of the report

The Convention on Nuclear Safety, hereinafter referred to as "the Convention", is one of the results of international discussions initiated in 1992 in order to contribute to maintaining a high level of nuclear safety worldwide. The convention sets a number of nuclear safety objectives and defines measures to meet them. France signed the Convention on 20th September 1994, the date on which it was opened for signature during the IAEA General Conference, and approved it on 13th September 1995. The Convention entered into force on 24th October 1996.

For many years France has been participating actively in international initiatives to enhance nuclear safety. It considers the Convention on Nuclear Safety to be an important instrument for achieving this aim. The areas covered by the Convention have long been part of the French approach to nuclear safety.

The purpose of this seventh report, which was drafted pursuant to Article 5 of the Convention and which covers the period 2013 to mid-2016, is to present the measures taken by France in order to fulfil each of its obligations as specified in the said Convention.

1.2 Installations concerned

Since the Convention applies to all nuclear-power generating reactors (see § 6.1) most of this report is dedicated to the measures taken in order to ensure their safety. However, as in previous reports, France has decided in this seventh report also to present the measures that were taken for all research reactors.

First of all, research reactors are actually subject to the same overall regulations as nuclear-power reactors with regard to nuclear safety and radiation protection. Then, within the framework of the *Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management*, to which France is a Contracting Party, an account was made of the measures taken in those respective fields with regard to research reactors. Lastly, the Board of Governors of the International Atomic Energy Agency (IAEA), of which France is a member, in March 2004 approved the *Code of Conduct on the Safety of Research Reactors*, which reiterates most of the provisions of this present Convention.

In this report, the acronym BNI (Basic Nuclear Installation) is used to represent all of the French nuclear installations as a whole (nuclear power plants, research reactors, fuel cycle installations, research laboratories, radioactive waste disposal facilities…). This acronym concerns therefore many installations out of the area covered by this report since some provisions of certain legislative texts applied to all the BNI without distinction.

1.3 Report authors

This report was produced by ASN, the French nuclear safety authority, which coordinated the work on it, with contributions from IRSN (Institute for Radiation Protection and Nuclear Safety) and from nuclear reactor licensees, Électricité de France (EDF), the French Alternative Energies and Atomic Energy Commission (CEA) and the Laue-Langevin institute (ILL). The final version was completed in July 2016 after consultation with the French parties concerned.

1.4 Structure of the report

For this report, France took into account the lessons learned with the six previous reports: it is a self-standing document, which has been developed mostly on the basis of existing documents and reflects the views of the regulatory body and the licensees. Hence, for every chapter in which the regulatory body is not the only entity to express its own views, a three-fold structure was adopted: firstly a description of the regulations by the regulatory authority, followed by an overview presented by the licensees of their measures for regulatory compliance, and finally an analysis by the regulatory authority of licensee measures.

This report is structured according to the Guidelines on National Reports, as revised at the sixth review meeting in 2014. The presentation progresses "article by article", with each one giving rise to a separate chapter at the beginning of which the corresponding text of the Convention appears in a box with a half-tone background. After the introduction, which presents certain general aspects as well as national nuclear policy, the summary gives a description of the main changes that have taken place since the sixth national report and the safety prospects for the next three years. Part C covers general considerations (chapters 4 to 6), part D summarises laws and regulations (chapters 7 to 9), part E is dedicated to general nuclear safety considerations (chapters 10 to 16), part F presents the safety of facilities (chapters 17 to 19), and finally part G presents international cooperation measures (chapter 20). The report is supplemented by seven appendices.

1.5 Publication of the report

The Convention on Nuclear Safety does not stipulate any obligation regarding public communication of the National Reports. Nonetheless, as part of its mission to inform the public and in its continuous efforts to improve the transparency of its activities, ASN has decided to make the French national report accessible to any interested person. Consequently, this report is available on ASN's website (http://www.french-nuclear-safety.fr/), in French and in English, along with questions/answers concerning the French national report.

2. National nuclear policy

2.1 Nuclear safety policy

The first decision of the French government concerning nuclear energy was, in 1945, to create a public research organisation, called the French Atomic Energy Commission, which became the French Alternative Energies and Atomic Energy Commission (CEA) on 10th March 2010. The first French experimental reactor became critical in December 1948, thus paving the way for the construction of other research reactors, followed by further reactors designed to generate electricity.

The French nuclear power reactors within the scope of the Convention were built and are today operated by a single licensee, Électricité de France (EDF). All the reactors except one, the high-flux reactor (RHF), operated by the Laue-Langevin Institute (ILL), were built and are operated by CEA.

With regard to nuclear safety, Act 2006-686 of 13th June 2006 concerning transparency and security in the nuclear field, known as the “TSN Act”, plus its implementing texts, extensively overhauled the legislation and the regulations concerning the nuclear safety of nuclear facilities.

The Government thus stipulates the general regulations applicable to nuclear activities by decree or by order. It issues the few major individual resolutions concerning major nuclear installations, notably the plant creation and decommissioning authorisations. It takes measures based on the opinions of ASN, opinions which are made public at the same time as the measures to which they refer.

The TSN Act created ASN (the French nuclear safety authority), an independent administrative authority, tasked on behalf of the State with monitoring nuclear safety and radiation protection, to protect workers, patients, the general public and the environment against the risks associated with civil nuclear activities. The regulation of nuclear safety and radiation protection by ASN is described in chapter 8. Some of these resolutions must be approved by the Minister responsible for nuclear safety (Minister of the Environment, Energy and the Sea (MEEM)).

Act 2015-992 of 17th August on *energy transition for green growth,* known as the "TECV Act”, reinforced the legislative framework of nuclear safety and information of the public. The framework applying to the local information committees (CLI) for the BNIs is modified so that for BNIs on the national borders, the CLIs can include members from the other countries concerned. Over and above proposals made by the licensees in the “social specifications” submitted to the Government in July 2012 and already implemented in calls for bids, the Act regulates the use of contractors and subcontracting within BNIs for activities with significant safety implications, using a graduated system. Finally, the decommissioning arrangements were renovated in order enshrine in law the principle of dismantling as early as possible, in accordance with the following procedure:

- the licensee which intends to carry out final shutdown of its facility is required to notify this 2 years in advance (failing which, as early as possible). This facility may not then be subsequently restarted;
- it is then required to submit a file proposing the decommissioning conditions within 2 years;
- decommissioning is then prescribed by decree.

Finally, a facility that has been shut down for 2 years is considered to be definitively closed, except in special cases validated by the Minister responsible for nuclear safety, although the duration in such cases may not exceed 5 years.

Ordinance 2016-128 of 10th February 2016 comprising various provisions in the nuclear field strengthens the regulation of nuclear safety and the prevention of malicious acts using radioactive sources or nuclear materials.

This ordinance, implementing the TECV Act, first of all reinforces ASN's means of inspection and powers of sanction, by giving ASN more graduated tools such as fixed penalties and daily fines. ASN set up a sanctions committee accordingly. The authority can now also inspect the nuclear licensees outside the strict perimeter of the facilities.

The ordinance then creates a new obligation for the physical protection of radioactive sources, whether used in the nuclear industry, conventional industry, or for research, in order to prevent theft and malicious use. This system will be monitored by ASN. It also gives the Defence High Civil Servant at the French Ministry of the Environment, Energy and the Sea (MEEM) reinforced, graduated powers of inspection, in order to ensure that the nuclear licensees provide effective protection of nuclear materials against the risks of theft and malicious use.

The ordinance also introduces a certain number of other advances in the fields of nuclear safety and transparency. It more specifically:

- transposes the European directive on radioactive waste, reaffirming the ban on disposal in France of radioactive waste from abroad and requiring that waste produced in France be disposed of in France;
- extends the transparency obligations to the nuclear licensees and reinforces their responsibility;
- reaffirms the importance of the health protection of workers in the nuclear sector;
- in areas with a radon potential, creates an obligation for the vendor or landlord to inform the real estate buyers or tenants of the existence of these risks;
- authorises the creation of institutional controls on land and buildings polluted by radioactive substances.

2.2 Energy policy

With the TECV Act, France now has tools for overseeing and controlling the electricity production mix.

Energy transition will now involve a diversification of the sources of electricity production and supply, in particular with the aim of reducing greenhouse gas emissions.

This diversification will first of all require more rapid deployment of renewable energies by 2020, in accordance with France's undertakings to Europe, which implies a reduction in the nuclear share in order to reach a target of 50% nuclear power production by 2025.

The Act also aims to enable the electricity mix to be controlled through operating licenses for electricity production installations. A license will only be issued if the installation is compatible with the objectives of the Act and the multi-year energy programming (PPE). In particular, any new authorisation to operate a nuclear electricity production installation will need to comply with the current nuclear production capacity ceiling (63.2 GW) as stipulated in the Act. The commissioning of the Flamanville EPR will require that EDF close a plant or two reactors with total equivalent power.

B - SUMMARY

3. Summary

3.1 The challenges identified at the 6th Review Meeting

Following the 6th CNS Review Meeting, the following challenges were identified for France, in addition to regulation of the reactors in operation:

1. **Finalise integration of the lessons learned from the Fukushima Daiichi NPP accident**

   On this point, see § 6.3.1.3 which presents the stress tests, the 3 implementation phases and the progress made by the post-Fukushima national action plan. Also see § 14.1.1.2 related to Stress Tests.

2. **Finalise the studies for the continued operation of the NPPs beyond 40 years**

   On this point, see § 6.3.1 which deals with continued operation of the nuclear power reactors.

3. **Continue to examine safety culture issues**

   Following the IRRS mission held in France in 2014, ASN initiated international benchmarking work on safety culture, in order to draft a policy document specifying how ASN deals with this question in its practices and how safety culture is an integral part of ASN's four core values (competence, rigour, independence and transparency).

4. **Continue to work in the field of probabilistic safety assessments (PSA)**

   - Earthquake - seismic risk
   - Internal events – data reliability
   - Spent fuel storage pool – loss of coolant and rapid draining
   - Fire – validation of hypotheses

   On this subject, see §14.3 concerning application of probabilistic risk assessment methods.

5. **Focus on transferring and maintaining skills (succession planning)**

   - Staff turnover of about 40% over the period 2008 – 2017
   - Reinforcement of training programmes

   On this point, see § 11.2 concerning human resources.

6. **Guarantee sufficient human and financial resources**

   - Need for particular skills to successfully complete the forthcoming complex projects (implementation of post-Fukushima measures, continued operation of NPPs, harmonisation of population protection measures)

   On this point, see chapter 8 and § 11.2.

7. **Maintain efforts to ensure the quality of maintenance activities and identify issues concerning outage management (for example, reducing the collective dose and managing outage schedules)**

On this point, see § 19.3.

8. **Define guidelines concerning the role of subcontracting in a severe accident situation**

   On this point, § 12.4.3 (work done on organisational and human factors as relating to the stress tests) and § 19.7.4 (Publication of the national action plan on the implementation in France of the recommendations resulting from the European stress tests carried out in 2011).

3.2 International peer review missions and regulator independence

In France, the 2006 TSN Act gave ASN the status of an independent administrative authority (see § 2.1). ASN carries out its duties independently and with complete impartiality. This independence is embodied by the ASN Commission (see § 8.1.1.1).

ASN is closely involved in the IRRS (*Integrated Regulatory Review Service*) audit missions abroad and itself underwent one of these missions in 2006 and its follow-up mission in 2009. At France's request, ASN hosted another "full scope" IRRS audit mission in 2014 (see § 10.4.1).

For many years now, France has also asked IAEA to carry out OSART (Operational Safety Review Team) in-service safety assessment missions (see Appendix 5) and makes French experts available to take part in such missions abroad. In 2016, all French NPPs underwent at least one OSART mission.

Moreover, all the French NPPs are audited by the World Association of Nuclear Operators (WANO) by means of peer reviews. Since 2015, each unit is to be reviewed every four years, in conjunction with an EDF nuclear inspectorate audit (see § 10.2).

3.3 Main changes since France's 6th national report

3.3.1 Changes to the regulatory framework

The 2006 TSN Act and its implementing texts (BNI "procedures" Decree, "BNI" Order of 7th February 2012 (see § 7.1.3.1.2) and ASN statutory resolutions) set a framework for rigorous work and intervention. It is continuing with integration of the "reference levels" produced by WENRA, the European Nuclear Regulators Association (see § 7.1).

In 2014, the 2014/87/EURATOM directive of 8th July 2014 was published, supplementing the 2009/71/Euratom directive of 25th June 2009 establishing a community framework for the nuclear safety of nuclear installations and making substantial improvements to it (see § 7.1).

The TECV Act comprises a Title VI, the provisions of which reinforce nuclear safety and information of the public (see § 7.1).

Ordinance 2016-128 of 10th February 2016 constituting various provisions in the nuclear field, comprises legislative measures for the transposition of the Directive of 8th July 2014 and measures designed to reinforce the regulation of nuclear safety and radiation protection, by extending ASN's powers of oversight and sanction (see § 7.1).

In addition, the requirements concerning the safety case to be provided by the licensee are broadly based on the IAEA safety standards.

French regulations - which require a periodic safety review of nuclear installations - and the objectives set by ASN for the ongoing periodic safety reviews, both comply with the objectives of the Vienna declaration on nuclear safety, described in § 3.5, for existing reactors (periodic safety review, compliance with pertinent standards and best practices), as well as Council directive 2014/87/Euratom of 8th July 2014.

3.3.2 Transparency and public information

ASN takes part in public information within its areas of competence, notably by making the information in these fields accessible to the greatest number (see § 8.1).

Since January 2013, ASN has been posting its position statements on important subjects on its website. Moreover, pursuant to the TECV Act, all IRSN opinions issued at the request of the authorities after 17th February 2016 are published.

With regard to the nuclear facility licensees, transparency and communication measures are taken at various levels to optimise public information about operation of the facilities, technical events and activities carried out concerning safety (see § 9.2).

3.3.3 Changes further to safety reassessments

The main results of the safety reassessment of the nuclear installations, whether following the periodic review process or at implementation of modifications based on operating experience feedback, are presented in § 6.3. The main areas for change are as follows for nuclear power reactors:

- reinforcement of seismic resistance;
- controlling the risks resulting from explosive gases;
- site robustness to external natural hazards and electrical disruption;
- improved prevention of severe accident situations;
- mitigation of the risk of rapid drainage of spent fuel storage pools;
- improved severe accident management;
- equipment qualification in post-accident conditions.

Moreover, following these safety reassessments, ASN gave its general assessment of NPP performance in terms of safety, radiation protection, environment and labour inspection.

- In 2009, ASN issued an initial generic opinion on the continued operation of the 900 MWe reactors beyond thirty years. This assessment is to be supplemented by an individual opinion for each reactor: see details in § 6.3.1.1.2.
- Golfech 2 is the last 1300 MWe reactor to have adopted the improvements resulting from the second periodic safety review (in 2014). The conclusions of the second periodic safety reviews of the Belleville 1 and 2, Cattenom 4, Flamanville 1 and 2, Golfech 1 and 2, Paluel 3 and 4 and Penly 2 reactors are currently being examined. ASN intends to reach a decision concerning the continued operation of these reactors and set additional prescriptions to consolidate the safety of these sites in 2016 and 2017. In addition, in early 2015, ASN issued a first generic opinion on the continued operation of the 1300 MWe reactors beyond thirty years of operation. ASN will issue a specific opinion on the continued operation of the Paluel 2 reactor (the first 1300 MWe reactor to have integrated the safety improvements specified for the third periodic safety review) after submission of the periodic safety review conclusions report (scheduled for 2017).
- The four 1450 MWe reactors carried out their first ten-yearly outage inspection and took the opportunity to conduct the planned conformity checks and the modifications resulting from the first periodic safety review. In 2016, ASN will issue a ruling on the continued operation of these reactors after reviewing the conclusions reports submitted by EDF.

B - Summary

For the research reactors, the safety reassessments primarily concern the following fields:

- seismic resistance,
- fire protection,
- containment of radioactive substances,
- improved management of aspects common to several installations on a given site.

Moreover, a more harmonised approach to safety has been developed in recent years for this wide variety of installations, derived from the rules applicable to the power reactors. This approach in particular concerns the safety assessment based on "operating conditions" (postulated initiating events) and the safety classification of the associated equipment. This has led to significant progress in terms of safety.

3.3.4 The results of implementation of post-Fukushima measures

On the basis of the conclusions of the stress tests carried out both in Europe and nationally, ASN issued a range of resolutions on 26th June 2012 (EDF and CEA) and 10th July 2012 (ILL), requiring that EDF, CEA and ILL create:

- a "hardened safety core" of material and organisational provisions aimed at:
  - ➢ preventing a severe accident or limiting its progression;
  - ➢ limiting large-scale radioactive releases;
  - ➢ enabling the licensee to perform its emergency management duties.
- a local emergency centre allowing emergency management of the nuclear site as a whole in the event of an extreme external hazard;
- for EDF, a nuclear rapid intervention force (FARN) which, using mobile means external to the site, can intervene on a nuclear site in a pre-accident or accident situation.

And secondly, a range of corrective measures or improvements (notably the acquisition of complementary communication and radiological protection means, the implementation of additional instrumentation, extensive consideration of internal and external hazard risks, and improvements in the way emergency situations) are handled. For CEA's Masurca reactor, the conclusions of the stress tests (see § 14.1.1.2) led ASN to prescribe the removal of the fissile material stored in the facility.

ASN issued additional requests in a range of resolutions on 21st November 2013 for the ILL, 21st January 2014 for EDF and 8th January 2015 for CEA, designed to clarify certain hardened safety core design requirements and site provisions for the management of emergency situations. For CEA, these provisions, which are specific to an individual reactor or common to all the installations on a given site, in particular comprise setting up an organisation to ensure local reinforcements between sites, on the one hand for long-term management of an accident situation and, on the other, to ensure independent operation of the hardened safety core equipment for the first 48 hours.

For the nuclear power reactors, to take account of both the engineering constraints involved in these major works and the need to introduce the post-Fukushima improvements as soon as possible, their implementation by EDF has been organised in three phases:

- **<u>Phase 1 (2012-2015):</u>** implementation of temporary or mobile measures to reinforce the response to the main situations of total loss of the heat sink or electrical power supplies:

- **<u>Phase 2 (2015 – about 2020):</u>** implementation of definitive design and organisational means that are robust to extreme hazards, such as the fundamental elements of the hardened safety core designed to deal with the main situations of total loss of the heat sink or electrical power supplies beyond the baseline safety requirements in force.
- **<u>Phase 3 (as of 2019):</u>** this phase supplements phase 2, in particular to improve the level of coverage of the potential accident scenarios considered. EDF states that these means have also been defined with a view to continuing operation of the reactors beyond forty years.

For research reactors, the supplementary stress tests are scheduled to run until 2016. The deployment of organisational measures to manage emergency situations and new equipment belonging to the hardened safety core will continue until 2018. The ILL will be the first BNI to completely deploy its "hardened safety core" which will be virtually complete by the end of the major outage scheduled for 2017.

More details on the post-Fukushima measures and their implementation are presented in § 6.3.1.3.

3.3.5 Organisational and human factors

ASN considers that progress is needed with regard to the contribution of human and organisational factors to the safety of nuclear facilities and therefore set up the COFSOH (Steering Committee for Social, Organisational and Human Factors, see § 12.4.3). The discussions held within this committee cover the following topics: subcontracting conditions and the relations between ordering customer and subcontractors, the boundary between "managed safety" and "regulated safety", the management of emergency situations and the legal questions raised by these subjects.

3.4 Issues identified by the special rapporteur to the 6th review meeting on the post-Fukushima question

During the CSN 6th review meeting, a peer review of all national reports on the topic of post-Fukushima measures was carried out by a special rapporteur, Mr Petteri Tiippana (Finland).

Following the observations arising from this review, a certain number of challenges to be considered by the Contracting Parties were identified by the special rapporteur:

1. **How to reduce disparities between the Contracting Parties with regard to the safety improvements to be made to the nuclear facilities?**

   Incorporation of international operating experience feedback (OEF) is dealt with in § 19.7.

   More specifically with regard to the post-Fukushima measure, § 14.2.1.6 states that the France national action plan takes account of the recommendations arising from the European peer review and those arising from the 2nd CSN extraordinary meeting. This action plan takes account of international OEF and is not simply the result of national deliberations.

   Finally, ASN actively participates in the work of the WENRA association aimed at "upwards" harmonisation of the safety levels in new and existing facilities.

2. **How to harmonise the emergency plans and response measures?**

   The 2014 position of the HERCA and WENRA associations (see § 16.1) for improved transboundary coordination of the protective measures during the first phase of a nuclear accident recommends:

- outside emergency situations, exchanges between countries to promote improved mutual familiarity with and understanding of their emergency organisations;
- in an emergency situation:
  - if sufficient information is available, alignment of the population protection measures in neighbouring countries with those decided on by the country in which the accident occurred;
  - if urgent population protection measures are needed, but little information is available, predefined “reflex” measures are to be implemented.

A summary of the implementation of this approach by the Member States must be presented to ENSREG in 2016 (see § 16.1).

3. How to take greater advantage of operating experience feedback from nuclear installations and regulatory oversight, as well as from the international peer review services?

France carries out periodic safety reviews of the facilities, enabling operating experience feedback to be integrated and modifications made to improve reactor safety (see § 6.3). The France national action plan established in the wake of the Fukushima Daiichi NPP accident takes account of the peer review performed within the European Union. Finally, the routine operation of the facilities benefits from regular peer reviews (OSART, reviews by the WANO association) (see § 3.2)

4. How to reinforce the independence of the regulatory body, safety culture, transparency and openness?

- Concerning the independence of the regulatory body, see § 3.2.
- Concerning licensee transparency, see § 9.2.
- Concerning safety culture, see § 10.

5. How to encourage all countries to commit to international cooperation and meet their commitments?

Cooperation between safety regulators is being developed within bilateral, regional (for example European) and international frameworks. These three cooperation contexts would appear to be both useful and complementary for the implementation of measures at different levels.

Bilateral exchanges are often highly informative and of great value to both parties. On the one hand they lead to improved understanding of regulations and practices in the field and, on the other, allow continuous monitoring of topical subjects on both sides. They are crucial to relations between authorities regulating transboundary NPPs.

At a regional level, the steps taken by the safety regulators generally look at broader subjects with a wider perspective. Regional clubs and associations constitute a forum for reflection and discussions of interest to both nuclear and non-nuclear countries sharing the same geographical region but sometimes without the human and financial resources needed to develop extensive bilateral relations. The importance of deploying common tools to facilitate the circulation of information and harmonise the management of emergency situations between neighbouring countries is self-evident. Peer reviews by members from the same geographical region on precise topics would seem likely to be able to effectively improve the safety of the facilities.

International forums bring together a large number of safety regulators and representatives from member countries, with the organisation of major events, in particular the convention review meetings. The difference in the size of NPP fleets, the large number of participants and the content of the debates can lead to the dilution of important messages and thus hinder the implementation of the recommendations made at the conclusion of the review meeting. Holding transverse reviews of the contributions of the various countries on clearly defined topics covering fields of interest common to all or some of the contracting parties could stimulate high-level discussions and lead to a few clear and concise recommendations, the implementation of which could be presented at interim meetings between two review meetings.

§ 20.1 presents ASN's international activities.

3.5 Implementation of the principles of the Vienna declaration

At the CSN 6th review meeting, the Contracting Parties approved the organisation of a Diplomatic Conference, the aim of which was to enable the Contracting Parties to discuss the amendments proposed by Switzerland concerning Article18 of the Convention.

This conference was held in Vienna on 9th February 2015 and led to a consensus of all the Contracting Parties present to adopt the Vienna declaration on nuclear safety.

This declaration contains three main principles, which reflect one of the three fundamental objectives of the Convention, that is to prevent accidents with radiological consequences and mitigate the consequences should an accident occur.

1. **The new NPPs must be designed, sited and built in accordance with the goal of preventing accidents at commissioning and during operation and, in the event of an accident, of mitigating any releases of radionuclides causing long-term off-site contamination and of preventing early releases of radioactive materials and releases of radioactive materials on a scale such that long-term protective measures are necessary.**

   With regard to the new NPPs (EPR reactor under construction), more specifically see § 7.1 concerning the legislative and regulatory framework, § 18.3.2 concerning design criteria and § 19.4.2 concerning the management of incidents and accidents.

   The Flamanville 3 authorisation decree (Decree 2007-534) 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”. ASN will not be able to authorise the commissioning of Flamanville 3 until EDF has demonstrated safety case compliance with these requirements. In its commissioning authorisation application file for Flamanville 3, EDF transmitted its safety case. A session of the Advisory Committee for reactors was devoted to analysing this safety case in October 2015. ASN anticipates issuing a position statement on this subject in 2016.

2. **Complete and systematic safety assessments must be carried out periodically and regularly throughout the life of the existing facilities, in order to identify the safety improvements needed to achieve the above-mentioned objective. The reasonably possible or feasible safety improvements must be implemented in good time.**

With regard to the existing power reactors, see § 6.3.1.1 and 14.2.1.3 concerning periodic safety reviews, § 6.3.1.2 concerning modifications made further to operating experience feedback, § 6.3.1.3 concerning steps taken further to the stress tests, § 7.1 concerning the technical and regulatory framework and § 19.4.2 concerning the management of incidents and accidents.

France carries out periodic safety reviews of the facilities, enabling operating experience feedback to be integrated and modifications to be made to improve reactor safety (see § 6.3). These periodic safety reviews comprise not only an assessment of the control of equipment ageing, but also a reassessment of the safety of the facility, based on the safety objectives of the more recent facilities. On this occasion, ASN asked the licensees to make modifications to the facilities in order to ensure closer compliance with these objectives.

The "BNI" order (see § 7.1.3.1.2) in fact asks the licensees to implement a system for processing deviations detected during operation. These deviations may in particular lead to questions being asked with regard to the quality of the design and construction of the nuclear facility. Relevant corrective or preventive measures are then taken, under ASN supervision, without waiting for the next periodic safety reviews.

3. **National prescriptions and regulations designed to ensure compliance with this objective throughout the service life of the NPPs must take account of the pertinent IAEA safety standards and, as applicable, other best practices identified in particular during the CSN review meetings.**

French legislation and regulations applicable to BNIs are based on the fundamental principle of the prevention of accidents with radiological consequences and the mitigation of said consequences should an accident occur.

The Environment Code (article L. 593-7) thus states that a creation authorisation may only be issued for a BNI if, in the light of scientific and technical knowledge, the licensee can demonstrate that the technical or organisational measures it is required to take at the design, construction and operating stages, as well as the general principles proposed for decommissioning, are such as to prevent or adequately mitigate the risks or drawbacks of the facility for the protected interests (public health and safety and the protection of nature and the environment).

The Environment Code (Article L.593-18) requires that the licensee of a BNI periodically conduct a safety review of its facility, taking international best practices into account. The purpose of this periodic review is to assess the situation of the facility in the light of the rules applicable to it and to update the assessment of the risks or drawbacks that this facility presents with regard to the above-mentioned protected interests, more specifically taking account of the condition of the facility, the experience acquired during its operation, changes in knowledge and in the rules applicable to similar facilities. These safety reviews are held every ten years.

With regard to the nuclear power reactors, the periodic safety review process includes examination of operating experience feedback, changing knowledge and changing safety standards, in particular those of IAEA. The OSART missions conducted on the sites or in the licensee's head office departments (see Appendix 5), are also based on the IAEA standards and best practices in force.

Ordinance 2016-128 of 10th February 2016 comprising various nuclear provisions reinforces the regulations by requiring that the regulations on nuclear safety and its oversight be maintained and improved (Article L. 591-2 of the Environment Code). This Code (Article L. 591-6) also now requires that every ten years, the State conduct at least a periodic self-assessment of its regulations and its regulatory authority (ASN) and undergo an international peer review with a view to the continuous improvement of nuclear safety. This obligation, which appeared in the ASN internal regulations, is now enshrined in law. These assessments will be organised jointly by the Ministers responsible for nuclear safety or radiation protection and by ASN. They will take the form of "IRRS" missions, as mentioned in § 3.2 and § 10.4.1.

Finally, Articles L. 591-7 and L. 591-8 of the Environment Code stipulate on the one hand that thematic nuclear safety and radiation protection reviews will be organised every six years by the State in the form of national evaluations followed by peer reviews and, on the other, that an international peer review will be held in the event of an accident. These assessments and peer reviews will be organised jointly by the Ministers responsible for nuclear safety, radiation protection, civil security and by ASN.

The BNI Order and the ASN statutory resolutions (see Appendix 2) also incorporate the WENRA reference levels into the French regulations.

3.6 Safety outlook for the next three years

ASN work and regulation will be focused on the following main elements:

3.6.1 Regulation of the NPPs in service

Regulation of the NPPs in service remains a priority for ASN, which considers that improving the facilities in operation first of all requires control of the condition of the reactors, of the operating baseline requirements (including the general operating rules) and of routine work such as maintenance, oversight and operations. EDF must continue its efforts in these areas. With regard to environmental protection, ASN is continuing to examine the discharge and water intake license modification files and will set discharge limits on the basis of the best available techniques, ambient environment protection targets and lessons learned from the plants in service.

The periodic safety review for the 900 MWe reactors, with a view to extending their service life beyond 40 years, is the framework adopted by ASN, on the one hand to query EDF's ability to maintain its installations and their operating documentation in conformity with the defined requirements and, on the other, to reinforce the safety objectives of these installations. ASN considers that it is important to share the lessons it learns from this approach with other countries.

3.6.2 Experience feedback from the Fukushima Daiichi NPP accident

Following on from the actions of 2012, ASN is paying particular attention to how EDF, CEA and ILL take account of experience feedback from the accident at the Fukushima Daiichi NPP. ASN is specifically monitoring the steps necessary for implementation of the additional safety measures requested following the stress tests. ASN issued a position statement on the proposal by these licensees to deploy a "hardened safety core" of material and organisational measures to control the fundamental safety functions in extreme situations. ASN supplemented its requests by a range of resolutions dated 21st November 2013, 21st January 2014 and 8th January 2015, to clarify certain provisions of the "hardened safety core" and associated requirements. It is currently reviewing the natural hazard levels to be considered for the situations adopted for the hardened safety core and the design of these systems as related to the prevention and accident control strategies proposed.

B - Summary

3.6.3 Monitoring of the Flamanville 3 EPR reactor

ASN has received the commissioning and partial commissioning authorisation application files for Flamanville 3. It analysed the acceptability of these two files and sent requests for additional information to EDF. ASN has also begun the technical examination of these files. ASN was thus able to examine subjects concerning the equipment classification approach, the level 1 probabilistic safety assessments and the detailed design of certain systems.

Oversight of construction (§ 18.3.4.1) and of the start-up tests (§ 19.1.2) for Flamanville reactor 3 will continue until the end of the commissioning authorisation application review procedure. At the peak of the systems erection and testing activity, ASN intends to focus its oversight on EDF's monitoring of the quality of work and the prevention of occupational accident risks. At the same time, ASN will continue with its review of the commissioning authorisation application file. It will aim to cooperate as extensively as possible with its foreign counterparts, particularly within the framework of the MDEP group, with the goal of achieving harmonised positions.

3.6.4 Monitoring of the RJH and ITER reactors

The two main research facilities currently under construction in France are the RJH and ITER. ASN regulated the main steps in the design and construction of these facilities through resolutions issued in 2011 and 2013. Regular inspections at the suppliers have so far demonstrated that safety issues on these worksites are addressed satisfactorily.

The significant delays on these worksites have no safety implications as yet. The changes to the calendar have led ASN to accept a request from ITER for modification of the resolution regulating the design and construction of the facility. The Resolution 2013 – DC – 0379 of 12th November 2013 has been amended by Resolution 2015 – DC – 0529 of 22nd October 2015 in order to change some of the submission deadlines for certain safety analyses (detritiation system, automated transfer hood, auxiliary building, etc.).

C – GENERAL PROVISIONS

4. Article 4: Implementation measures

Each Contracting Party shall take, within the framework of its national law, the legislative, regulatory and administrative measures and other steps necessary for implementing its obligations under this Convention.

This report presents the legislative, regulatory and administrative measures and other steps taken by France to implement its obligations under the Convention.

5. Article 5: Presentation of reports

Each Contracting Party shall submit for review, prior to each meeting referred to in Article 20, a report on the measures it has taken to implement each of the obligations of this Convention.

This report is the seventh French report submitted for review in compliance with Article 5 of the Convention.

6. 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

6.1.1.1 The existing NPPs

The NPP reactors currently covered by the scope of the Convention include 58 PWR reactors, built in successive standardised series, which were coupled to the grid between 1977 and 1999 and are all in service.

In 2015, the PWR reactors produced 416.8 TWh, or about 76% of the electricity generated in France (415.9 TWh and 77% respectively in 2014; 403.7 TWh and 73% in 2013). They are located on 19 NPPs in operation comprising from two to six reactors of the same type (PWR). The 58 reactors have been built by the same supplier, Framatome, which is today known as AREVA NP. The following reactor series are identified (refer to the location map in Appendix 1 - § 1.1):

Among the thirty-four 900 MWe reactors:

- the CP0 series, comprising the two reactors at Fessenheim and the four reactors at Bugey ;
- the CPY series, comprising the other twenty-eight 900 MWe reactors (Dampierre, Gravelines, Blayais, Tricastin, Chinon, Cruas and Saint-Laurent-des-Eaux).

Among the twenty 1300 MWe reactors:

- the P4 series, comprising the four reactors at Paluel, the two reactors at Flamanville and the two reactors at Saint-Alban ;
- the P'4 series, consisting of the two reactors at Belleville-sur-Loire, the four reactors at Cattenom, the two reactors at Golfech, the two reactors at Nogent-sur-Seine and the two reactors at Penly.

The N4 series, which consists of four 1450 MWe reactors: two at Chooz and two at Civaux 1/2.

In December 2015, the average age of the reactors, based on the dates of the first reactor criticality phases, stood as follows:

- 34 years for the thirty-four 900 MWe reactors;
- 28 years for the twenty 1300 MWe reactors;
- 18 years for the four reactors of the N4 plant series.

Because of the standardisation of the French nuclear power reactor fleet, certain technological innovations were introduced successively as design and construction of the reactors proceeded.

The CPY series differs from the CP0 series in building design, in the addition of an intermediate cooling system between that used for containment spraying in the event of an accident and that containing river water, and in a more flexible control.

Significant changes in relation to the CPY plant series were made in the design of the core protection circuits and systems for the 1300 MWe reactors and in the buildings housing them. The power increase involves a reactor coolant system with four steam generators (the 900 MWe reactors are equipped with three steam generators). Furthermore, the reactor containment comprises a double concrete wall instead of a single wall with a steel leak tightness liner, as on the 900 MWe reactors. The reactors of the P'4 series differ slightly from those of the P4 series, particularly with regard to the fuel building and systems.

Finally, the N4 series differs from the previous series in the more compact steam generator design and the primary pump design, and in the use of a computerised interface for reactor operations.

6.1.1.2 The Flamanville 3 EPR reactor

Construction of an EPR type reactor began on the Flamanville site in 2007.

As at the end of 2015, 98% of the main civil engineering work has been completed: the 2 domes of the reactor building have been concreted. Most of the mechanical components of the nuclear steam supply system have been delivered to the site and introduced into the reactor building. Welding of these components is in the final stages and has been marked by the detection of several defect indications in the welds. The reactor vessel at present is the subject of a complementary qualification programme (see § 18.2.4.2.1).

6.1.2 Research reactors

Although the research reactor safety is not within the scope of the Convention, this national report describes the measures being taken concerning the French research reactors, which are subject to the same regulations as nuclear-power reactors.

Administratively speaking, 11 research reactors are in service in France, which means that they are still subject to the regulatory process of an operating installation. Consequently, these figures take account of the number of installations shut down, either temporarily for renovation or modification, or permanently, pending decommissioning (case of Phénix, see below). One reactor, Ulysse, changed status during the period due to the promulgation of its final shutdown and decommissioning decree in August 2014.

The vast majority of research reactors in France are also of the pool type. Only the Masurca reactor, a critical mock-up intended for neutron studies for fast-neutron reactor technology, is air-cooled. The Phénix fast neutron reactor, which was used for research and produced electricity, was taken off the grid in 2009, ceased all operation at power that same year and has been kept shut down.

Most of those reactors were commissioned between the 1960s and the 1980s. The reactors have generally undergone significant work to improve their safety since then. However, on completion of its periodic safety review, the safety requirements led to final shutdown of the Osiris reactor in 2015. The Phébus reactor has also been definitively shut down.

Among these 11 research reactors, 10 are operated by CEA at its Cadarache, Saclay and Marcoule sites.

The High-flux Reactor (HFR) is located close to CEA's Grenoble site and is operated by the *Institut Laue-Langevin* (ILL), a research institute grouping several European partners.

CEA, in partnership with EDF and AREVA and other foreign entities, is building the Jules Horowitz reactor (RJH) in Cadarache, with a view to it taking over from the European irradiation reactors currently in service but whose ageing will lead to their shutdown in the short or medium term. This new pool-type irradiation reactor will help cover research and development needs as well as, for example, production of artificial radionuclides for medical purposes and doped silicon for the electronics industry.

The civil engineering work is continuing and reactor commissioning is currently scheduled for 2019.

In France the regulations applicable to research reactors are the same as those which apply to other nuclear facilities, in particular power reactors. The analysis of their safety case and the steps taken to guarantee it are the result of a “graduated approach” consisting in adapting the resources to be implemented to the various risks potentially presented by these facilities. When relevant, ASN can call on requirements which apply specifically to research reactors, or to certain types of operations performed in them. These are however simply adaptations of regulatory requirements that exist elsewhere.

The list of French research reactors in service, along with a map showing their locations, is given in Appendix 1.

To these reactors can be added the ITER (International Thermonuclear Experimental Reactor) project, which concerns an experimental facility designed to provide scientific and technical demonstration of control of thermonuclear fusion obtained by magnetic confinement of a deuterium-tritium plasma, during long-duration experiments with significant power (500 MW for 400 s).

6.2 Main significant events over the past three years

The analysis of significant events over the period 2013-2015 and ASN's assessment, are given in §19.6. The main significant events (INES level 1 or 2) are described below:

6.2.1 Nuclear power reactors

Significant radiation protection event notified on 26th April 2013 involving the external contamination of a maintenance worker.

On 24th April 2013 an employee of Kaefer Wanner, an EDF service provider company, was accidentally exposed on the neck to a dose exceeding the corresponding annual regulatory limit.

The worker was irradiated during the scheduled shutdown of reactor n° 4 of the Blayais NPP (Gironde) when performing maintenance work. He was examined by the site's occupational medicine service and his clinical assessment was normal.

The analysis of this incident provided the opportunity to review the management of contaminated persons.

Because the annual regulatory dose to the skin was exceeded, ASN confirmed the level-2 rating of this event on the International Nuclear Events Scale (INES).

Significant event for general safety notified on 28th March 2014 concerning a temperature deviation in the premises housing the emergency turbine generator set (TAS LLS)

The heat produced by the emergency turbine generator set (TAS LLS) leads within less than one hour to temperatures in the room in question exceeding the maximum permissible temperatures for some of the equipment items necessary for operation of the TAS LLS.

In the event of total loss of the electrical power supplies or failure of the two backed-up electrical distribution switchboards LHA and LHB, the TAS LLS supplies electricity for the following functions:

- injection at the primary pump seals (IJPP) which is necessary to maintain primary system integrity,
- emergency lighting in the control room,
- the ultimate instrumentation & control which enables the steam generator (SG) emergency feedwater flow to be regulated, among other things.

Furthermore, for the Bugey reactors, operation of the steam generator turbine-driven auxiliary feedwater pump (TPS ASG) situated in the same room as the TAS LLS, cannot be guaranteed. Consequently, the TAS LLS and - for the Bugey reactors - the TPS, might not be able to fulfil their function, that is to say maintain the integrity and cooling of the main primary system during the 24-hour period adopted in the safety case for situations of total loss of electrical power supplies, called "station blackout" (SBO).

ASN has asked EDF to put in place a series of protective and compensatory measures until this deviation is lastingly resolved.

In view of these factors, the event was rated level 1 on the INES scale.

Significant safety event notified on 29th May 2015 involving untimely opening of valve 1 GCT 021 VV leading to reactor trip and safety injection at Cattenom.

On 28th May 2015, reactor 1 of the Cattenom NPP was maintained at a nuclear power approaching 2% of its nominal power after having completed the restarting tests which followed its maintenance and partial refuelling outage. Reactor cooling was ensured by the steam generators.

The reactor protection system triggered a series of automatic measures which automatically shut down the reactor as a result of a turbine bypass system (GCT) valve being blocked in the fully open position. The deterioration of the reactor's thermohydraulic parameters led the licensee to trigger the on-site emergency plan (PUI).

The technical cause of this event was the failure of a secondary system steam blowdown valve positioner.

The leakage of steam was stopped by closing a second valve. EDF reduced the pressure and temperature of the reactor main primary system. The conditions allowing connection of the normal cooling system on shutdown were attained and this system was connected without delay. The reactor was subsequently brought to normal operating conditions. There were no discharges into the environment.

ASN conducted reactive inspections on the Cattenom site as of 29th May 2015. The event was rated level 1 on the INES scale.

Significant safety event notified on 12th October 2015 involving loss of the external electrical power supplies of the Flamanville NPP reactor 2.

On 9th October 2015, reactor 2 of the Flamanville NPP had been in shutdown status for maintenance and refuelling since 22nd August 2015. The reactor core was unloaded and the fuel assemblies were stored in the spent fuel pit. In this configuration, the safety function which consists in cooling the spent fuel pit must be ensured continuously.

While work was in progress on the main electrical power supply, the rupture of a seal in the auxiliary transformer cooling system caused an oil leak leading to shutdown of the cooling system and loss of the reactor's external electrical power supplies. Electrical power for the spent fuel pit was then supplied by an emergency generator set. The licensee tightened the monitoring of this generator set and planned for a sufficient supply of fuel to supplement the available reserves.

EDF also prepositioned the site's combustion turbine in preparation for the contingency of a generator set failure. It also had sufficient water makeup resources to top up the spent fuel pit as required.

The criteria for triggering the on-site emergency plan were not reached, and there were no discharges of radioactive substances or hydrocarbons into the environment. The auxiliary transformer was powered on again on 13th October 2015 at 9h05. Two reactive inspections were carried out, one on 13th October 2015, the other on 22nd and 23rd October 2015.

This event was rated level 1 on the INES scale.

Significant safety event notified on 12th November 2015 concerning the seismic resistance of the RRI (component cooling system) standardised train of the CPY plant unit.

EDF notified a first significant event affecting the seismic resistance of the 1300 MWe plant unit RRI in 2010. This event led EDF to initiate complementary studies on all the reactors in the fleet. The studies demonstrated that the N4 and CP0 plant series were not concerned by this deviation in conformity. In 2014 however, the licensee signalled the emergence of a conformity deviation on the CPY series and notified a significant safety event on 12th November 2015. The deviation affects several supports for which the line design notes do not exactly correspond to the drawings.

Consequently, the optimised design calculations demonstrate that several supports in the common part of the component cooling system (RRI) might not withstand a safe shutdown earthquake (SSE), which would prevent the RRI system from fulfilling its safety function.

Loss of the RRI system would ultimately lead to a break in the primary system through loss of primary pump seal cooling. Loss of the system would also ultimately lead to exposure of the fuel elements through loss of the fuel cooling pool cooling system and would affect the regeneration function of the nuclear sampling system (REN) secondary heat exchangers.

EDF has implemented measures to counter loss of the RRI. More specifically, the use of its local and national means for resupplying water to the spent fuel pit, and temporary instructions have been drawn up to protect the primary pump seals by manual isolation. The work to restore the conformity of this system is currently in progress. The most sensitive reactors will be brought into conformity in 2016, the others will follow in 2017 and 2018.

The event was rated level 1 on the INES scale.

6.2.2 Research reactors

An event that occurred on the RHF installation in the Laue-Langevin Institute (ILL) on 13th July 2013 was rated level 1 on the INES scale. This event relates to the presence outside the reactor building of a beam of ionising radiation emitted by an experimental device, in an area not provided for this purpose. Two researchers who were standing near the reactor building were alerted of the presence of an unexplained significant dose rate by their active dosimeter. The investigations revealed that an experimental instrument had been put into service when its radiological protection was not completely installed; it was shut down as soon as the anomaly was discovered. The two researchers reportedly received a maximum effective dose of 15 µSv, compared with an authorised limit of 20 mSv or 20000 µSv per year. Complementary investigations were undertaken for the sixteen persons having potentially moved around the area during the period in question. These investigations did not reveal radiological exposure exceeding the recording thresholds.

An event that occurred on the RHF installation in the Laue-Langevin Institute (ILL) on 24th June 2015 was rated level 1 on the INES scale. An operator exposed the skin of the palm of his hand to a dose exceeding one quarter of the annual regulatory dose limit when inspecting a radiation protection device which involved handling a radioactive calibration source. The estimated dose received on the palm of the operator's hand was 250 mSv.

An event on 8th July 2015 concerning noncompliance with the negative pressure required within the RHF reactor building at the Laue-Langevin Institute (ILL) was rated level 1 on the INES scale. The negative pressure inside the reactor building containment ensures dynamic containment. The licensee observed a slight positive pressure in the containment when measuring the operating parameters of the installation. This situation lasted about eleven hours. The loss of negative pressure should have been signalled by an alarm as soon as it occurred, but the alarm had been disabled and therefore could not function.

6.3 Continuation of reactor operation: Control of ageing and periodic safety review of the nuclear installations

The safety reassessments mechanism is presented in chapter 14. The main safety improvements currently being implemented or which have already been made to the nuclear facilities since France's previous report, are summarised in the following sections.

6.3.1 Measures taken on nuclear power reactors

Pursuant to article L. 593-18 of the Environment Code, the licensee is obliged to conduct a periodic review of its installations every ten years in order to ensure that they comply with the applicable rules, to verify control of their ageing, and to review their safety. The 10-yearly outages provide the ideal opportunity to carry out large-scale inspections and to make modifications to the installations to enhance their safety.

6.3.1.1 Periodic safety reviews

The periodic safety review process, which is based on the R&D results and observations from the maintenance activities which ensure the conformity and integrity of the equipment over time with respect to ageing mechanisms (see § 19.3.2.2), enables EDF to continue operating the reactors, subject to ASN agreement. It is based on an examination of operating experience feedback, advances in knowledge and changes in safety standards.

The periodic safety review is carried out during the reactor 10-yearly outages. The following table shows the progress of the 10-yearly outages (VD) for the different standardised nuclear reactor plant series.

	VD1 10 years	VD2 20 years	VD3 30 years	VD4 40 years
900 MWe – 3 loops (34 units)	Done	Done	2009 to 2020	2019 to 2030
1300 MWe – 4 loops (20 units)	Done	Done	2015 to 2024	2025 to 2034
1500 MWe – 4 loops (4 units)	Done	2019 to 2022	2029 to 2032	2039 to 2042

Table 1: 10-yearly outages of the nuclear power reactor plant series

Over the 2013-2015 period the main projects concerned the 900 MWe reactors (performance of the 3rd 10-yearly outages (VD3) and preparation of the 4th 10-yearly outages (VD4s)), the 1300 MWe reactors (performance of the VD2s, preparation and first VD3) and the 4 reactors of the N4 series (preparation of the VD2s).

As at the end of 2015, the VD3s have been carried out on 20 reactors of the 900 MWe series (out of 34). The VD2s have been carried out on the 20 reactors of the 1300 MWe series and the first VD3 has started on a 1300 MWe reactor. The VD1s have been carried out on all the N4-series reactors.

6.3.1.1.1 Ageing control: demonstration of in service resistance of reactor vessels

During operation, the mechanical properties of the reactor vessel metal undergo changes making it more susceptible to thermal shocks under pressure or to sudden rises in pressure when cold. The demonstration of the reactor vessel's resistance to sudden rupture takes this phenomenon into account, but must be revised periodically to take account of the development of knowledge.

The following steps were taken as of start-up to prevent any risk of rupture:

- a programme for monitoring the phenomenon of metal embrittlement due to irradiation: test pieces made of the same metal as the vessel were placed inside it and are used to perform mechanical tests;
- periodic inspections to verify the absence of defects or, if manufacturing defects are indeed found, to check that they do not develop.

ASN regularly examines the vessel files transmitted by EDF.

Thus the file concerning the in-service behaviour of the 900 MWe reactor vessels for the ten years following their third ten-yearly outage inspections was presented to the Advisory Committee of Experts for nuclear pressure equipment in June 2010. ASN considered that operation of these vessels for the period considered was acceptable, but has asked EDF to conduct further investigations and provide additional data to reinforce the guarantees obtained. ASN has more specifically reissued its request for 5-yearly re-inspection of the Tricastin 1 reactor vessel, which displays 20 defects under the liner and asked EDF to maintain or install heating of the safety injection system on the Tricastin 1, Fessenheim 2 and St Laurent B 1 reactors in order to limit vessel loadings in the event of an accident situation. ASN is at present examining the first answers provided by EDF on this matter, and in April 2016 it stated its position on the file concerning the in-service behaviour of the 1300 MWe reactor vessels beyond their third ten-yearly outages.

6.3.1.1.2 Third ten-yearly outage of the 900 MWe reactors (VD3)

Details about ageing management during 900 MWe reactors VD3 are addressed in § 14.2.1.4

The main changes made following adoption of the 900 MWe VD3 safety baseline requirements include:

- strengthening of seismic resistance; the work mainly concerns the Bugey site;
- greater consideration given to the risk arising from explosive gases. Premises comprising an explosive atmosphere risk were equipped with hydrogen detectors and/or explosion-proof equipment;
- enhanced site robustness to external natural hazards, mainly by improving the long-term reliability of the diesel generators;

- consideration of the risk of rapid drainage of spent fuel storage pools. The purpose of the modifications to be implemented is to increase the time available to the operator to return the fuel assemblies to a safe position during handling: automatic shutdown of pool pumps at very low level and measurement of emptying rate;
- improved severe accident management, notably by increasing the reliability of the reactor coolant system depressurisation device with the pressuriser valves, even in the event of severe accidents generated by a station black-out situation;
- improving reactor performance and addressing the obsolescence of the I&C hardware through the renovation of certain equipment which would be unable to reach a 40-year service life.

In 2009, ASN issued an initial generic opinion on the continued operation of the 900 MWe reactors beyond thirty years. This assessment is to be supplemented by an individual opinion for each reactor. After making a statement on the continuation of operation of the Tricastin reactor No.1 beyond its third periodic safety review in 2010, and on that of the Fessenheim reactor no.1 after its third 10-yearly outage (VD3) in 2011, ASN approved the continued operation of the Bugey reactor No.2 in 2012, of the Fessenheim reactor No.2 and Bugey reactor No.4 in 2013, of the Bugey reactor No.5 and Dampierre reactor No.1 in 2014, and of the Tricastin reactors No.2 and 3 in 2015. These ASN resolutions on the continuation of operation are available on the ASN website. Furthermore, the Blayais NPP reactors No.1, 3 and 4, Dampierre NPP reactors No.1, 2, 3 and 4, Gravelines NPP reactors No. 1, 2, 3 and 4, Bugey NPP reactor No.3, Chinon NPP reactor No. 1, Saint-Laurent NPP reactors No.1 and 2, Tricastin NPP reactor No.4 and Cruas NPP reactors No.1 and 3 have incorporated the improvements resulting from the periodic safety review carried out during their third 10-yearly outage.

The noteworthy work undertaken on the Fessenheim NPP reactors No.1 and 2 further to the ASN prescriptions and completed in 2013 includes reinforcement of the basemat and installation of an ultimate makeup system.

ASN will likewise rule on the continued operation of the reactors which have not yet received a ruling after examining the periodic safety review reports submitted by EDF (in 2016 and 2017, Dampierre 2, Blayais 1, Gravelines 1, Bugey 3, Gravelines 3).

6.3.1.1.3 Second ten-yearly outage of the 1300 MWe reactors (VD2)

In 2006, ASN declared itself to be in favour of continued operation of the 1300 MWe reactors beyond their second ten-yearly outage, provided that the modifications decided on during this review were effectively implemented. The improvements arising from this safety review have been integrated until 2014, on the occasion of the second ten-yearly outage. The most significant modifications include:

- optimisation of the filtered containment venting system (sand filters) in the event of a loss of heat sink and steam generators feedwater supply;
- diversification of the means of monitoring water level of the steam generators feedwater tank;
- start-up of the safety injection and containment spray systems by means of a secure command;
- improved reliability and robustness of the ebulliometer;
- modification of the I&C on the chemical and volume control system letdown line;
- improved start-up of the emergency turbine generator with resupply of the test pump;

- increased reliability of the cooling function by the residual heat removal system.

The first 1300 MWe VD2 outage was that of Paluel 2 in 2005. Operating experience feedback from this reactor was able to validate the batch of modifications for the entire plant series.

Over the 2013-2015 period ASN ruled on the continued operation of the following reactors: Nogent 1 and 2, Penly 1, Cattenom 2 and 3 and Saint-Alban 1 and 2. These ASN resolutions on continued operation are available on the ASN website.

In 2016 and 2017, ASN will inform the Minister responsible for nuclear safety of its position regarding the continued operation of the following reactors: Belleville 1 and 2, Cattenom 4, Golfech 1 and 2, Flamanville 1 and 2, Paluel 3 and 4 and Penly 2.

6.3.1.1.4 First ten-yearly outage on the reactors of the N4 plant series

In 2008, ASN issued a resolution on the guidelines for the first periodic safety review for the 1450 MWe reactors. They in particular concern the level 1 probabilistic safety assessments and the hazard assessments. This periodic safety review focuses on ensuring conformity of the plant series with changes to the baseline requirements since coupling of the reactors and not included in the initial safety analysis report. The conclusions of the 1300 MWe VD2 and 900 MWe VD3 periodic safety reviews transposable to the N4 plant series, were also incorporated. These ten-yearly outage began in 2009 and ended in 2012.

The following modifications specific to the N4 plant series aim at:

- completing the equipment upgrades linked to qualification for post-accident environmental conditions;
- increasing the reliability of tripping of the reactor cooling pumps in the event of a degraded atmosphere, as well as the seismic qualification of the control rod drive mechanisms' cooling system;
- reduce the probability of fuel damage by modifying the sequences brought to light by the probabilistic safety assessments (PSA).

ASN plans communicating its position on the continued operation of the four reactors to the Minister responsible for nuclear safety in 2016 after examining the periodic safety review reports submitted by EDF.

6.3.1.1.5 Third ten-yearly outage of the 1300 MWe reactors (VD3)

In 2011, ASN ruled on the orientations for the periodic safety review associated with the third ten-yearly outage for the 1300 MWe reactors.

The studies conducted within this review follow on from the studies carried out for the 900 MWe VD3 and take account of international operating experience feedback and the lessons learned from R&D. Examples include:

- the reactor operating conditions, the management of severe accidents, the radiological consequences of accidents (excluding severe accidents) and the confinement of radioactive substances in all operating conditions;
- the validity review of the safety assessments, verification of reactor robustness to external or internal electrical disturbances and the criticality risks, as well as the risks linked to the storage of fuel in their storage pool;

- the level 1 probabilistic safety assessments concerning the probability of core melt, the scope of which was more specifically expanded to include risks associated with fire, on-site flooding and earthquake, and level 2 assessments concerning the radiological consequences of a severe accident;
- the reassessment of the risks of internal hazards and the risks of external natural hazards linked to the climate, to earthquakes, to the environment, or to human activities. Verification that the protection measures are sufficient and effective, with the definition of new measures as and when necessary.

In 2015, ASN generically ruled in favour of continued operation of the 1300 MWe reactors beyond their third ten-yearly outage, provided that the modifications decided on during this periodic safety review are effectively implemented and complementary studies are carried out. ASN will then rule on each reactor individually after analysing the periodic safety review close-out report which will be communicated by EDF.

Paluel reactor 2 is the first to undergo its third ten-yearly outage, started in 2015. The last ten-yearly outage (VD3) of a 1300 MWe reactor is planned in the end of 2024.

6.3.1.1.6 Second ten-yearly outage of the reactors of the N4 series

In 2015, ASN ruled on the orientations of the periodic safety review associated with the second ten-early outages of the 1450 MWe reactors.

These follow on from the studies carried out for the 1300 MWe series VD3 and take account of international operating experience feedback and the lessons learned from R&D. Examples include:

- The reactor operating conditions, the management of severe accidents, the radiological consequences of accidents (excluding severe accidents) and the containment of radioactive substances in all operating conditions;
- The validity review of the safety assessments, verification of reactor robustness to external or internal electrical disturbances and the criticality risks linked to the storage of fuel in the spent fuel pools;
- The level 1 probabilistic safety assessments concerning the probability of core meltdown, the scope of which was extended to include risks associated with fire, and level 2 assessments concerning the radiological consequences of a severe accident;
- The reassessment of the risks of internal hazards and the risks of external natural hazards associated with the climate, earthquakes, the environment, or human activities;
- Verification that the protection measures are sufficient and effective, with new measures being defined if necessary.

The Chooz B reactor No.2 is the first to undergo its second 10-yearly outage (VD2) scheduled for 2019. The last VD2 of an N4 reactor is scheduled for the end of 2022.

ASN will rule on the continued operation of the reactors and transmit its position to the Minister responsible for nuclear safety in the same way as for the other reactors after examining the conclusions report submitted by EDF.

6.3.1.1.7 Fourth ten-yearly outage of the 900 MWe reactors (VD4)

C – General provisions – Articles 4 to 6

For this periodic safety review, ASN has set EDF the objective of adopting a continuous safety improvement approach at each review, to take into account the best international practices (particularly the work of WENRA) and the development of knowledge and the rules applicable to similar installations, and new reactors in particular.

The French regulations, which oblige a periodic safety review of nuclear installations, and the objectives set by ASN for the VD4-900 review meet the objectives of the Vienna Declaration on Nuclear Safety for existing reactors described in § 3.5 (periodic safety review, integration of relevant standards and good practices).

EDF proposes the following objectives for this periodic safety review:

- Review the conditions of reactor operation and severe accident management with the aim of reducing the risks of early or large radiological discharges and the radiological consequences of accidents (excluding severe accidents) to tend towards situations where it is not necessary to deploy population protection measures;
- Review the validity of the safety studies, the criticality risks and the risks associated with the storage of fuel in the spent fuel pits (the aim is to reduce the risk of exposure of fuel assemblies stored under water to a residual level) ;
- The level 1 probabilistic safety assessments concerning the probability of core meltdown (by obtaining a residual risk level that is about the same as the targeted level for the 3rd generation reactors), the scope of which is extended to include risks associated with fire, on-site flooding, on-site explosion and earthquake, and level 2 assessments concerning the radiological consequences of a severe accident;
- The reassessment of the risks of internal hazards and the risks of external natural hazards associated with the climate, earthquakes, the environment, or human activities, verification of the adequacy and effectiveness of the protective measures and, if necessary, defining new measures;
- The assessment of the behaviour of the installation in an extreme contingency situation, with the aim of avoiding significant discharges and lasting radiological consequences in space and in time;
- The assessment of the behaviour of the 900 MWe reactors to the operator delays and the reference operating conditions (Plant Condition Category - PCC) of the EPR;
- Improvement of the operating conditions with regard to organisational and human factors (OHF);
- The control of ageing and obsolescence.

Following an analysis of the various elements supplied by EDF, and after asking IRSN and the Advisory Committees of Experts for nuclear reactors and nuclear pressure equipment for their opinions in 2015, ASN issued a position statement on these orientations on 20th April 2016. In this document, the Appendix of which was open to public consultation on the ASN website from 26th January 2016 to 1st February 2016, and which formed the subject of a meeting for discussion with the stakeholders, ASN asks EDF to make several additions to the envisaged oversight and study programmes. These demands include in particular an evaluation of the impact of integrating the requirements applicable to installations presenting more recent objectives and safety practices. When transposable, the demands are also based on those formulated in 2015 in the context of the third periodic safety review of the 1300 MWe reactors.

The Tricastin reactor No.1 will be the first to undergo its fourth 10-yearly outage scheduled for 2019. The last 10-yearly outage of a 90 MWe reactor is scheduled for 2030.

6.3.1.2 Modifications made in the light of operating experience feedback from all plant series

The organisation put in place by EDF to take into account national and international operating experience feedback (OEF) is described in § 19.7.2.

Following the events affecting the reactors in service, modifications were started, with short completion schedules, outside the scope of the normal periodic safety review processes. The main modifications are described below.

6.3.1.2.1 Protection against external climatic hazards

Flooding

Following the flooding on the Blayais site in December 1999, EDF initiated a reassessment of the protection of the sites against external flooding risks. This covers:

- the revision of the flood safety level (CMS)[1];
- the integration of additional unexpected events that may lead to flooding on a site;
- reactor operating procedure to be applied.

For all sites, following protective measures were adopted: protection works, implementation of appropriate alert and operating procedures, deployment of a local and national emergency response organisation.

The stress tests showed that the reassessments performed were able to provide the facilities with a high level of protection against the risk of flooding. The measures enabling these requirements to be satisfied gave rise to additional work. All the planned work to enhance the safety of the installations following the Blayais NPP flooding was completed in 2014 in accordance with ASN requirements.

Heat sink

The clogging and partial loss events affecting the heat sinks at Cruas and at Fessenheim in December 2009 led EDF to initiate an action plan to increase their robustness. EDF initiated a design review of all heat sinks and the detailed conclusions for each site were transmitted in 2012. This design review details the safety recommendations made to remedy the weak points detected. The implementation of the next actions are in progress.

Heatwave and drought

In the summers of 2003 and 2006, the whole of France experienced exceptionally high temperatures. These heatwave conditions led to high air and heat sink temperatures, as well as low water flow rates at the end of the season. These parameters affect the performance of the safety auxiliaries, but also the energy production auxiliaries and the authorised thermal discharge conditions.

After carrying out short-term corrective actions, the robustness of the reactors to high temperatures has been reassessed.

[1] This level is the water level to be considered when designing the protection systems, according to the situation of the site. The design hypotheses are mainly the thousand-year flood levels, plus 15%, for riverside sites and a tidal coefficient of 120 combined with a wind of 120 km/h for coastal sites.

In 2009, ASN issued an initial opinion concerning the “extreme heat” baseline requirements proposed by EDF for the 900 MWe reactors. In 2012, for the 900 MWe reactors, ASN approved the implementation of the necessary material modifications. ASN also issued a new opinion on EDF’s answers in 2013.

The deployment studies for the “Heat Waves” baseline requirements are currently being revised by EDF further to ASN's position statement of 2013. Application of the modifications is nevertheless now well under way.

6.3.1.2.2 Replacement of the steam generators

The integrity of the steam generator tube bundles is a major safety issue, since deterioration of a bundle can cause leaks from the primary to the secondary system. Furthermore, a tube rupture of one of the bundle tubes (SGTR) would lead to bypassing of the reactor containment, which is the third confinement barrier. Steam generator tubes are subject to several types of deterioration such as corrosion, wear or clogging. The steam generators are the subject of a special in-service monitoring programme, established by EDF, reviewed periodically and examined by ASN. After inspection, tubes that are too badly damaged are plugged to remove them from service. Moreover, to reduce the deposition of iron contained in the reactors’ secondary system feedwater system on the tubes and the surface internals, remedial or preventive chemical cleaning is performed for each reactor concerned by such phenomenon.

Since the 1990s, EDF has been running a steam generator replacement programme (RGV). This programme first concerned the SGs equipped with tube bundles made of an Inconel 600 type alloy that is not heat-treated. Operating experience feedback has shown the susceptibility of this material to a number of corrosion phenomena leading to deterioration of the tubes.

The 900 MWe series SG replacement programme was completed in 2015. This is followed by the RGV for the 900 and 1300 MWe reactors for which the tube bundle is made of heat-treated inconel, which is less susceptible but nonetheless remains vulnerable to cracking at the base of the tubes related to primary perimeter.

The campaign to replace the steam generators of the 900 MWe plant series equipped with tube bundles in non-heat-treated Inconel 600 alloy was completed in 2015. This is followed by the RGV for the 900 and 1300 MWe reactors for which the tube bundle is made of heat-treated inconel, which is less susceptible but nonetheless remains vulnerable to cracking at the base of the tubes related to the primary area.

Replacement of the 900 and 1300 MWe plant series steam generators originally equipped with tube bundles in heat-treated Inconel 600 alloy will be carried during the fourth 10-yearly outage at the latest. The first 900 MWe steam generator replacement of this type was carried out in 2014 on the Cruas reactor No.4. The first 1300 MWe steam generator replacement began on the Paluel reactor No.2 in 2015.

ASN always carries out an inspection on the occasion of steam generator replacement. It also monitors the manufacture of the spare steam generators.

6.3.1.3 Steps taken following the stress tests

Further to the Fukushima Daiichi NPP accident, ASN issued a set of resolutions dated 5th May 2011 asking the licensees of major nuclear facilities to perform stress tests (see § 14.2.1.6).

These were carried out on the basis of specifications which were consistent with the ENSREG specifications developed for the European stress tests. This approach also concerned the Flamanville EPR reactor No.3, currently under construction.

On completion of these stress tests, ASN considered that the nuclear facilities examined displayed a sufficient level of safety not to require the immediate shutdown of any one of them.

Their continued operation nevertheless requires increasing, beyond the existing safety margins, their robustness to extreme situations and enabling them to cope with the occurrence of natural phenomena of exceptional scale, exceeding those considered in the design basis or in the periodic safety reviews of the installations.

The results of these tests and their analysis by IRSN were presented to the Advisory Committees concerned in November 2011 and formed the subject of an ASN position statement issued on 3rd January 2012. This position was itself examined within the framework of the European stress tests, which were completed in April 2012.

On the basis of the opinions of IRSN and the Advisory Committees of Experts (see § 8.1.3) and the conclusions of the European stress tests, ASN issued a series of resolutions dated 26 June 2012 requiring EDF to set up firstly:

- a hardened safety core of material and organisational provisions aiming at:
  - preventing an accident with fuel melt, or limiting its progression;
  - limiting large-scale radioactive releases;
  - enabling the licensee to perform its emergency management duties.
- a local emergency centre allowing emergency management of the nuclear site as a whole in the event of an extreme external hazard;
- a nuclear rapid intervention force (FARN) which, using mobile means external to the site, can intervene on a nuclear site in a pre-accident or accident situation.

And secondly, a set of corrective actions or improvements (notably the acquisition of communication and complementary radiological protection means, the implementation of complementary instrumentation, extensive consideration of internal and external hazard risks, improvement of the addressing of emergency situations), and studies of modifications and additional means enabling ASN to take a stance on future safety options.

ASN has supplemented its demands with a set of resolutions dated 21st January 2014 aiming to clarify certain design provisions of the hardened safety core.

ASN's demands are part of a continuous process to improve safety with regard to the targets set for the 3rd generation reactors, and aim in addition to be able to cope with situations far beyond those normally considered for this type of installation.

These demands are issued in application of the defence-in-depth approach and as such concern measures to prevent and mitigate the consequences of an accident, based on both additional fixed means and external mobile means planned for all the installations of a site beyond their initial design basis.

Given the nature of the required works, the licensee must carry out studies for the design, construction and installation of new equipment structures, which require firstly time and secondly a schedule to optimise their implementation on each nuclear power plant. Insofar as these major works are carried out on nuclear sites which are in service, it is also necessary to ensure that the safety of the power plants is not reduced during the work phases.

C – General provisions – Articles 4 to 6

To take account of both the engineering constraints involved in these major works and the need to introduce the post-Fukushima improvements as soon as possible, their implementation by EDF is planned in three phases:

Phase 1 (2012-2015): implementation of temporary or mobile measures to enhance protection against the main situations of total loss of the heat sink or the electrical power supplies:

- reinforcing of the existing on-site emergency equipment (pumps, generator sets, hoses, etc.);
- installation of medium-capacity ultimate backup diesel-generator sets;
- reinforcing of the earthquake resistance (SSE) and flood resistance (maximum thousand year flood) of the emergency management premises;
- installation of tappings for connecting mobile equipment, particularly the FARN's equipment;
- setting up the FARN (it has been capable of intervening on all the sites since the end of 2015);
- installation of electrically backed-up level measurement instrumentation in the pools.

Deployment of the measures associated with phase 1 is finished for all the reactors.

Phase 2 (2015 -until about 2020): implementation of definitive design and organisational means that are robust to extreme hazards, such as the fundamental elements of the hardened safety core designed to respond to the main situations of total loss of the heat sink or electrical power supplies beyond the baseline safety requirements in force:

- installation of a large-capacity ultimate backup diesel-generator set, including the construction of a dedicated building to house it;
- setting up of a dedicated ultimate water source;
- installation of an ultimate water makeup system for each reactor and each pool;
- reinforcing of the earthquake resistance of the containment venting filter;
- installation of sodium tetraborate baskets to reduce the emission of gaseous iodine in a severe accident situation on reactors that do not have SIC (silver-indium-cadmium alloy) control rod clusters;
- installation of the first protections against extreme flooding (high-intensity rainfall and earthquake-induced rupture of tanks) in addition to the existing protected volume measures;
- installation of redundant means for detecting reactor vessel melt-through or the presence of hydrogen in the containment;
- installation of the first devices to prevent, in the event of a break in the transfer tube or the pool compartment drainage pipes, exposure of the fuel assemblies during handling and enable them to be placed in a safe position using the emergency manual controls;
- implementation of an automatic reactor trip in the event of an earthquake;
- reinforcing of the operating teams to be capable of managing all the extreme situations studied in the stress tests;
- construction on each site of an emergency centre capable of withstanding extreme external hazards (functionally independent in an emergency situation).

C – General provisions – Articles 4 to 6

EDF has started the majority of the studies necessary for the implementation of these measures (level of seismic risk to adopt, ultimate backup diesel-generator sets, electrical distribution and instrumentation & control of the hardened safety core, on-site pumping tests for the ultimate heat sink, on-site emergency centre, etc.).

These studies will be examined by the Advisory Committee of Experts for nuclear reactors (GPR).

Phase 3 (as from 2019): this phase supplements phase 2, in particular to improve the level of coverage of the potential accident scenarios considered. EDF indicates that these means have also been defined with a view to continuing operation of the reactors beyond forty years:

- removal of the residual power by the steam generators by means of an independent ultimate backup feedwater system supplied by the ultimate heat sink;
- addition of a new makeup pump to the primary system;
- finalisation of the ultimate makeup connections - through fixed circuits - to the steam generator auxiliary feedwater supply system and to the spent fuel pool;
- installation of an ultimate instrumentation & control system and the definitive instrumentation of the hardened safety core;
- installation of a reactor containment ultimate cooling system (to avoid opening the containment venting-filtration system);
- implementation of a solution of dry spreading then passive flooding of the corium with water to prevent basemat melt-through by the corium in the event of partial or total core meltdown;

It should be noted that EDF still has to carry out feasibility studies on these last two points.

The discussions on the implementation of the phase 3 provisions on each of the EDF reactors are not yet finalised and will form the subject of several meetings between 2016 and 2018.

ASN will verify the implementation of the planned provisions during its inspections.

Planned examination for the reactors in operation

The setting up of this hardened safety core, and the provisions of phase 2 and 3 in particular, requires validation of the design hypotheses for the material provisions, verification that the solutions proposed by the licensee will the meet the set safety objectives and that they are technologically achievable.

On the basis of the file submitted by EDF and the studies still to be carried out, ASN will ask ISRN and the GPR for their opinion on the most important points in these files. Five meetings of the GPR have been scheduled to date. They concern the following topics:

- extreme natural hazards considered for the dimensioning of the hardened safety core of the PWRs;
- strategies for operational management of accidents that can occur on the reactor and pool and on the functional adequacy of the equipment (new or existing) for the strategies;
- measures proposed by EDF to mitigate the consequences of a core meltdown accident in the short and long term;
- ability to manage complex accident situations;
- assessment of the stress test results.

Planned examination for the Flamanville 3 EPR reactor

For the EPR reactor under construction in France, the examination concerning the defining of the extreme natural hazards to be considered for the hardened safety core will be reviewed at the first meeting of the GPR planned for the reactors in operation. The other subjects are addressed primarily in the ongoing examination of the commissioning authorisation application for this reactor.

6.3.2 Measures taken for research reactors

6.3.2.1 CEA reactors

Periodic safety reviews

At the end of the periodic safety review of the OSIRIS reactor, given the significant design differences between this older facility and the best techniques currently available for protection against external hazards and the containment of materials in the event of an accident, CEA considered in 2008 that 2015 would be the last year of operation for the Osiris reactor. Beside this, residual studies from the 2009 periodic safety review underwent complementary analyses, particularly with regard to the handling conditions of the spent fuel from the Orphée reactor stored in the facility. The spent fuel handling conditions have been made more robust to improve control over the criticality risk

Examination of the second periodic safety review of the Éole and Minerve reactors led ASN, through a resolution of 30th October 2014, to make continuation of operation dependent on removing the majority of nuclear materials stored in the facility in the short term and making limited improvements of its earthquake resistance by the end of 2017 at the latest, then bringing into conformity with the current earthquake resistance requirements before the end of 2019. CEA thus removed a large proportion of the radioactive substances stored in the facility's storeroom in 2015, thereby reducing the radiological impact of an accident by 95%.

With regard to Phébus, CEA informed ASN at the end of 2014 that the periodic safety review of the facility scheduled for 2017 would be combined with the procedure for final shutdown of the installation.

As regards Masurca, CEA submitted a periodic safety review file for the installation in April 2015. In 2015 ASN asked for it to be supplemented, notably regarding the conformity of the equipment necessary in the short term to meet the requirements defined by CEA.

A final shutdown/decommissioning application has been made for the Phénix reactor, for which a decree authorising decommissioning should be signed in 2016.

With regard to Orphée, the periodic safety review of the installation formed the subject of an action plan which has almost been completed in 2016.

Stress tests

The majority of the CEA installations have undergone stress tests (see 14.1.1.2 for details of the procedure), further to the Fukushima Daiichi nuclear accident, in accordance with the measures imposed by ASN for these stress tests. A first batch of installations considered to be priorities concerned 5 reactors: Osiris and Isis, Jules Horowitz Reactor, Masurca and Phénix. A second batch concerned the other 2 reactors: Cabri and Orphée). The Phébus, Eole and Minerve reactors will undergo stress tests at their next periodic safety review.

C – General provisions – Articles 4 to 6

On completion of the stress tests on the priority nuclear facilities, ASN considers that the level of safety of the research reactors examined is sufficient for it not to demand the immediate shutdown of none of them.

As with the NPP reactors, their continued operation does however require that their robustness to extreme situations be increased beyond their existing safety margins, as rapidly as possible.

26th June 2012 for the first batch of installations assessed, 8th January 2015 for the second batch: ASN has thus issued resolutions setting complementary requirements for the batch 1 and 2 installations and for the measures common to the Cadarache and Marcoule centres. In addition to the common request applicable to all BNIs, for the definition and implementation of a "hardened safety core" of material and organisational measures to control the fundamental safety functions in extreme situations, the main requests concerned:

- no later than 31st December 2014, the removal of the fissile material from the Masurca facility to a facility with a satisfactory seismic design, as CEA had promised to do previously;
- improvements to the facilities concerning the flooding or sodium fire control risk, for the Phénix reactor;
- improvements concerning the loss of cooling risk for the Osiris reactor;
- improvements concerning the risks of flooding and loss of cooling and the behaviour in the event of an earthquake, for the Jules Horowitz reactor;
- the implementation of emergency shutdown of the Orphée reactor on seismic detection.

These new requirements generate an important amount of work and large-scale investments, which have begun in 2012 and will be spread over several years.

Although the RJH is of very recent design integrating experience feedback from the other experimental reactors, the stress tests have revealed improvement possibilities which CEA could implement relatively easily given the state of progress of reactor construction. In September 2012, CEA proposed a "hardened core" of robust material and organisational measures to cope with the situations envisaged in the stress tests. ASN required implementation of these measures in a resolution dated 8th January 2015.

The stress tests on ITER, required as part of the experience feedback from the Fukushima NPP accident, was transmitted in September 2012 by ITER Organisation. It was examined by the ASN Advisory Committee of Experts in July 2013 and resulted in ASN requesting complementary studies in 2014.

At the same time, ASN has initiated a programme of targeted inspections on the research reactors, on the same topics as the inspections carried out on the NPP reactors. These inspections, scheduled between June and October 2011, were followed in 2012 by follow-up inspections to ensure compliance with the requests made further to the previous inspections.

6.3.2.2 The Institute Laue-Langevin high-flux reactor (RHF)

Periodic safety reviews

The last periodic safety review took place in 2007 following implementation of the steps defined by the 2002 periodic safety review, one key subject of which was the seismic strength of the facility with regard to the 2001 Basic Safety Rule concerning the seismic hazard. The Laue-Langevin Institute (ILL) is to undergo a periodic safety review in 2017.

Stress tests

The defining of the hardened safety core for the ILL and the associated requirements formed the subject of ASN resolutions dated 10th July 2012 and 21st November 2013. The ILL responds in a reactive and determined manner to the lessons learned from the Fukushima accident, resulting in rapid implementation of substantial enhancements.

The ILL is continuing the consolidation of its defence in depth by carrying out the work defined following the post-Fukushima stress tests and is thus setting up a "hardened safety core" of backup equipment. More specifically:

- the seismic depressurisation system guaranteeing the absence of direct leaks and therefore unfiltered discharges, is installed;
- the groundwater system will guarantee the water inventory over the long term;
- the emergency command post is operational and allows monitoring of the installation and control of the backup systems, even in extreme situations.

6.4 Continued reactor operations

6.4.1 Nuclear power reactors

This item was addressed under § 6.3.1.

6.4.2 Research reactors

This item was addressed under § 6.3.2.

D – LEGISLATION AND REGULATIONS

7. 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

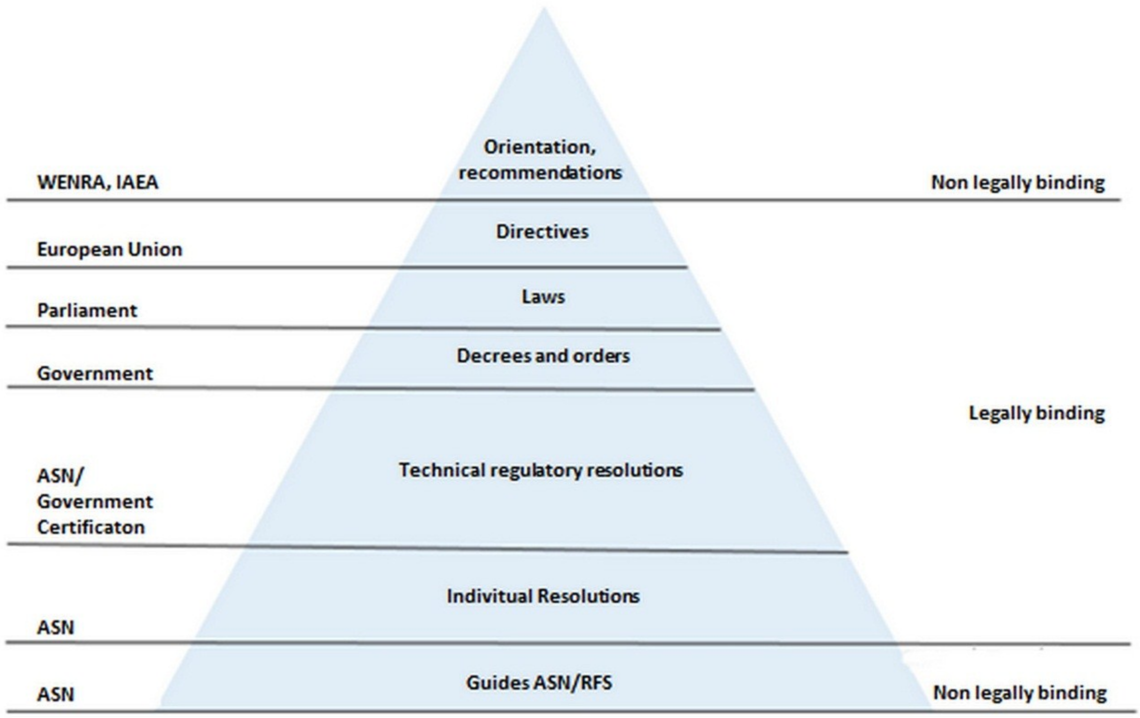


Figure 1: Various levels of regulations

The BNI legal system was extensively overhauled by the TSN Act (13th June 2006) and its implementing decrees, more specifically the BNI procedures decree (2nd November 2007), but also, at a technical level, by the order of 7th February 2012 setting the general rules for BNIs, which will be supplemented by about fifteen ASN regulatory resolutions. Three Acts specifically concerning BNIs – the TSN Act, Programme Act 2006-739 of 28th June 2006 on the sustainable management of radioactive materials and waste (known as the “waste” Act) and Act 68-943 of 30th October 1968 on civil liability in the nuclear energy field (known as the “RCN” Act) – are codified in the Environment Code.

D – Legislation and regulation – Articles 7 to 9

Some of the provisions of parts I, IV and the provisions of part IX of book V of the Environment Code underpin the BNI licensing and regulation system.

The provisions of the Environment Code, their implementing decrees and the order of 7th February 2012, some of which predated the directive, transpose into French law the directive 2009/71/Euratom of 25th June 2009 establishing a Community framework for the nuclear safety of nuclear facilities.

The directive of 8th July 2014 amends the directive of 25th June 2009 and brings substantial improvements concerning the following points:

- the concepts used in the directive which are convergent with those of the IAEA (incident, accident, nuclear installation design-basis accident, etc.);
- the highlighting of the principles of "defence in depth" (different levels of protection aiming to prevent an accident or to mitigate its consequences) and "safety culture". This is an important step forward that takes into consideration past nuclear accidents;
- clarification of responsibilities in the oversight of the safety of nuclear installations;
- the safety objectives for nuclear installations which stem directly from the baseline safety requirements used by WENRA, the European Nuclear Regulators' Association;
- a review of the safety of each nuclear installation at least once every ten years;
- the organising, every 6 years, of peer reviews by the European counterparts on specific safety themes, conducted in the spirit of the stress tests;
- the obligation for nuclear installation licensees and the nuclear safety authorities to inform the local populations and the stakeholders.

Ordinance 2016-128 of 10th February 2016 introducing various provisions concerning nuclear activities, taken on approval of Act No. 2015-992 of 17th August 2015 (the Energy Transition for Green Growth Act), allows the transposition of the legislative part of several directives, including the directive of 8th July 2014.

This act of 17th August 2015 and the ordinance of 10th February 2016 bring substantial modifications to the legislative framework governing nuclear activities and their oversight.

Main provisions of the act of 17th August 2015 concerning the nuclear field:

- **reinforcement of transparency and informing 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;
- **reinforcement of the BNI system** with regulation of the use of subcontracting, the change of the BNI authorisation system and renovation 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**

Lastly, the ordinance of 10th February 2016 enhances the effectiveness of nuclear safety and radiation protection oversight by giving ASN power to impose daily penalty payments and pecuniary sanctions, and by extending ASN's powers of oversight and sanction to certain activities performed outside the BNI perimeter (central services of the licensees, subcontractors, etc.), by instituting a sanctions committee within ASN.

D – Legislation and regulation – Articles 7 to 9

7.1.1 Principles

The BNI legal system is said to be "integrated", because it aims to prevent or manage all risks and detrimental effects a BNI is liable to create for humans and the environment, whether or not these are radioactive. It confirms that the four main principles of environmental protection apply to nuclear activities: prevention, precaution, polluter-pays, and public participation. In this regard it reproduces the environmental Charter, which is part of the Constitution. It refers to the Public Health Code's radiation protection principles: justification, optimisation and limitation. It lays down the fundamental principle of the responsibility of the licensee for the safety of its facility, enshrined in international law, applicable on a day-to-day basis and essential to ensuring that each party, licensee and regulatory authority, is fully aware of its responsibilities.

7.1.2 Regulatory provisions

The legislative provisions of the Environment Code are implemented by about fifteen decrees, the main ones being:

- Decree 2007-830 of 11th May 2007 concerning the BNI list;
- Decree 2007-831 of 11th May 2007 setting the procedures for appointing and qualifying nuclear safety inspectors;
- Decree 2007-1557 of 2nd November relative to BNIs and oversight of the nuclear safety of radioactive substance transport (called the BNI procedures decree), modified by the decree relative to the modification, the final shutdown and the decommissioning of basic nuclear installations, and to subcontracting (decree 2016 -846 of 28 June 2016);
- Decree 2007-1572 of 6th November 2007 concerning technical inquiries into accidents or incidents concerning a nuclear activity;
- Decree 2008-251 of 12th March 2008 concerning BNI local information committees;
- Decree 2010-277 of 16th March 2010 concerning the High Committee for Transparency and Information on Nuclear Security (HCTSIN).

7.1.3 Technical rules applicable to BNIs

7.1.3.1 Ministerial and interministerial orders

7.1.3.1.1 Pressure equipment

BNIs comprise two types of pressure equipment: nuclear pressure equipment (ESPN), that is to say which makes up the main primary and secondary systems (MPS and MSS), and which contains radioactive products, and conventional equipment not specific to nuclear facilities but which is installed in them. The applicable regulations are detailed in the following table.

	NUCLEAR PRESSURE EQUIPMENT		NON-NUCLEAR PRESSURE EQUIPMENT
	PRESSURISED WATER REACTOR MAIN PRIMARY AND SECONDARY SYSTEMS	OTHER NUCLEAR PRESSURE EQUIPMENT	
PROVISIONS	Chapter VII of the Title V of the book V of the Environmental Code ; Title I, IV and V of the decree n°99-1046 of 13th December 1999		
	Title I and IV of the order of 12th December 2005. From 19th July 2016: titles I and IV of the order of 30th December 2015.	Title I and IV of the order of 12th December 2005. From 19th July 2016: titles I and IV of the order of 30th December 2015	
PROVISIONS RELATED TO CONSTRUCTION	Title II of the order of 12th December 2005 From 19th July 2016: Title II of the order of 30th December 2015	Title II of the order of 12th December 2005 From 19th July 2016: Title II of the order of 30th December 2015	Title II of the decree n°99-1046 of 13th December 1999 From 19th July 2016: articles R.557.9-1 and following of the environmental code
PROVISIONS RELATED TO OPERATION	Title III of the decree n°99-1046 of 13th December 1999 ; Order of 10th November 1999	Title III of the decree n°99-1046 of 13th December 1999 ; Title III de of the order of 12th December 2005	Title III of the decree n°99-1046 of 13th December 1999 ; Order of 15th March 2000

Table 2: ESPN regulations

7.1.3.1.2 Order of 7th February 2012

Further to the publication of the "TSN" Act in 2006, a complete overhaul of the general regulations relative to BNIs incorporates the principles ("reference levels") of the common baseline requirements developed by WENRA, the European Nuclear Regulators' Association. The order of 7th February 2012 setting the general rules relative to BNIs, called the "BNI Order", is an important step in this process.

This order significantly reinforces the regulatory framework applicable to BNIs, as it details a large number of requirements and provides a legal basis for several of the requirements expressed by ASN further to the analysis of the stress tests demanded of the licensees following the Fukushima Daiichi NPP accident.

The “BNI” order implements a legislative provision of the Environment Code and defines the essential requirements applicable to BNIs for protection of the interests enumerated by the act: public health and safety, protection of nature and the environment.

This order, which takes up and reinforces the previous regulation, gives a legal basis for certain ASN practices or gives regulatory weight to requirements that had hitherto been the subject of individual resolutions. It also allows application of several of the WENRA reference levels.

It was published in the Official Journal of 8th February 2012 and most of its provisions entered into force on 1st July 2013 (see Figure 1) and have been translated in the 8 following points :.

- **General provisions**

This part stipulates that the order applies throughout the existence of the BNI, from design through to delicensing. It specifies that the goal is to protect all the interests mentioned in Article L. 593-1 of the Environment Code, beyond simply preventing accidents (called “nuclear safety”): this is the concept of “integrated safety”.

- **Organisation and responsibility**

The main subjects addressed are:

- technical capabilities: the licensee must indicate how it organises its technical capabilities, that is to say whether they are held internally, in subsidiaries or through third parties with whom formal agreements must be made; the most fundamental capabilities must be held by the licensee or one of its subsidiaries;
- monitoring of outside contractors: this can no longer be subcontracted, but the licensee can obtain assistance;
- the licensee's policy now extends to integrated safety;
- the integrated management system: the existing principles, extended to include integrated safety, are reapplied, with the added obligation of analysing national and international experience feedback;
- public information: the provisions supplement those concerning environmental information of the public as determined by the Environment Code, clarifying certain aspects of public access to information.

- **Demonstration of nuclear safety**

This part defines the requirements concerning the demonstration of the control of accident risks (whether or not radiological) that the licensee must provide. The required approach is largely inspired by the IAEA standards, and the ASN technical directives for the latest generation of reactors (EPR). The main new requirements are:

- general application to all BNIs of the principles applied to reactors, such as the probabilistic assessments in addition to the deterministic assessment;
- consideration of internal and external hazards, and combinations thereof;
- the licensee must demonstrate that accident scenarios leading to large-scale, rapid releases are precluded.

- **Control of detrimental effects and impact on health and the environment**

This part governs water intake and effluent discharges, monitoring of said intakes and discharges and of the environment, the prevention of pollution and detrimental effects, and the conditions in which the authorities are informed. The main new provisions are:

- use of the best available techniques within the meaning of the ICPE (installations classified on environmental protection grounds) regulation;
- limiting discharges and noise emissions to the level of the thresholds in the general regulations applicable to ICPEs;
- a ban on the discharge of certain hazardous substances and discharge into the water table;
- implementation of monitoring of emissions and the environment (aligned with ICPE regulations whenever relevant);
- the application, in general, of a number of ICPE ministerial orders to the equipment necessary for BNI operation;
- the production of an annual discharge forecast and an annual impact report by the licensee.

- **Pressure equipment designed specifically for BNIs**

This part refers to the applicable interministerial orders pending modification of the provisions in effect.

- **Waste management**

Over and above the general principles taken from previous orders in force and from the WENRA levels, this part contains some new requirements concerning waste packaging:

- application of the acceptance specifications of the disposal facilities for which the packages are intended;
- for waste for which the disposal route is still being studied: packaging subject to ASN approval;
- for legacy waste: repackaging as soon as possible to make it suitable for disposal;

These requirements are supplemented by Part 8 which also contains provisions applicable to storage facilities for waste from BNIs.

- **Preparedness for and management of emergency situations**

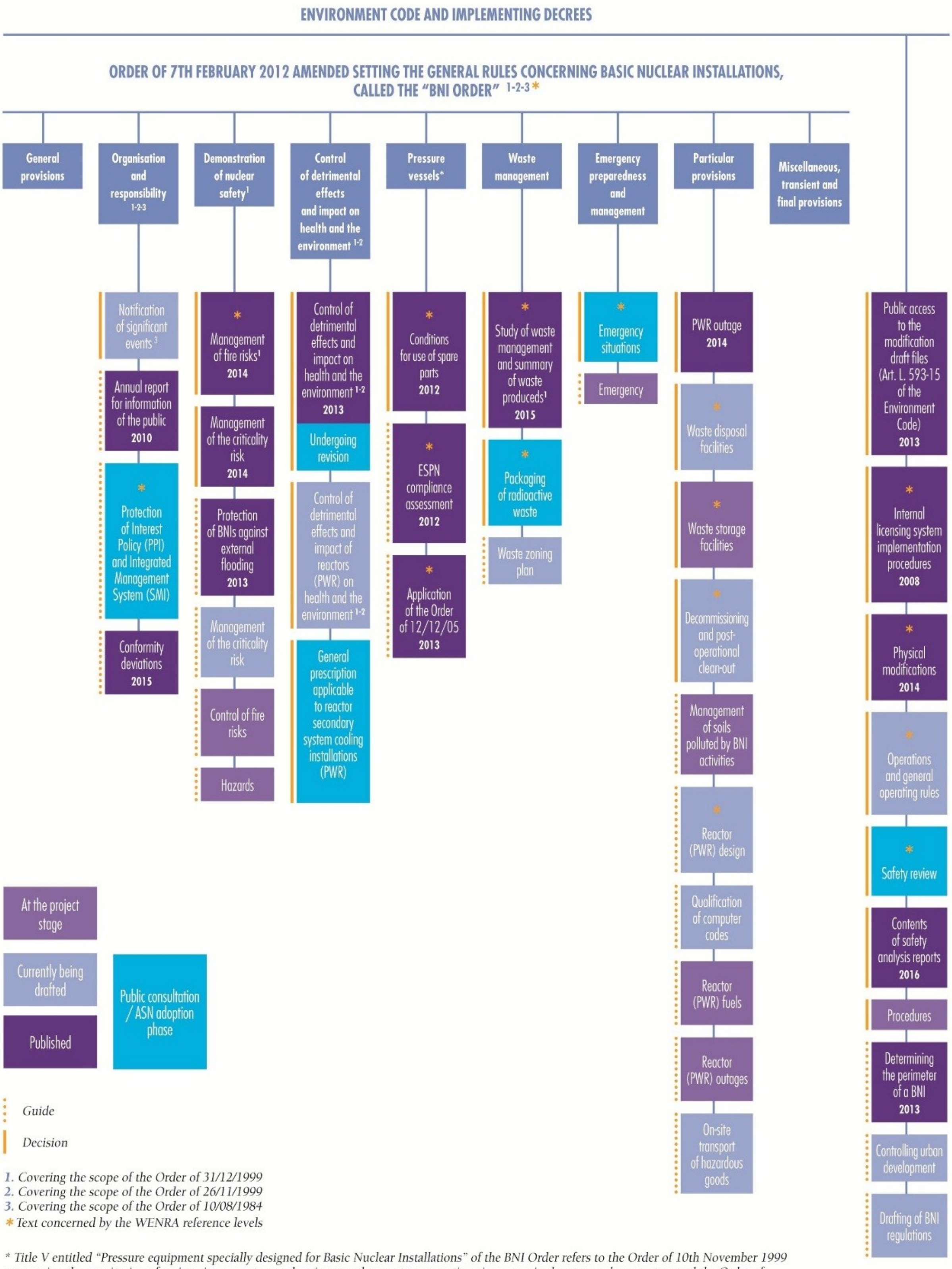
This part specifies the licensee's responsibilities in an emergency situation, the emergency management means that must be available, and the requirements of the on-site emergency plan. It introduces the possibility of the on-site emergency plan being shared by several BNIs, or even with ICPEs operated by the same licensee.

- **Particular provisions**

This part defines the particular provisions (see Figure 1) applicable to certain categories of facilities or to certain activities within a BNI:

- the nuclear power reactors (concerning the containment and the probabilistic assessments);
- the on-site transportation of dangerous goods (if it does not comply with the general regulations governing the transportation of hazardous materials, it must comply with the provisions of the general operating rules which are subject to ASN approval);
- decommissioning (particularly regarding the updating of the decommissioning plan);
- the storage of radioactive substances (including waste and spent fuel), as an independent BNI or within a BNI (in particular, definition of acceptability criteria, of a storage time, possibility of retrieving substances at any time, etc.);

- radioactive waste disposal facilities.



** Title V entitled "Pressure equipment specially designed for Basic Nuclear Installations" of the BNI Order refers to the Order of 10th November 1999 concerning the monitoring of main primary system and main secondary system operations in pressurised water nuclear reactors and the Order of 12th December 2005 concerning nuclear pressure equipment.*

Drafts for modification of these Orders are currently being prepared.

Figure 2: Structure of the draft new technical regulations

7.1.3.2 Technical regulatory resolutions issued by ASN

Pursuant to the Environment Code, ASN can adopt regulatory resolutions to clarify the decrees and orders relating to nuclear safety and radiation protection, which are subject to approval by the Minister in charge of nuclear safety or radiation protection.

ASN defined a programme of regulatory resolutions which clarify decree 2007-1557 of 2nd November 2007 or the order of 7th February 2012 setting out the general rules applicable to BNIs ("BNI" order).

About fifteen ASN regulatory resolutions will detail some of the conditions of application of this order for various subjects (see Appendix 2 – table 12). This order is nevertheless stand-alone and is applicable without the adoption of said resolutions.

The order of 7th February 2012, like the ASN statutory resolutions, is subject to consultation by the public which is thus associated with the development of the texts establishing the regulations relative to nuclear safety.

7.1.3.3 Basic safety rules and ASN guidelines

ASN has developed basic safety rules (RFS) on various technical subjects concerning both PWRs and other BNIs. These are 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 the provisions of an RFS if it can demonstrate that the alternatives it proposes implementing are able to attain the safety objectives it sets.

As part of the overhaul of the general technical regulations, the RFS have been either integrated in the regulation or taken over and updated within ASN guidelines.

There are at present about forty RFS and other technical rules from ASN which can be consulted on its website. The list of RFS and of the guidelines is given in Appendix 2 – § 2.3.4.

7.1.3.4 French nuclear industry professional codes and standards

The nuclear industry produces detailed rules dealing with the state of the art and industrial practices. It compiles these rules in "industrial codes". These rules allow concrete transposition of the requirements of the general technical regulations, while reflecting good 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, gathers 60 French and International industries including EDF, AREVA and CEA. The RCC (design and construction rules) codes were drafted for the design, manufacture and commissioning of electrical equipment, civil engineering structures and mechanical equipment.

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

7.2 Authorisation procedures

French legislation and regulations prohibit the operation of a nuclear facility without authorisation. The BNIs are currently regulated by part IX of book V of the Environment Code. This part provides for a creation authorisation procedure followed by a commissioning authorisation and authorisations for substantial or significant modifications to the installation. With regard to decommissioning, once the licensee has notified both the Minister responsible for nuclear safety and ASN of final shutdown of its BNI, this is carried out under the conditions prescribed in the decommissioning decree.

Any licensee who operates a facility, either without the required authorisations or decree in breach of these authorisations, may be subject to administrative and penal sanctions as stipulated in the Environment Code.

The procedures are specified by the BNI procedures decree.

7.2.1 Safety options

The licensee envisaging operating a BNI may, even before initiating the authorisation procedure, ask ASN for an opinion on all or some of the options it has adopted to ensure the safety of its facility. The applicant is advised of ASN's opinion, which may provide for additional studies and justifications that may be necessary for a possible creation authorisation application. ASN generally asks a competent Advisory Committee (GPE) to review the project.

The safety options must then be presented in the authorisation application file in a preliminary version of the safety analysis report (PSAR).

This preparatory procedure does not take the place of the review of the subsequent authorisation applications, but is designed simply to facilitate them.

7.2.2 Creation authorisation and decommissioning decree

The BNI creation authorisation application is submitted to the Minister responsible for nuclear safety by the company which intends to operate the facility, which then acquires the status of licensee. The application is accompanied by a file comprising a number of items, including the detailed plan of the facility, the impact assessment, the preliminary safety analysis report, the risk management study and the decommissioning plan.

Decommissioning is separate from final shutdown. Once the licensee has notified the Minister responsible for nuclear safety and ASN of final shutdown of its BNI no later than two years prior to final shutdown (this period may be shorter if so justified by the licensee), he sends the Minister a file which notably contains the updated decommissioning plan, an impact assessment, a preliminary version of the safety analysis report and a risk management study concerning the final shutdown and decommissioning operations for the facility, as well as the general surveillance and upkeep rules to be observed.

Radioactive waste disposal facilities are subject to this same legal system. When the facility stops receiving waste, it is considered to be definitively shut down and the licensee must obtain a decommissioning decree; decommissioning comprises all the operations carried out after final shutdown in preparation for closure of the facility.

ASN examines the files jointly with the Minister responsible for nuclear safety. The consultations and inquiries provided for by law and conducted in parallel with the public and the technical experts are the same for the creation authorisation and the decommissioning decree.

The impact assessment is subject to the opinion of the Environmental Authority within the General Council for the Environment and Sustainable Development.

7.2.3 Public inquiry

In addition to a possible public debate, as presented in § 17.1.5 or the consultation of the member States of the European Union (see § 7.2.5), the BNI creation and then decommissioning authorisations are published following a public inquiry.

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

The Prefect opens the public inquiry in every commune whose territory is located partly within a radius of 5 km of the installation. This inquiry shall last at least one month and no more than two. The file submitted by the licensee to support its authorisation application is made available. However, as the safety analysis report is a bulky document and hard for non-specialists to understand, it is supplemented by a risk management study.

Since June 1st 2012, the main documents making up the inquiry file are made available to the general public electronically by the Authority responsible for opening the inquiry. This approach aims to make it easier for the public to understand the projects, in particular those who do not live where the inquiry is being held. Using this means of providing access to information and the possibility of also submitting observations in electronic format, should significantly facilitate and improve the public's ability to express an opinion.

7.2.4 Formation of a Local Information Committee (CLI)

A Local Information Committee (see § 8.2.4) can be created as soon as the BNI creation authorisation application is submitted. In any case, it must be in effect once the authorisation has been issued.

7.2.5 Consultation of other countries of the European Union

Pursuant to Article 37 of the treaty instituting the European atomic energy community and the "BNI procedures" decree, it is only possible to authorise the creation of a facility liable to discharge radioactive effluent into the environment after consulting the European Commission.

7.2.6 Consultation of technical organisations

The preliminary safety report appended to the creation authorisation application is transmitted to ASN, which submits it in turn for review to one of its supporting advisory committees, following a report from IRSN.

After conducting its review and noting the results of its consultations, ASN proposes to the Ministers in charge of nuclear safety the terms of a draft decree authorising or refusing the creation of the installation.

7.2.7 The creation authorisation decree (DAC)

The Minister responsible for nuclear safety sends the licensee a preliminary draft decree granting or refusing creation authorisation. The licensee has a period of two months in which to present its comments. The Minister then obtains the opinion of ASN.

The BNI creation authorisation is issued by a decree signed by the Prime Minister and countersigned by the Minister responsible for nuclear safety.

The creation authorisation decree (DAC) determines the perimeter and characteristics of the facility. It also sets the duration of the authorisation, as applicable, and the time until commissioning of the facility.

Furthermore, it designates the essential components that require protective measures regarding public health and safety or the protection of nature and the environment.

7.2.8 ASN requirements for DAC implementation

For implementation of the DAC, ASN defines requirements relatives to BNI design, in construction and in operation, that it deems necessary for nuclear safety.

ASN defines requirements concerning BNI water intakes and discharges. The specific prescriptions setting the limits on discharges from the BNI (whether under construction or in operation) into the environment are subject to approval by the Minister responsible for nuclear safety. BNI modification projects that could cause a significant increase in its water intakes or discharges to the environment are made available to the public for examination.

An ASN regulatory resolution n° 2013-DC-0352 of 18th June 2013 specifies how the procedure for making project information available to the public is to be implemented.

7.2.9 BNI modifications

Any substantial modification of the facility must undergo a procedure similar to that for a creation authorisation application.

As the regulatory texts currently stand, a modification is considered to be "substantial" in the cases mentioned in the BNI procedures decree:

- a change in the nature of the facility or an increase in its maximum capacity;
- a modification of the key elements for protection of the interests mentioned in the first paragraph of Article L.593-1 of the Environment Code, which are included in the authorisation decree;
- the addition, within the perimeter of the facility, of a new BNI, the operation of which is linked to that of the facility in question.

The other modifications are "significant" modifications of the installation and are subject, depending on their significance, either to notification to ASN or to the authorisation of ASN under the terms of article L. 593-15 of the Environment Code (in its wording pursuant to the Energy Transition for Green Growth Act. As the regulatory texts currently stand, significant modifications remain subject to "notification under the terms of article 26" of the BNI procedures decree of 2nd November 2007).

7.2.10 The other facilities located within a BNI perimeter

The following are located within the perimeter of a BNI:

- the BNI;
- the equipment and installations necessary for BNI operations; depending on its type, this equipment may technically be comparable to conventional installations but, as a part of the BNI, it is subject to the BNI regulations;
- classified equipment and installations which do not necessarily have a direct link with the BNI.

The equipment required for operation of the BNI is covered in full by the BNI regime as stipulated in the “BNI procedures” decree of 2nd November 2007. The other equipment within the perimeter of the BNI and by its nature subject to an administrative regime (water or ICPE) remains subject to this regime. ASN nonetheless has competence to take individual measures and monitor and regulate it.

7.2.11 Commissioning authorisations

The authorisation to commission a BNI is issued by ASN. It is detailed in § 19.1.

7.3 Regulation of nuclear activities

Regulation of nuclear activities is one of ASN's fundamental duties. This regulation consists in verifying that all parties in charge of a nuclear activity assume their responsibility in full and comply with the requirements of the regulations concerning nuclear safety and radiation protection. It contributes to assessing the performance of a licensee and to estimating the issues and implications associated with a nuclear activity.

In the case of BNIs, ASN regulation of nuclear safety and radiation protection extends to include protection of the environment and, in the NPPs, to labour inspectorate duties.

Regulation covers several levels:

- Before the licensee carries out any activity subject to authorisation, by means of a review and analysis of the files, documents and information supplied by the licensee to justify its actions. This regulation aims to ensure that the information supplied is pertinent and adequate;
- During operation, by means of visits and inspections on all or part of the facility, by documentary and field checks during important interventions such as scheduled nuclear reactor outages and by analysing significant events. This regulation involves sampling and analysis of the justifications provided by the licensee concerning the performance of its activities.

As and whenever necessary, ASN receives the support of IRSN.

Although historically focused on verifying the technical conformity of installations and activities with regulations and standards, regulation now encompasses a broader dimension taking in human and organisational factors.

In order to consolidate the credibility and quality of its actions, ASN:

- has defined a qualification system for its inspectors based on recognition of their technical skills;
- has adopted a number of foreign practices identified during the course of inspector exchanges between regulatory authorities;
- promotes the openness of its inspectors to other inspection practices.

ASN aims to ensure that the principle of the operator's prime responsibility for safety and radiation protection is respected. It applies the concept of proportionality when determining its actions, so that the scope and thoroughness of its regulation is commensurate with the issues in terms of nuclear, health and environmental safety.

7.3.1 Scope of regulation

7.3.1.1 Nuclear safety regulation

Nuclear safety encompasses all the technical provisions and organisational measures relative to the design, construction, functioning, shutdown and decommissioning of basic nuclear installations, and to the transport of radioactive substances, taken with a view to preventing accidents or mitigating their consequences in order to protect workers, the general public and the environment against the effects of ionising radiation. Moreover, technical measures to optimise management of radioactive waste and effluents are usually included in nuclear safety provisions.

In its regulatory duties, ASN is required to look at the equipment and hardware in the installations, the individuals in charge of operating it, the working methods and the organisation, from the start of the design process up to decommissioning. It reviews the steps taken concerning nuclear safety and the monitoring and limitation of the doses received by the individuals working in the facilities, and the waste management, effluents discharge monitoring and environmental protection procedures.

7.3.1.2 Radiation protection regulation

In BNIs, ASN ensures that the regulations for the protection of individuals against ionising radiation are implemented. In the same way as for nuclear safety, this work continues throughout the life of nuclear facilities. It consists in ensuring that the operator takes all measures for monitoring and limiting the doses received by the workers.

ASN checks compliance with these rules by examining specific cases and by dedicated inspections. In addition, the implementation of criteria common to all operators for the notification of radiation protection events enables ASN to be better informed of any abnormal situations which have occurred.

7.3.1.3 Pressure equipment

A large number of systems contain or carry pressurised fluids and are consequently subject to the regulatory requirements applicable to pressure equipment, regulation of which is the responsibility of ASN in the BNIs.

Of the BNI pressure equipment regulated by ASN, the main primary and secondary systems of EDF's pressurised water reactors (PWRs) are particularly important. Owing to the fact that in normal conditions they operate at high pressure and temperature, their in-service performance is one of the keys to the safety of the NPPs. ASN thus pays particularly close attention to the regulation of these systems.

This regulation in particular applies to the in-service surveillance programmes, non-destructive testing, maintenance work, handling of deviations affecting the systems and periodic system requalification.

7.3.1.4 Working conditions in BNIs

Regulating the application of all provisions relating to labour regulatory framework (in particular concerning occupational safety or social measures to protect the personnel) is the responsibility of the staff of the labour inspectorate.

There are three main labour inspectorate duties – control, information and advice – dealing with working conditions and worker protection. They draw their legitimacy not only from international standards (more specifically Standard n° 81 from the International Labour Office) but also from the national texts regulating the inspection services.

In NPPs, regulation actions regarding nuclear safety, radiation protection and labour inspection very often deal with common topics, such as worksite organisation or subcontracting conditions. Hence, the legislator has entrusted the attributions of labour inspectors to engineers or technicians appointed accordingly by the Chairman of ASN from among ASN staff. They act under the authority of the Minister in charge of labour.

In the other BNIs, such as research reactors, exchanges with conventional labour inspectors are a valuable source of information on the labour relations situation, in the context of a nuclear safety and radiation protection approach that is more attentive to the importance of people and organisations.

7.3.2 BNI regulation procedures

The operator is required to provide ASN with the information necessary for its regulatory duties. This information must enable the technical demonstrations presented by the operator to be analysed and the inspections to be targeted. The information must also allow identification and monitoring of the key events marking BNI operation.

When ASN regulatory actions reveal breaches of compliance with safety regulatory requirements, penalties (see § 7.4) can be imposed on the operators, if necessary after formal notice to comply. These penalties can include prohibition of restart or suspension of operation of a nuclear facility until corrective measures are taken.

7.3.2.1 Technical review of files submitted by the licensee

Review of the supporting documents produced by the operators and technical meetings organised with BNI operators or the manufacturers of equipment used in the installations are one form of ASN's regulatory duties.

At the design and construction stages, ASN checks the safety reports describing and justifying the design principles, the equipment design calculations, the equipment utilisation and test rules, and the quality organisation set up by the prime contractor and its suppliers. ASN also regulates the manufacture of PWR main primary system (CPP) and main secondary system (CSP) equipment.

Once the nuclear installation has started operating, all safety-related modifications proposed by the operator are subject to ASN approval. In addition to these checks necessitated by changes in installations or their operating procedures, ASN requires the operators to conduct periodic safety reviews (see § 14.2.1.3), to reinforce safety requirements according to changes in techniques and doctrine on the one hand and to experience feedback on the other.

Examination of these files may lead ASN to accept or reject the licensee's proposals, or to ask for additional information, studies or works to ensure conformity. ASN issues its requirements in the form of an authorisation or a resolution.

7.3.2.1.1 Evaluation of the information provided

The purpose of the files provided by the licensee is to demonstrate that the objectives set by the general technical regulations, or those set by the licensee itself, are met. ASN checks the completeness of the file and the quality of the demonstration.

Whenever it considers it necessary, ASN requests an opinion from technical support organisations (see § 8.1.3), the most important of which is IRSN. The safety assessment involves the collaboration of many specialists and effective coordination in order to identify the essential safety issues. IRSN assessment relies on research and development programmes and studies focused on risk prevention and improved understanding of accidents. It is also based on in-depth technical exchanges with the licensee teams responsible for designing and operating the facilities.

For the more important issues, ASN requests the opinion of the competent advisory committee, while for other matters, the safety assessments are given in IRSN opinions transmitted directly to ASN.

7.3.2.1.2 The main areas concerned

Scheduled NPP outages

Nuclear power plants are periodically shut down for refuelling and for maintenance of their main components.

Given the importance for safety of the maintenance work done during the outage and the safety risks of certain outage situations, ASN requires detailed information from the licensee. The programme of operations planned during the reactor outage can be subject to additional requests from ASN. During worksite inspections, the inspectors carry out spot checks on the conditions in which the various works in progress are conducted.

Other information submitted by the licensees

The licensee submits periodic activity reports and summary reports on water intake, liquid and gaseous discharges and the waste produced.

Similarly, there is a considerable volume of information on specific topics, such as the installation's seismic behaviour, fire protection, PWR fuel management, relations with contractors, etc.

7.3.2.2 Internal authorisations

The licensees of nuclear facilities are, in all cases, responsible for the safety of the activities they perform.

ASN however considers that the operations taking place in the BNIs with the highest nuclear safety and radiation protection implications must be subject to prior authorisation. Conversely, it considers that operations with limited implications should remain the sole responsibility of the licensee (see § 9.1).

In the case of intermediate operations with major nuclear safety and radiation protection implications but which do not call into question the safety hypotheses adopted with respect to BNI operation or decommissioning, the Environment Code allows the licensee to authorise them, provided that it sets in place a reinforced and systematic internal check mechanism with sufficient guarantees of quality, independence and transparency. The decision on whether or not to perform the operations must be formally authorised by the licensee's personnel that it has duly qualified for this purpose. This organisation is called the "internal authorisations system". It can be presented to the BNI's CLI.

This system of internal authorisations is governed by the BNI procedures decree and by ASN resolution 2008-DC-106 of 11th July 2008 which specifies the requirements ASN sets for the licensees for implementation of such a system.

ASN obviously ensures regular and careful oversight of the system right from its inception through site inspections or evaluation of the information files submitted by the operator. It maintains disciplinary powers and notably has the right to suspend authorisation to use the system of internal authorisations if a licensee fails to meet its obligations.

ASN shall also be notified of the operations intended for internal authorisation, so that it can schedule any necessary inspections.

Operations concerning the system of internal authorisations may, for instance, involve renovation work on the facilities, less significant decommissioning activities, periodic safety reviews of experimental devices or experiments complying with predetermined conditions.

This internal authorisations system is currently in place with several licensees, including EDF, AREVA, ANDRA and CEA.

7.3.2.3 Use of experience feedback

A system of deviation notification complying with the requirements of the BNI order is in force[2]. This requires the licensee to implement a reliable system for detection of the deviations which could occur, such as equipment failures or operating rules application errors. This system should allow early detection of any deviation from normal operations.

The significant event notification and processing procedures are described in more detail in § 19.6 and § 19.7. Significant event notification should not be confused with radiological emergency situations, for which a different organisation is put into place, or with a system designed to penalise errors by the licensee or an individual.

7.3.2.4 Inspection

7.3.2.4.1 Principles and objectives

In order to take account of health and environmental issues and the licensee's nuclear safety and radiation protection performance, ASN identifies the activities and topics with the greatest implications, on which it focuses its inspection efforts.

In order to assess these issues, ASN relies on state-of-the-art scientific and technical knowledge, on information resulting from external inspections, on the review of the files submitted by the licensees and on the results of its regulatory oversight duties. ASN may at all times revise its assessment of the issues in the light of changes to these elements and of significant events that have occurred in France or elsewhere in the world.

Compliance with the baseline safety requirements by the nuclear licensees is verified by spot inspections in order to check effective implementation of the provisions concerning safety, radiation protection and the related fields regulated by ASN.

Inspection is the primary means of verification available to ASN. Without being systematic or exhaustive, it is a means of detecting individual anomalies or any drift indicative of a deterioration in the safety of the facilities.

During the inspections, the licensee is notified of factual reports concerning:

- discrepancies between the situation observed during the inspection and the regulatory texts or documents drawn up by the licensee pursuant to the regulations;
- anomalies in the facility or points which, in the opinion of the inspectors, require further substantiation.

Deviations identified during the inspection can lead to administrative or penal sanctions.

ASN draws up an annual programme of inspections. This programme is not communicated to the nuclear facility licensees. It defines priorities for reinforced controls on topics or activities with the most significant implications. It also allows adequate distribution of ASN's resources in a manner commensurate with the potential implications of the various facilities.

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[2] BNI order: order of 7th February 2012 setting general rules for basic nuclear installations;

The licensee is notified of the visit a few weeks beforehand, although some inspections (about 20%) are unannounced. They mainly take place on the nuclear sites. They may also concern the head office departments (or design departments) of the main nuclear licensees, the workshops or design offices of the subcontractors, the construction sites, the plants or workshops manufacturing various components that are important for safety.

The inspections are generally performed by two inspectors, one of whom is more specifically in charge of directing the operations, and can be assisted by an IRSN representative specialising in the facility visited or the technical topic of the inspection. ASN performs different types of inspections:

- routine inspections;
- in-depth inspections taking several days and requiring a full team of inspectors, with the purpose of carrying out detailed examinations;
- inspections including sampling and measurements, for spot checks on discharges that are independent of those of the licensee;
- inspections carried out further to a significant event;
- worksite inspections during reactor outages or particular works, especially during the decommissioning phase.

Within 21 days of completion, each inspection is the subject of a follow-up letter which is made public on the ASN website.

7.3.2.4.2 Inspection practices in 2015

In 2015, 658 nuclear safety inspections were carried out in the BNIs, including more than 330 on the nuclear power reactors.

7.3.3 ASN organisation for BNI regulation

7.3.3.1 Inspection in the BNIs

In order to achieve its goals, ASN has inspectors duly appointed and certified by the ASN Chairman, as defined by decree 2007-831 of 11th May 2007, provided that they have acquired the required level of legal and technical competence through their professional experience, tutoring or training. They carry out their inspection activities under the authority of the ASN Director General and have access to practical inspection tools that are regularly updated. They swear an oath and are bound by professional confidentiality.

As at 31st December 2015, there were 183 nuclear safety inspectors, with 98 in the ASN regional divisions and 85 in the head office departments. These inspectors oversee most of the inspections in the BNIs. Labour or radiation protection inspectors can also intervene in these facilities for inspections on these specific topics.

Year	Total	Unannounced inspections (all nuclear facilities)	Scheduled and unannounced inspections (nuclear power reactors)
2013	764	191	369
2014	773	184	381
2015	658	138	330

Table 3: Number of inspections performed by ASN in the BNIs

7.3.3.2 Regulation of pressure equipment manufacturing

The assessment of conformity of design and manufacture of the MPS and MSS equipment (NPE of level N1[3]) is carried out directly by ASN, assisted by an approved organisation if it wishes. The assessment of conformity of design and manufacture of the other NPE (N2 and N3) is carried out by approved organisations and monitored by ASN.

In this context, ASN carried out 19 inspections in the area of design and manufacture in 2015, 12 of which were in approved organisations. These inspections are supplemented by a large number of inspections carried out directly by the approved organisations.

All the inspections on manufacturers' premises carried out by the organisations are presented in § 18.2.4.1.

7.3.3.3 Significant events

ASN has defined a category of deviations called "significant events". These are events which are sufficiently important with regard to safety, the environment or radiation protection to justify rapidly notifying ASN of their occurrence and subsequently submitting a fuller analysis to ASN. It is compulsory to notify ASN of significant events, as provided for by legislation (Environment Code, Public Health Code, Labour Code), the order of 7th February 2012 and the order of 29th May 2009.

The criteria for notifying events deemed significant to the public authorities take into account:

- the consequences - whether real or potential - on the workers, the general public, patients or the environment, of events involving safety or radiation protection;
- the main technical, human or organisational causes that led to the occurrence of such an event.

ASN has moreover published guides which describe in greater detail the principles and criteria for notifying significant events

Analysis of a significant event covers compliance with the significant event detection and notification rules in force, the immediate technical measures taken by the licensee to maintain the facility in or bring it to a safe state and, finally, the pertinence of the significant event reports supplied by the licensee. The review and analysis of these events at a later date by ASN and its technical support organisation, IRSN, are described in detail in §19.6.4.

[3] NPE are classified in 3 levels depending upon the radioactive emission importance in case of NPE failure. NPE of level 1 are the most important for safety.

Year	Pressurised water reactor	Other BNIs	Radioactive materials transport
2013	817	193	51
2014	761	210	63
2015	712	226	66

Table 4 : Number of significant events notified by the BNI licensees and classified on the INES scale (including level 0)

7.4 Penalties

When ASN observes failures to comply with safety regulations, policing measures and administrative penalties can be imposed on the licensees after serving formal notice.

If a failure to fulfil obligations is observed, the Environment Code provides for a graduated scale of administrative police measures and penalties following formal notice and defined in Articles L. 171-8 and L. 596-4:

- the consignment to a public accountant of an amount corresponding to the cost of the work to be carried out;
- the automatic completion of the work at the licensee's expense, with the possibility of using the sums previously consigned to pay for the work concerned;
- suspension of operation of the facility or of the on-going action until the licensee has restored conformity.

The ordinance of 10th February 2016 supplemented these provisions to enable ASN to order:

- the payment of a maximum daily fine of 15,000 euros;
- the payment of an administrative fine of 10 million euros at the most for noncompliance with the provisions applicable to BNIs, 1 million euros for noncompliance with the provisions applicable to NPE and 30,000 euros in other cases. This fine is ruled by a sanctions committee which comprises four members who are members neither of the ASN Commission nor of ASN departments.

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

- in the event of severe and imminent risks, provisionally suspend operation of a BNI, immediately informing the Minister responsible for nuclear safety;
- at all times, prescribe the performance of assessments and the implementation of the steps necessary if the above-mentioned interests are threatened.

Furthermore, any Penal Code violations are recorded in reports drawn up by the inspectors and sent to the public prosecutor's office, which then decides on whether or not further action is justified.

The Environment Code makes provision for penalties, as detailed in Articles L. 596-11 et L. 596-12; these penalties comprise fines of from €7,500 to €150,000 € plus a possible prison term of from 1 to 3 years, depending on the nature of the violation. For legal persons found to be criminally liable, the amount of the fine can reach € 10,000,000.

The number of administrative measures (formal notice, activity suspension, etc.) issued by ASN and the number of formal notices served on the licensees between 2013 and 2015 are shown in the following table.

Year	Administrative measures	Formal notice transmitted to public prosecutor	Number of labour inspection formal notices
2013	16	10	10
2014	9	6	9
2015	4	4	3

Table 5: Administrative measures and formal notices concerning BNIs or radiative material transport, transmitted to the public prosecutor's office

8. Article 8: Regulatory body

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 French Nuclear Safety Authority (ASN)

Act 2006-686 of 13th June 2006 (codified in the Environment Code) created an independent administrative authority, ASN, tasked with regulating nuclear safety and radiation protection in all civil nuclear activities.

The Act gives ASN competence to issue regulatory resolutions to clarify the decrees and orders relating to nuclear safety and radiation protection, which are subject to approval by the Minister in charge of nuclear safety or radiation protection. It 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 Government retains the power to stipulate the general regulations applicable to nuclear activities by decree or by order. It issues the few major individual resolutions concerning major nuclear installations, notably the plant creation authorisations and decommissioning decrees. The Government is also responsible for civil protection in emergency situations.

ASN must be consulted by the Government on general regulatory texts within its areas of competence and on the major individual resolutions. It prepares draft regulatory texts for the Government and clarifies regulation by means of technical resolutions. The nuclear safety and radiation protection inspectors designated by ASN ensure monitoring and regulation of 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 contributes to information of the public. Finally, it contributes to operational management of radiological emergencies.

On technical matters, ASN relies on the expertise provided primarily by IRSN and by the Advisory Committees of experts (GPE).

In more detail:

- ASN is consulted on draft decrees and ministerial orders of a regulatory nature dealing with nuclear safety.

  It can take regulatory decisions of a technical nature to supplement the implementing procedures for decrees and orders adopted in the areas of nuclear safety or radiation protection, except for those relating to occupational medicine. For more details, see § 7.1;

- ASN examines BNI authorisation, creation, decommissioning files and BNI request for substantial modifications and makes proposals to the Government concerning the decrees to be issued in these areas. It defines the requirements applicable to these facilities with regard to the prevention of risks, pollution and detrimental effects. It authorises commissioning of these facilities and according to their importance, it authorises significant modifications or receives the declarations referred to installations. It pronounces their delicensing following decommissioning.

ASN also issues the authorisations for small-scale nuclear facilities (group together sereval areas using ionising radiations such as medicine, human biology, etc.) provided for by the Public Health Code and the authorisations or approvals for the transport of radioactive substances. For more details, see § 7.2;

- ASN verifies compliance with the general rules and specific requirements for nuclear safety and radiation protection applicable to BNIs, the manufacturing and the operation of nuclear pressure equipments, the transport of radioactive substances, and nuclear activities outside BNIs. It issues the required approvals to the organisations participating in the verifications and monitoring concerning nuclear safety or radiation protection. For more details, see § 7.3;
- ASN is involved in the management of radiological emergency situations. It provides the competent authorities with technical support in order to develop appropriate measures, within the framework of the emergency organisation plans, taking due account of the risks resulting from nuclear activities. When such an emergency situation arises, it assists the Government on all relevant issues within its areas 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. These measures are detailed in chapter 16;
- 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 activity report to Parliament, to the Government and to the President of the Republic. It also uses various channels and written media (monthly ASN newsletter, *Contrôle* magazine, annual report), website (http://www.french-nuclear-safety.fr/), public information and documentation centre, press conferences, seminars and exhibitions.

8.1.1 Organisation

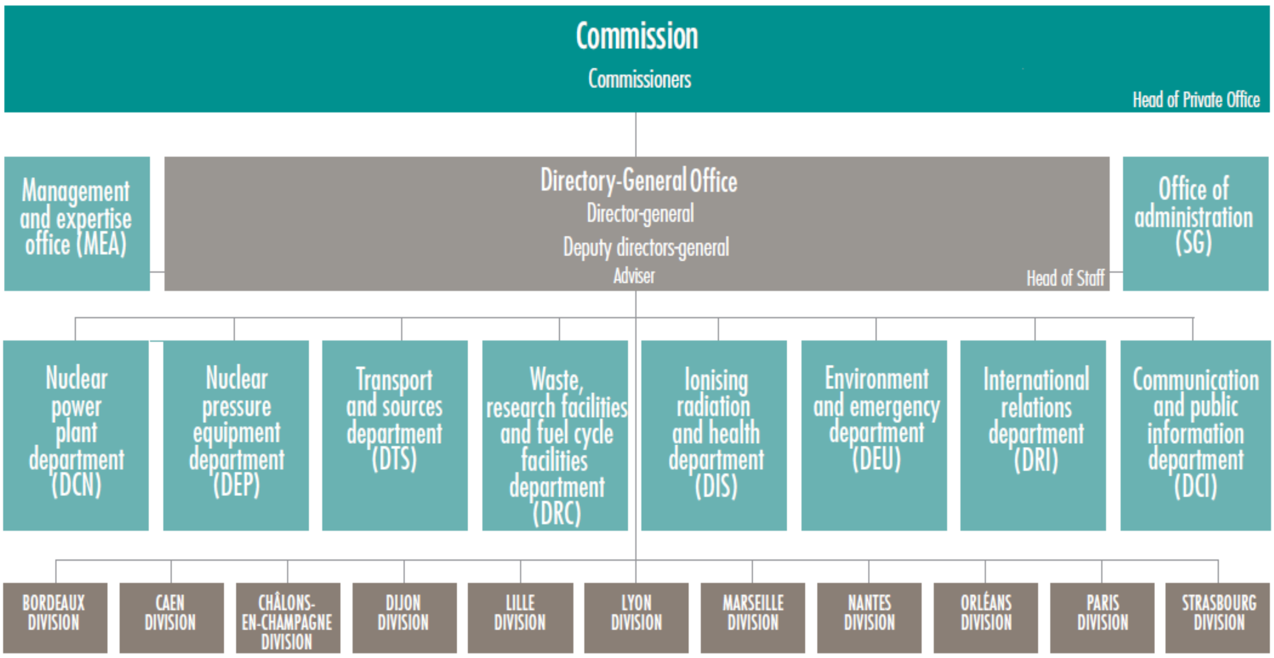

Figure 3: ASN - General Organisation

8.1.1.1 The 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. Three of the commissioners, including the Chairman, are appointed by the French President. The other two commissioners are appointed by the president of the National Assembly (lower house of the French Parliament) and by the president of the Senate (upper house), respectively.

The ASN commissioners exercise their functions on a full-time basis.

Once they are appointed, the commissioners are required to draw up three declarations of interests and one declaration of assets in application of three different legal frameworks:

- A declaration of interests on the basis of article L. 592-6 of the Environment Code mentioning the interests they hold or have held during the previous five years in the areas within the competence of ASN. This declaration, which is filed at the ASN head office and is held at the disposal of the members of the Commission, is updated at the initiative of the Commissioner concerned as soon as any change occurs that would modify the declaration. It is not made public. During the course of his or her mandate, no member may hold any interest that could affect his or her independence or impartiality. For the duration of their functions, the commissioners will express no personal views in public on subjects coming under the competence of ASN.
- A declaration of interests under article L. 1451-1 of the Public Health Code with regard to health product safety. The information in this declaration is made public on the ASN website, with the exception of information relating to the sums declared and the identity of relatives.
- A declaration of interests held on the date of appointment and in the five years preceding that date and a declaration of assets in application of the ordinary law 2013-907 of 11th October 2013 relative to transparency in public life. They are addressed to the High Authority for Transparency in Public Life Any substantial modification in the assets or interests held gives rise to a declaration in the same manner.

The duration of the mandate of the Commission members is six years. It is non-renewable. A member's functions may only be terminated in the event of inability or resignation as recorded by a majority vote of the Commission. The President of the French Republic may also terminate the term of any commissioner in the event of severe breach of duty.

The Commission defines ASN's strategy. In this respect, it draws up a multi-year strategic plan and develops general policies in the form of ASN doctrines and action principles for its essential missions, which include regulation, inspection, transparency, management of emergency situations, international relations, etc.

Pursuant to the law, the Commission submits ASN opinions to the Government and issues ASN's main resolutions. The members of the Commission act with complete impartiality, receiving no instructions either from the Government or from any other person or institution.

8.1.1.2 ASN head office departments

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

The head office departments comprise 8 thematic departments, an Office of Administration and a Management and Expertise Office (see Figure 2). The role of the ASN head office departments is to manage national matters concerning the activities for which they are responsible. They take part in defining the general regulations and coordinate the work of the teams in the regions responsible for field inspection of facilities and activities. Each ASN entity contributes to public information on nuclear safety and radiation protection.

8.1.1.3 The ASN regional divisions

ASN's regional divisions operate under the authority of the regional representatives. The divisions conduct most of the direct regulation of nuclear installations, radioactive material shipments and other small-scale nuclear activities. They review most creation authorisation application files submitted by operators within their geographical jurisdiction. In addition, they support ASN's head office departments in their review of major decisions. In emergency situations, they assist the departmental Prefect who is responsible for the protection of the population of the department. Lastly, they contribute to the public information mission entrusted to ASN by law.

8.1.2 ASN operation

8.1.2.1 Human resources

On 31st December 2015, ASN's total workforce stood at 483 staff, including 263 in head office departments, 216 in the regional divisions and 4 abroad.

On 31st December 2015, the average age of the ASN staff was 43.5 years old. This balanced age pyramid and the diversification of profiles in terms of recruitment, and thus of background, ensures that ASN holds the required qualified and complementary human resources to fulfil its mission. In addition, training, bringing younger staff on-board and the transmission of knowledge guarantee the required level of expert know-how.

Competence is one of ASN's four key values. A tutoring system, allied with initial and ongoing training, whether general, associated with nuclear techniques, or in the legal or communication field, 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 sessions. In 2015, about 3,700 days of training were provided to the ASN staff. The financial cost of the courses provided by organisations other than ASN amounted to €430,000.

8.1.2.2 Financial resources

Since 2000, all the personnel and operating resources involved in the performance of the tasks entrusted to ASN have been covered by the State's general budget. For 2015, the full-cost budget of ASN is approximately €80 million.

Moreover, as stipulated by the law, ASN relies on IRSN for technical expertise, backed up whenever necessary by research. The corresponding amount was €85 million in 2015.

8.1.2.3 Quality management system

To guarantee and improve the quality and effectiveness of its action, ASN defines and implements a quality 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 providing ASN internal rules for the sound conduct of each of missions;

- internal and external audits concerning implementation of the measures contained in ASN's quality 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 continuous improvement of its operation.

8.1.3 ASN's technical support bodies

ASN benefits from the expertise of technical support organisations in preparing its resolutions. The main organisation is IRSN. For several years, ASN has been making efforts to diversify its experts.

8.1.3.1 French Institute for Radiation Protection and Nuclear Safety (IRSN)

IRSN (French Institute for Radiation Protection and Nuclear Safety) is an industrial and commercial public institution (EPIC) whose missions are now defined by the Energy Transition for Green Growth (TECV) Act No. 2015-992 of 17th August 2015 and which is the French public expert in nuclear and radiological risks. IRSN contributes to the public policies with regard to nuclear safety and protection of health and the environment against ionising radiation. As a research and expert appraisal body, it acts in consultation with all the entities concerned by these policies, while at the same time maintaining its independence of judgement.

IRSN is placed under the joint tutelage of the Ministry of the Environment, Energy and the Sea, the Ministry of National Education, Higher Education and Research, the Ministry of Social Affairs and Health, and the Ministry of Defence.

IRSN runs and implements research programmes with a view to consolidating national public expert capability around the most advanced scientific knowledge at the international level and to contribute to the development of scientific knowledge concerning nuclear and radiological risks. It is tasked with technical support of the public authorities with competence for safety, radiation protection and security, not only in the civil sphere, but also for national defence purposes. According to its above-mentioned creation decree, it also performs certain public interest duties outside the research field, more specifically with regard to monitoring of the environment and of persons exposed to ionising radiation.

Those missions include training in radiation protection, the management and processing of dosimetric data concerning workers exposed to ionising radiation, the management of the inventory of radioactive sources, as well as contributing to information of the public about the risks associated with ionising radiation.

In accordance with the ISO 9001 certification it received in 2007, IRSN is developing its own quality policy based on a continuous-improvement approach in order to enhance the quality of its skills. In accordance with this approach, the opinion of ASN and of all organisations benefiting from IRSN's technical support is taken into account. Periodic meetings are also held to enable ASN and IRSN to discuss past, present and future expert appraisal work.

The Government consults ASN on the share of the State's subsidy to IRSN for its technical support mission for ASN. A five-year agreement signed by ASN and IRSN determines the technical support procedures, involving some 400 staff. It is described every year in a protocol which fine-tunes priorities according to the nuclear safety and radiation protection issues.

8.1.3.2 Advisory Committees of experts

In preparing its decisions, ASN relies on the Advisory Committees' opinions and recommendations.

Seven Advisory Committees (GPE) have been constituted to assist the ASN Director General. The Advisory Committees are consulted by ASN on the nuclear safety and radiation protection of installations and activities relating to their field of competence: nuclear reactors, laboratories and plants using radioactive materials, radiation protection in medical facilities, radiation protection in non-medical institutions, waste, transport and pressurised nuclear equipment.

For each of the subjects covered, the Advisory Committees study reports prepared by IRSN or other duly mandated expert, by an ad hoc working group created for the occasion or by one of the ASN entities. They issue an opinion together with recommendations.

The Advisory Committees comprise experts appointed for their competence, coming from varied backgrounds, such as industries, universities and associations. Every Advisory Committee may call upon any person recognised for his or her particular skills. It may also conduct a hearing of the licensee's representatives. The participation of foreign experts can bring new approaches to problems and benefit more widely from international experience.

With the constant concern of improving the transparency of nuclear safety and radiation protection, ASN publishes the documents relating to Advisory Committee meetings, especially its opinions and the position adopted by ASN. The programming and results of the work of the Advisory Committees are closely monitored by the management at ASN and IRSN. Discussion and coordination meetings are held three times a year to contribute to continuous improvement of the technical quality and consistency of Advisory Committee opinions, which remain key elements for ASN.

8.2 Other actors involved in nuclear safety and radiation protection

8.2.1 The Parliamentary Office for the Evaluation of Scientific and Technological Choices (OPECST)

Created by in July 1983, the Parliamentary Office for the Evaluation of Scientific and Technological Choices (OPECST) is a parliamentary delegation whose mission is to inform Parliament about the impact of scientific and technological choices, particularly with a view to ensuring that decisions are taken with the full knowledge of the facts. The OPECST is assisted by a Scientific Council consisting of 24 members from various scientific and technical disciplines.

The members of the OPECST duty is to examine the organisation of safety and radiation protection, both within the Administration and on operators' premises, to compare its characteristics with those of other countries and to check that authorities have sufficient resources to perform their mission. They also played an important role in the drafting of the TSN Act. The Office's reports are drafted before voting of the law in order to prepare the legislative decision, or afterwards for follow-up of implementation of the text passed.

Hearings are open to the press and have become a well-established tradition at the OPECST. They allow all interested parties to express their views, to put across their arguments and to debate publicly any given topic under the guidance of the OPECST Rapporteur.

In 2011, in the wake of the Fukushima Daiichi NPP accident, a Parliamentary delegation submitted a report on "nuclear safety, where the industry stands, today and tomorrow".

In July 2015, the OPECST (Parliamentary Office for the Evaluation of Scientific and Technological Choices) submitted a report on "The oversight of nuclear pressure equipment: the case of the EPR reactor vessel" (report of the public hearing of 25th June 2015 and the presentation of the conclusions of 8th July 2015).

It is before the OPECST that ASN tables every year its report on the status of nuclear safety and radiation protection in France.

8.2.2 Nuclear safety and radiation protection mission (MSNR)

The Nuclear Safety and Radiation Protection Mission (*Mission de sûreté nucléaire et de radioprotection* – MSNR) is the ministerial service placed under the authority of the French Ministry of the Environment, Energy and the Sea (MEEM), in order to deal on its behalf with the issues pertaining to the Government's jurisdiction in the field of nuclear safety and radiation protection.

Hence, the MSNR:

- drafts general regulations, in connection with ASN;
- leads individual administrative procedures pertaining to the ministers' jurisdiction;
- provides secretariat services to the High Committee for Transparency and Information on Nuclear Security (see § 8.2.3.1).

8.2.3 Advisory bodies

8.2.3.1 The High Committee for Transparency and Information on Nuclear Security (HCTISN)

In matters of nuclear safety and radiation protection, the *TSN Act* provided for the creation of a High Committee for Transparency and Information on Nuclear Security (*Haut Comité pour la transparence et l'information sur la sécurité nucléaire*), as an information, consultation and debate structure on the hazards induced by nuclear activities and their impact on human health, the environment and nuclear safety.

The High Committee is empowered to issue opinions on any issue within its jurisdiction, as well as on all associated controls and information. It may also address any topic relating to access to information regarding nuclear security and to propose any step aiming at ensuring or at improving transparency in nuclear matters.

The Ministers in charge of nuclear safety, the presidents of the competent committees of the National Assembly and of the Senate, the President of the OPECST, the presidents of the CLIs or INB operators may also call upon the advice of the High Committee on any information issue relating to nuclear safety and its regulation.

The Chairman of the High Committee is appointed by decree from among members of Parliament, representatives of the local information committees and public figures chosen for their competence.

8.2.3.2 The High Council for Prevention of Technological Risks (CSPRT)

The High Council for Prevention of Technological Risks (CSPRT) advises the Ministers in charge of Installations Classified on Environment Protection grounds (ICPE), nuclear safety and industrial security.

The High Council gives its opinion when demanded by the law or the regulation, notably on draft decrees provided by Article L.593-2 of the Environment Code. Its opinions are included to the projects submitted to ASN. ASN considers that obtaining the opinion of the CSPRT is one means of achieving greater consistency in the requirements applicable to the ICPEs and BNIs.

It analyses, among others, draft regulations or all questions related to BNIs submitted by the ministers in charge of these topics or ASN.

8.2.4 The Local Information Committees (CLI)

The TSN Act of 13th June 2006, now codified in books I and V of the Environment Code, has formally defined the status of the BNI local information committees (CLI). These Committees, set up by the President of the *Conseil général* and comprising elected officials, associations, trade unions, qualified personalities and representatives from the economic world, have a general duty to monitor, inform and discuss nuclear safety, radiation protection and the impact of nuclear activities on man and the environment with regard to the facilities that concern them.

The Energy Transition for Green Growth Act increases the competences of the CLIs which once a year must organise a public meeting that is open to all, which can for example ask the licensee to organise visits of the BNIs or to organise visits of installations after an appropriate delay following incidents rated level 1 or higher on the INES scale. The CLIs of nuclear sites situated in départements bordering other countries are open to the members of the neighbouring countries.

As regard texts involving individual measures for BNIs (such as creation authorisation decree or decommissioning), they are now subject to a hearing of the operator and the CLI by ASN, as provided for in ASN's resolution on 13th April 2010.

9. 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 principle of licensee prime responsibility is defined by the Environment Code.

The BNI order also deals with the licensee's integrated management system and requires that this latter define and implement a management system enabling it to ensure that the requirements concerning protection of the interests of the BNI regime are systematically taken into account for all decisions concerning its facility.

On behalf of the State, ASN ensures that this responsibility is assumed in full, in compliance with the regulatory requirements. The respective roles of ASN and the licensee are as follows:

- ASN defines the general safety and radiation protection objectives;
- the licensee proposes and documents technical measures for achieving them;
- ASN checks that these measures enable the objectives to be achieved;
- the licensee implements the approved measures;
- during inspections, ASN checks correct implementation of these measures and draws the corresponding conclusions.

9.2 Transparency and public information by the licensees

9.2.1 Measures taken by EDF

As a responsible industrial firm and being aware of the particular nature of the nuclear power generating activity, EDF has always, since the beginning of operation of the NPPs, sought to inform the public about the operation of the facilities, technical events and activities concerning this form of energy in general and all safety aspects in particular.

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 also adopted with respect to the staff and its representatives, the subcontractors, the regulatory bodies, the local communities, especially the CLIs, 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, and answering public queries about the safety and radiation protection measures taken.

The law in particular requires each site to publish an annual report describing the steps taken concerning nuclear safety and radiation protection, nuclear safety and radiation protection incidents and accidents, the nature and results of measurements of radioactive and non-radioactive environmental discharges, the nature and quantity of radioactive waste stored on the facility site. This report is made public and transmitted to the CLI of each site.

9.2.2 Measures taken by CEA

A CLI (see § 8.2.4) is in place for each CEA centre. CEA keeps the committees regularly informed of research activities, of the changing regulatory situation of the facilities and of any events concerning nuclear safety and radiation protection.

The follow-up to the Fukushima Daiichi NPP accident, in particular the stress tests, was the subject of special presentations by CEA and was widely discussed within the CLIs.

The CEA general management takes part in the annual meeting of all French CLIs representatives for the EDF, AREVA and CEA facilities.

Within the framework of the final shutdown and decommissioning authorisation application for the Phénix reactor, CEA - and its Marcoule centre more particularly - took part in the public inquiry and the hearings by the Government services concerned, as provided for by the procedure.

CEA takes part in the work of the HCTISN.

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 CLI meetings;
- participation in the regional industrial risks information programmes;
- updating its website (www.ill.eu) with information concerning the law, reactor safety, environmental monitoring, security, inspections, emergency exercises and incidents. The follow-up to the Fukushima Daiichi NPP accident was the subject of detailed presentations. Question-and-answer sections were included;
- participation in technical and scientific forums;
- public meetings in the communes, with the involvement of local companies.

E – GENERAL CONSIDERATION ON SAFETY

10. 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 ASN requests

To guarantee and improve the quality and effectiveness of its actions, ASN implements an organisation which is described in chapter 8.

In accordance with the duties entrusted to it, ASN from the outset asked the BNI licensees to adopt an organisation ensuring that absolute priority is given to nuclear safety.

The importance given to safety is underlined in the Environment Code and its implementing texts, such as the BNI order. These texts, which define the principles and objectives that every BNI licensee must consider when drafting its policy of protection of interests protected under the law[4] and its implementation at all stages in the design, construction, operation and decommissioning of the facilities contribute to its continuous improvement.

By enshrining it in the legislation, Ordinance 2016-128 of 10th February 2016 *constituting various nuclear provisions* reinforced the requirement on a BNI licensee to give priority to the protection of the protected interests and its permanent improvement. The law also requires the licensee to formally define its corresponding policy in a document which must explicitly stipulate this priority. The licensee must finally set up and formally define an integrated management system guaranteeing that the requirements concerning the protection of the protected interests are taken into account in the management of its installation.

Historically, this safety management system is based on the development of a nuclear safety culture. Safety management must be integrated into the company's general management system in order to guarantee protection of the interests mentioned by the Environment Code, while giving priority to the prevention of accidents and the mitigation of their consequences.

10.2 Measures taken for nuclear power reactors

Responsibility as a nuclear licensee for nuclear reactors is exercised within EDF SA at the main levels concerned: the President and CEO, the Director of the nuclear and thermal power plants (DPNT), the Director for engineering and new nuclear projects (DIPNN), the Director of the Nuclear Generation Division (DPN), who is the officer responsible for the operation of all French NPPs, and each NPP manager.

Given the importance of all EDF's nuclear activities and its responsibilities and involvement in the reactor operations in France, but also in Great Britain, the EDF Group adopted a Nuclear Safety Policy in 2012, which applies to all its activities within each Group company operating nuclear facilities (design and construction of new projects, operation of existing reactors, maintenance, waste management,

[4] Within the meaning of the Environment Code, these are interests with respect to the risks or drawbacks that the licensee's activities can present for public safety, health and hygiene or for protection of nature and the environment.

dismantling, engineering). This policy, which is inspired by international guidelines and safety requirements (IAEA SF-1 and GSR-3, INSAG 4 for the 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 demonstrate this, with the involvement of industrial partners. The responsibility for implementing this policy in each professional sector and each company lies with the corresponding managerial line.

It reaffirms the priority given to safety with a view to the sustainable use of nuclear energy, with a clear principle of responsibility and oversight at all levels of the company, a strong commitment to competence, safety attitudes and culture, a permanent search for progress, openness to international best practices, preparedness for emergency situations, and transparency and dialogue. This policy is disseminated to each member of staff and to each contractor and subcontractor.

An independent safety assessment is carried out on each site, on each company and on the Group. In the field of reactor safety, the safety and quality delegation in the NPPs, the nuclear inspectorate at the DPN, the general nuclear safety and radiation protection inspectorate reporting to the CEO of the EDF group are these independent entities, reporting to the site director, the DPN director, the DPI director and the CEO of the EDF Group respectively.

More specifically with regard to the NPPs, EDF has continued to reinforce the decision-making process in order to guarantee the priority given to safety. Since the early 2000s, implementation of the OSRDE (observatories for safety, radiation protection, availability and the environment) has been encouraged, in order to identify the conditions in which decisions are taken. In addition, work has been done in recent years, based on the INPO "effective decision-making" document, so that conditions favourable to good decision-making are systematically set up.

Furthermore, the nuclear power plants are audited at various levels:

- by the nuclear inspectorate, the DPN's auditing entity. These assessments, carried out every four years, consist in evaluating the level of safety, radiation protection and environment, by comparing the actual performance of the organisations and the baseline requirements established by the DPN management, and then in issuing recommendations to the entire hierarchical line in order to improve safety;
- by IAEA, through OSART missions (see Appendix 5), with a special nuclear inspection preparatory audit carried out between 18 months and two years in advance (1 OSART mission per year for the DPN);
- by the World Association of Nuclear Operators (WANO – see § 20.3) by means of peer reviews. These reviews consist of a plant assessment programme, covering technical and managerial aspects, performed by foreign licensee peers. They are also an opportunity for productive discussions between the assessment team and the operators of the plant inspected. They are implemented every 4 years on each site.

These WANO and IAEA assessments are also an opportunity for EDF engineers and managers to observe best practices in other countries.

In order to ensure that the required priority is given to safety, EDF set up a system based on defence in depth as of the beginning of operation of its facilities (in particular a quality approach with risk assessment, inspection and verification, an independent safety system) which was reinforced over time in order to ensure continuous progress, by integrating the lessons learned from operating experience feedback from the nuclear industry.

In particular, in order to meet the two-fold goal of safety management (INSAG 13, 1999) – improve safety results and reinforce the safety culture – the traditional arrangements have been added to since the early 2000s in two areas:

- "manager practices", with the distribution of the Safety Management Guide to the directors, department heads and 1st line managers, built around 3 key principles:
  - safety leadership;
  - personnel development and engagement;
  - continuous improvement and support tools (decision-making, self-assessment/diagnostic, field visit, team project, etc.);
- "personnel practices", with the development of work error-reduction practices (pre-job briefing, one-minute pause, self-check, cross-check, secure communication, debriefing).

Over the past 3 years, these 2 aspects have been reinforced by increased emphasis on development of the safety culture, with the aim of making it easier for new generations to enter the nuclear industry.

On the basis of international practices and its convictions on this subject – culture cannot be imposed, it is the result of managing change, with culture coming from the organisation, but also from the cultures originating in the various disciplines – EDF set up a national/sites working group which produced:

- A safety culture guide, which presents the traditional approach followed by EDF and the common points of safety culture reference, through 6 topics and 40 sub-topics,
- A range of change management levers, making it possible to step back and think, to adopt a position, but also to debate and discuss safety practices within a unit, departments and above all teams: safety perception questionnaire, safety culture observatory, e-learning, training, safety culture workshops, etc.

Finally, with regard to the oversight aspect, the deployment (now in all units) of an integrated management system constitutes an additional lever for guaranteeing that the required priority is given to safety.

10.3 Measures taken for research reactors

10.3.1 CEA reactors

The measures to ensure safety taken by CEA take into account the considerable variety of its installations, resulting from the broad range of research programmes CEA carries out, and the way those programs develop over time. The consequence is a diverse range of potential risks. Since 2006, CEA has adopted a safety policy which is implemented through a three-year plan. This approach has led to contracts which, within the units and at various hierarchical levels, formally define precise safety and radiation protection targets and the associated means. CEA thus also committed to a self-assessment approach based on a certain number of indicators for monitoring safety and the correct working of the organisation.

Nuclear safety is a priority of CEA. It is based on:

- 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 (refer to the organisation chart and its evolution in Appendix 3, § 3.2);

- a safety culture that is taught, maintained and developed;
- staff that are professional, skilled and capable of teamwork.

It should be noted that as of 1st January 2016, CEA's structural organisation has been modified (see Appendix 3, § 3.2). The following description corresponds to the effective organisation until 31st December 2015.

At a central level, the Chairman determines the broad safety outlines 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 strategic decisions.

With regard to nuclear safety, radiation protection and transport operations, the Chairman is assisted by the nuclear safety protection division. This division, which is part of the "risk management" centre, defines CEA's safety policy, which is based on constant progress.

The nuclear energy director, assisted by the quality and environment division, implements and monitors application of the CEA safety policy in all the installations.

Existing doctrine is given in the CEA nuclear safety manual. It comprises:

- circulars that are General Management Directives;
- recommendations which aim to define CEA doctrine.

At local level, the centre directors and installation managers, who comprise the management hierarchy, ensure that the defined safety policy is applied in each installation for which they have responsibility.

The check function is carried out by entities independent of those forming part of the management hierarchy. The check function reviews the efficiency and adequacy of the actions taken, and of the internal technical controls. General nuclear safety support units provide the installations with assistance in the centres.

At the level of the Chairman, the supervision task falls under the responsibility of the General and Nuclear Inspectorate (IGN) of the CEA's Risk Control Sector. The IGN performs scheduled inspections (about 10 every year) and reactive inspections after significant events. The IGN Director may decide on the inspectorate's intervention on relevant topics.

CEA has reinforced the organisational and radiation protection arrangements in the operations performed by outside contractors.

CEA is also continuing to reinforce certain areas for progress, including:

- the organisation of the technical support provided to the installations in certain areas of expertise, such as earthquakes, civil engineering, criticality and human factors;
- organisational arrangements concerning management of contractors.

10.3.2 The ILL high-flux reactor (RHF)

Nuclear safety has always been and remains the priority at ILL. The level of safety reached by ILL is based on the following organisation:

- a radiation protection-safety-environment unit reporting directly to the Institute's Director;
- a quality-risk unit reporting directly to the senior management;

- a reactor division, the head of which, with authority delegated by the director, is responsible for the operation and safety of the reactor and its auxiliaries.

The management of the equipment and activities important for protection (EIP and AIP) is defined in the IMS integrated management system, in accordance with the BNI Order.

10.4 ASN analysis and oversight

10.4.1 ASN

ASN's actions are based on its quality management system, built around internal and external audits.

With a view to ensuring continuous progress, in 2006 ASN hosted an IRRS "full scope" mission (all nuclear safety and radiation protection fields), and in 2009 an IRRS follow-up mission .

From 17th to 28th November 2014, ASN hosted a new IRRS mission to look at all of its activities, chaired by Mark Satorius, EDO of the American Nuclear Regulatory Commission and by Ann McGarry, Director of the Office of Radiological Protection at the Irish Environmental Protection Agency.

During the mission, twenty-nine experts from the nuclear safety and radiation protection authorities of Australia, Belgium, Canada, Cuba, Czech Republic, Finland, Germany, Hungary, India, Ireland, Japan, Morocco, Norway, Pakistan, South Korea, Spain, Switzerland, United Kingdom, United States and IAEA met teams from ASN and the other State departments concerned. Mr Satorius and Mrs McGarry also had a meeting with Mr Le Déaut, Chairman of the Parliamentary Office for the Evaluation of Scientific and Technological Choices.

The conclusions of the mission were presented to ASN on 28th November 2014 and were the subject of a press release from the IAEA. This extremely detailed mission confirmed the robustness and rigorousness of the regulation and monitoring carried out in France by ASN.

The positive points or best practices highlighted included ASN's work as an independent regulatory body, the effective regulatory structure taking advantage of the support from IRSN and the Advisory Committees of experts, France's long-standing commitment to safety and the robust and efficient organisational structure, attaching considerable importance to the impartiality of the commissioners, Advisory Committees and all the personnel, the extensive involvement of the stakeholders in the regulatory processes and the transparency of the decision-making process, the broad communications and, finally, the coordination between the oversight organisations involved in emergency planning and the efficient interaction with the licensees in this field.

Several points were however identified as requiring attention:

- the need to assess the exhaustiveness of the regulatory framework for monitoring exposure in the medical field and the coordination between the organisations involved;
- the reinforcement of the system used by ASN to assess and modify its regulatory framework;
- in ASN's integrated management system, the need to specify all the processes ASN needs in order to perform its role.

The conclusions of the mission also show that new means must be examined in order to guarantee that ASN has the human and financial resources it needs for effective oversight of nuclear safety and radiation protection in the future.

The IAEA final report was transmitted to France in the first quarter of 2015 and posted on the ASN website.

ASN frequently takes part in the auditor teams for missions performed abroad at other nuclear safety regulators.

10.4.2 The licensee

ASN's regulation of the safety policy and management system (at local and national level) of the BNI licensees is carried out every year at several levels:

- verify 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, examine the organisations put into place by the licensee and how they function, including from the managerial angle;
- analyse the methods for assessing licensee safety management, the means of leveraging improvements that they identify and the gains achieved by the organisational modifications implemented.

In addition to the inspections, ASN regulation is based on the assessments conducted at its request by IRSN and the GPR. For example, the GPR had been asked in 2015 for its opinion on the management of safety and radiation protection of subcontracted operations during reactor outages.

ASN publishes its opinion and its analysis of safety management policy in the annual reports on the state of nuclear safety and radiation protection in France. These opinions appear in all the following chapters of this report, especially in chapters 12 and 13.

NPP licensees

ASN considers that the safety policy of the EDF Group, approved by its CEO in 2012, is satisfactory.

ASN observes that EDF has gradually built up a management system incorporating safety, based on principles such as quality management, continuous improvement, experience feedback management, rigorous intervention practices, consideration of organisational and human factors, complementarity of controls and individual commitment. These principles were applied in arrangements which today constitute the foundations of the EDF safety management system. Nonetheless, despite a proactive commitment to "priority for safety" at all EDF management levels, simultaneously taking account of all requirements and objectives (safety, radiation protection, environmental protection, availability, labour organisation, costs, etc.) can in certain situations lead to losing sight of the safety requirements, potentially affecting the decisions that need to be taken. In this respect, ASN considers that the system OSRDE which is capable of analysing how safety is taken into account in the decision-making process, in the face of other demands such as facilities availability, needs to be better used to create an effective organisational experience feedback tool.

ASN sees the presence of an internal safety check body, independent of the operational side and structured at several levels, as a strong point. This independent channel benefits from significant resources as well as clear support from the management of the NPPs. However, problems with filling certain safety engineer positions and a trend towards these positions being occupied mainly by young safety engineers from the operations sections, have been observed. This trend could lead to the independent safety function experiencing problems in the complete performance of its duties with respect to the operations side.

ASN also identifies a considerable number of projects being initiated by EDF at the same time. When taken individually, each of these projects would seem to be correctly incorporating safety-related considerations or aiming to remedy the shortcomings identified by EDF. However, the combined effect of initiating all of these projects, at the same time as a large-scale programme of skills renewal at EDF, could make the situation a complex one. EDF must remain vigilant in ensuring that this combination of projects does not lead to destabilisation of certain professional sectors, which is the opposite of the defined objective, and that it remains compatible with the workload on the professional sectors.

Research reactor licensees

For CEA, although ASN considers that safety management is satisfactory on the whole, it wants to see progress in the monitoring of outside contractors. A large-scale inspection operation revealed organizational shortcomings in some facilities, being confirmed by other inspections. CEA must be attentive to maintaining the skills necessary to ensure the required quality and safety of subcontracted activities.

For the ILL, its declaration that nuclear safety has always been and remains the priority at ILL takes the following tangible form;

- at an organisational level, by the existence of a radiation protection unit (radiation protection and environmental monitoring department) and a Quality – Risk unit reporting directly to the Institute's director and a safety unit reporting to reactor Division;
- at an operational level, by the definition of "important for protection" activities which are in principle subject to a two-level control process.

11. Article 11: Financial and human resources

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.

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 ASN requests

The environment code requires that, when creating a BNI subject to authorisation, "the authorisation 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".

The BNI order requires that the licensee have adequate resources - specifically financial resources – for defining, implementing, maintaining, evaluating and improving an integrated management system. It also requires that the licensee have adequate resources to implement the policy for public health and safety and protection of nature and the environment.

In addition, the 28th June 2006 Act creates an arrangement for ring-fencing funds to meet the costs of decommissioning nuclear facilities and managing radioactive waste.

The legal arrangement aims to secure the funding for nuclear costs, in compliance with the "polluter-pays" principle. It is therefore up to the nuclear licensees to cover the cost of this funding, by creating a portfolio of specific assets able to cover the anticipated costs. This is done under the direct control of the State, which analyses the licensees' situation and can prescribe the measures necessary if the identified resources are felt to be insufficient or inadequate. In any case, the nuclear licensees remain responsible for adequate financing of their long-term costs.

The legal arrangements require that the licensees make a prudent assessment of the cost of decommissioning their facilities or, for radioactive waste disposal facilities, their final shutdown, upkeep and surveillance costs. They also evaluate the cost of managing their spent fuel and their radioactive waste. They thus submit three-yearly reports and annual updates.

11.1.2 Measures taken for nuclear power reactors

With a net installed power of 136.2 GWe worldwide as at 31st December 2014 for global production of 623.5 TWh, the EDF Group has one of the world's largest power generating fleets and, of the top ten energy producers, its fleet emits the least CO2 per kilowatt-hour produced, thanks to the contribution of nuclear energy (72.9 GWe), hydraulic and other renewable energies (28.3 GWe) to its production mix.

In 2014, the Group achieved consolidated sales of 75 billion euros, an EBIDTA of 17.6 billion euros and a net income of 4.9 billion euros.

In France, the net production of electricity by EDF in 2014 was 460.4 TWh, of which 415.9 TWh was from nuclear sources (63.13 GWe), 37.5 TWh hydraulic (19.9 GWe) and 6.9 TWh fossil (13.7 GWe), out of a total of 540.6 TWh from all the producers taken together. In 2015, the nuclear production was 416.8 TWh.

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 operating lifetime. To date, the total investments will reach 55 billion euros by 2025 for the 58 reactors in service. This programme in particular includes an overall amount of 10 billion euros in order to comply with ASN's prescriptions designed to take account of the lessons learned from the Fukushima Daiichi NPP accident.

This approximate costing will subsequently be gradually validated after the programme deployment solutions have been optimised, additional assessment work has been done and the multi-year planning (multi-year energy planning (PPE) and Strategic Plan) included in the Energy Transition Act, has been taken into account. This industrial programme will be gradually implemented in order to meet the objectives of the Energy Transition Act, multi-year energy planning, the ASN opinions and prescriptions and the authorisation procedures involving in allowing reactor operation beyond 40 years.

In this context, EDF will continue with a large amount of work and aims to ensure the long-term future for its technical and industrial assets, through measures that are technical as well as organisational and human. The programmes to renovate or replace large components in the NPPs, such as electricity generators, transformers or steam generators, will continue.

Furthermore, to secure financing of its long-term nuclear commitments, EDF has in the past few years set up a portfolio of assets exclusively devoted to meeting provisions linked to dismantling of the NPPs and to the back-end fuel cycle facilities (long-term management of radioactive waste, share of the provision for the last NPP cores concerning the future cost of long-term management of radioactive waste). As at 31st December 2015, these dedicated assets represented a value of 23.5 billion euros.

EDF considers that all of the above shows that adequate financial resources are available to ensure the safety of each nuclear facility throughout its lifetime.

11.1.3 Measures taken for research reactors

11.1.3.1 CEA reactors

Together with radiation protection, more than 33 million euros are spent each year on the safety of CEA's research reactors. This evaluation does not include the works performed within the context of the stress tests.

11.1.3.2 The ILL high-flux reactor (RHF)

The ILL is the world leader in neutron research. Its annual budget is about €80M, 20% of which is devoted to investments, both for major maintenance work, upgrades or new work on the reactor, and for continuous modernisation of the scientific instruments.

11.1.4 ASN analysis and oversight

11.1.4.1 Nuclear power reactors

EDF underwent a number of changes in 2000 and 2004, with changes to both the domestic market and its statutes. In late 2005, the company was partially privatised, with the State retaining an 86% holding and the legislative framework stipulating that it must hold at least 70% of the capital and voting rights.

In its dialogue with ASN, the licensee reaffirms that cost control remains a concern, particularly the economic feasibility and the justification of certain requests or certain schedules and the handling of very urgent issues during reactor outages.

In 2013, the licensees submitted their fourth three-yearly report on the financing of decommissioning and radioactive waste management to the French Ministry of the Environment, Energy and the Sea (MEEM). Generally speaking, the robustness of the assessments produced needs to be more clearly substantiated and the uncertainties surrounding decommissioning and waste management operations, with an impact on the costs, must be clarified. ASN and MEDDE in particular identified the fact that greater account must be taken of the cost of soil remediation during installations decommissioning, as must the impact of possible delays in the availability of radioactive waste treatment, packaging, storage or disposal facilities. Finally, the cost of implementing long-term management solutions for high level and intermediate level long-lived radioactive waste was re-evaluated at 25 billion euros (economic conditions of 31st December 2011) by an order of 15th January 2016, which means that the licensees are required to increase their corresponding provisions.

11.1.4.2 Research reactors

Research facilities are frequently operated by major public research organisations. Their resources are thus sensitive to the context of the State Budget. If the funding source, represented by the State, provides certain guarantees, it also sometimes leads to unavoidable decisions that may compromise the future of certain research installations. The renovations and upgrades of current safety requirements, following periodic safety reviews, often entail extensive work and remain difficult. These operations can thus take several years. ASN ensures that budgetary constraints have no impact on safety and radiation protection for the operation of research facilities.

ASN considers that the "major commitments" initiative implemented by CEA since 2007 must be continued and regularly expanded to include new "major commitments". Any extension to the deadline must therefore firstly be duly justified, and secondly be discussed beforehand with ASN. Generally speaking, ASN remains vigilant in ensuring compliance with the commitments made by CEA, both for its facilities in service and those being decommissioned. Were this to prove necessary, ASN could issue instructions, as was the case in 2012 for storage removal operations in the MASURCA facility. Despite the delays in meeting certain commitments, the overall results of this system are on the whole positive. In 2015, 22 of the 35 major commitments defined since 2007 for all of the CEA BNIs were thus met. In 2015, at ASN's request, CEA defined a further 9 major commitments, staggered between 2016 and 2022.

For several years now, ASN has observed the following on CEA's facilities:

- significant delays in the performance of decommissioning operations and the recovery and packaging of legacy waste,
- very significant increases in the envisaged duration of the decommissioning and legacy waste recovery operations,
- significant delays in the transmission of the decommissioning authorisation application files

In October 2015, ASN therefore asked CEA to carry out an overall review of the decommissioning strategy for the nuclear facilities and for management of CEA's radioactive materials and wastes; this review in particular concerns the pertinence of the level of the financial resources devoted to these operations.

11.2 Human resources

11.2.1 ASN requests

It is up to the licensee of a BNI to have sufficient, appropriate and qualified human resources. The regulatory requirements are given in the environment code and the BNI order, more generally concerning the resources that must be at the disposal of a BNI licensee.

In addition, the BNI order states that "the activities important for protection, their technical check, the verifications and assessments are carried out by persons with the necessary skills and qualifications". 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.

What ASN expects in terms of human resources management and skills in particular will be clarified by the ASN guide on safety policy and management in BNIs (guide 15), and on the "Emergency" resolution (see § 10.1).

11.2.2 Measures taken for nuclear power reactors

At the end of 2015, the workforce of the EDF nuclear operation division (DPN), responsible for operating the nuclear reactors, stood at about 23,250, distributed among the 19 NPPs in operation and the 2 national engineering units. Engineers and managers represented 36% of the workforce (8,400 staff), supervisors 60% (13,800 staff) and operatives 4% (1000 staff).

To these 23,250 staff must be added EDF's human resources devoted to design, to new constructions, to engineering of the NPPs in service and support functions, and to dismantling of nuclear reactors:

- about 5,800 engineers and technicians from engineering centers split 75% management and 25% supervisors;
- nearly 280 engineers and technicians from the nuclear fuel division (DCN);
- more than 600 engineers and technicians from EDF's research and development division (EDF R&D).

For the development of a safety culture, the accountability policy implemented within the company means that a vast majority of the personnel devotes a significant percentage of their time and activities to nuclear safety and radiation protection.

If one considers only those personnel whose role and duties are exclusively concerned with nuclear safety, then more than 500 staff are involved.

About 1050 people are devoted to security and radiation protection activities.

Since 2006, EDF has been devoting considerable efforts to guaranteeing the skill levels and the careers of the staff, by adopting a forward-looking jobs and skills management approach (GPEC), based on uniform principles for all the NPPs, built up gradually from actual feedback from the field. These aspects are the subject of monitoring, oversight and specific check.

Between 2008 and 2015, the DPN underwent significant turnover in human resources (1000 new staff), a very considerable increase in the numbers of staff undergoing training and an increase in headcount (nearly 24%, up from 18750 to 23250 over the period) in order to deal with: performance improvements, regulatory changes and the aftermath of the Fukushima Daiichi NPP accident, preparation for the start-up of the Flamanville 3 EPR and the operating life extension with deployment of the Grand Carénage major overhaul programme.

The volume of training has also risen significantly: it has been multiplied by nearly 3 in 10 years, reaching 3 million hours in 2015. The initial training curricula have been added to and adapted to this new context, with the creation of "Nuclear joint know-how academies", along with programmes that have been revised for each specific professional sector. Based on the experience feedback from other international licensees, training committees were set up at the various management levels, more specifically to allow reactive training to be carried out. Mock-up spaces for training prior to intervention by EDF and contractor personnel are being installed on each site and the Systematic Approach to Training (SAT) is being gradually deployed in those disciplines with safety implications.

Similarly, with regard to engineering, a "nuclear engineering key skills development plan" (PDCC) was launched in 2006, involving 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 succession planning choices.

New entrants at the engineering follow a 5-week training course on the common knowledge of the "design" engineer (operation, safety and quality culture, security and radiation protection, etc.).

11.2.3 Measures taken for research reactors

11.2.3.1 CEA reactors

At a minimum, a safety engineer is on duty in each facility. This engineer is familiar with the facility and has experience of analysing and handling safety issues. The facility also has criticality expertise. For the reactors, depending on their size, these functions can be performed by a team comprising several engineers

In accordance with the requirements of the BNI order and the "human resources" chapter of standard ISO 9001-version 2008, the skills of the persons assigned to positions that are important for the safety of a BNI must be guaranteed.

The principles adopted for the qualification and certification procedure are:

- the separation of qualification and certification responsibilities;
- assessment of qualification by a manager who, if so deemed necessary, may call in specialists;
- assessment of qualification, notably by validating the skills acquired during professional experience rather than 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 certification decisions;

Prior to taking up their duties, the facility heads follow specific training covering the following aspects: management of staff and operations, nuclear safety at CEA, the operational legal responsibilities of the licensee, radiation protection and waste management.

Furthermore, the safety issues are supervised and coordinated by the following various contributors:

- the nuclear safety unit within each centre;

- the nuclear protection and safety department.

For certain technical matters, experts can be called on from one or more of the centres of expertise created by CEA (see § 10.3.1 and the Appendix 3 § 3.2 to take account of the new CEA organisation since 1st January 2016) and run by the DPSN.

The human resources needed for this work requires from 10 to 20 engineers on each site.

11.2.3.2 The ILL high-flux reactor (RHF)

In order to meet safety requirements, the ILL has since 2008 employed a second safety engineer, who also reports directly to the head of the reactor division, and now has a quality-risk engineer reporting to the Senior Management.

For surveillance of the facility and radiological monitoring of the personnel; the radiation protection unit comprises 9 staff under the authority of a radiation protection engineer.

For environmental surveillance, the ILL set up a new laboratory in 2010, employing 7 technicians under the responsibility of an engineer.

In order to carry out the post-Fukushima actions, the ILL set up a project structure which utilises both the services of the ILL and personnel from outside contractors. An additional safety engineer was hired for the duration of this project, covering the period 2012-2016.

11.2.4 ASN analysis and oversight

ASN regulation of human resources is based on inspections and assessments conducted with the support of IRSN and the Advisory committees, covering the subjects of human and organisational factors (see chapter 12) and safety management (see chapter 10). Human resources are also checked during BNI construction and decommissioning inspections.

For the nuclear power reactors, the organisation in place on the sites for skills management is well-documented and coherent. Inadequacies on certain sites are however still being found during the inspections, concerning the forward planning of jobs and skills management (GPEC) so as to be able to prepare for renewal of skills. Failure to anticipate large scale departures from certain disciplines was therefore observed on a few sites. The relative balance observable hitherto could be jeopardised by a significant transition between generations and the high levels of work required as a result of the stress tests and the periodic safety reviews. The success of the large-scale skills renewal programme underway at EDF entails an unprecedented effort in terms of considerable investment in training and tutoring of new recruits.

Generally speaking, the training programmes are run satisfactorily and the deployment of the professional sector academies is identified as being a strong point for the training of new arrivals on the sites. However, deviations are still observed during inspections or following significant events and some staff have still not received the scheduled training, or the content of the training proves to be incomplete.

For CEA research reactors, safety management was reviewed by the ASN Advisory committee in 2010, which led to CEA making a commitment to present an approach to identify the safety and radiation protection skills needed in the short to medium term, along with the results of its implementation. CEA presented its succession planning approach to ASN in 2013, enabling personnel turnover to be prepared in advance. In 2015, CEA stated that its main human resources constraint was the small number of retirements in the short term, generating constraints on the recruitment flow and on the workforce optimisation and deployment operations to be carried out over the period, in line with programme developments. CEA also stated that it wished to focus on its core business, research, which includes operation of research reactors. It makes extensive use of subcontracting for related activities, such as waste management and decommissioning work. ASN will remain vigilant to ensuring that the specific skills necessary for monitoring these subcontracted activities are maintained and developed.

12. 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 ASN requests

ASN is counting on integration of organisational and human factors (OHF) that is compatible with the safety issues identified by the licensee, in the following fields of activity:

- engineering activities, during the design of a new facility or the modification of an existing one;
- the activities carried out for operation of existing installations, throughout their service life;
- the compilation of experience feedback concerning reactor design, construction and operation.

Social, organisational and human factors received particular attention during the stress tests performed in France.

12.2 Measures taken for nuclear power reactors

The way in which Organisational and Human Factors (OHF) are taken into account in the engineering and operating activities comprises two main aspects:

- implementation of the Socio-Organisational and Human (SOH) impacts analysis in any design, modification and decommissioning project with safety implications;
- support for operational improvements by the HF experts working with the operational staff, within the units and at national level, with the assistance of R&D.

SOH approach in engineering:

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:

- an SOH coordinator is present in each engineering unit, providing expertise for the management and project heads;
- 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 fleet;
- changes to the practices of the design managers, incorporating human and organisational aspects, jointly with the licensee 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 licensee;
- a key role for the plant series structures, to ensure cooperation between engineering and licensee in the design/change work;

- gradual implementation, with coverage of projects with major implications: VD3 1300, EPR UK, Grand Carénage, Colimo[5], post-Fukushima or safeguard projects.

Furthermore, on the basis of the data resulting from the SOH impacts, an INSAG-18 approach was initiated in the major projects, to identify and characterise the potential safety consequences of the changes envisaged.

Operational HF consultants:

The incorporation of OHF during operations is extensively supported by the work of the site HF Consultants and by the national teams (UNIE, 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 3 main fields: development of safety management and the safety culture, improvement of socio-technical and organisational situations, development of Human Factors skills.

In order to reinforce these duties, new baseline requirements have been defined, modifying the various aspects of the duties and ensuring that the professional training system set up is adequate.

12.3 Measures taken for research reactors

12.3.1 CEA reactors

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

- specialists in the protection and nuclear safety department and in the safety support units of the CEA centres;
- contacts in the facilities, more specifically in each research reactor;
- 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. These latter meet one day each year to discuss external and CEA internal practices.

Actions are focused on several areas:

- the performance of OHF studies in several facilities, following the emergence of identified problems or incidents;
- the performance of systematic OHF interventions during the periodic safety reviews, more specifically concerning the operation phases and the handling of fuel and experimental devices.

Various documents were published between 2013 and 2015: two technical data sheets concerning emergency management and operational documents and a guide describing the general OHF method at CEA.

Training courses continued on the subject of incorporating OHF into activities with safety implications and a significant OHF component and training on OHF integration into events analysis was set up.

[5] The Colimo project aims to modernise the lock-out methods in order to enhance safety and improve the peace of mind of those involved in operation and maintenance.

In terms of R&D, CEA continued its cooperation with the Institute for Energy in Halden (Norway) on the topic of operation and MTO (Man Technology Organisation) and signed a partnership agreement with the Paris Ecole des Mines on the study of interactions in networked companies and skills maintenance when changes in these companies occur.

Exchanges were held outside CEA:

- within the IMdR (risk control institute) on the topic of "organisation and control of risks";
- bi-annual meetings and the workshop in February of the "Working Group on Human and Organisational Factors" (ECCD-CSNI-WGHOF).

12.3.2 The ILL high-flux reactor (RHF)

The steps taken by the RHF in the field of OHF broadly follow those of CEA. The two institutions are regularly in contact on this subject.

12.4 ASN analysis and oversight

12.4.1 Organisational and human factors in nuclear power reactor operations

ASN regulates the steps taken by the licensee to improve the OHF integration into all phases of the lifecycle of an NPP.

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 observes that the efforts made to deploy the SOH approach, in particular in all the engineering centres, must be continued in order to achieve the hoped for effects.

ASN also checks the activities carried out for operation of existing NPPs, 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 EDF or subcontractor personnel, all of which can have an impact on the safety of facilities and of workers, along with skills, training and qualifications management carried out by the licensee.

ASN notes that on the whole there is now greater presence of EDF managers in the field, mainly to disseminate and implement managerial policies and requirements. ASN considers that this presence however still does not contribute enough to a better understanding of the realities in the field on the part of the site's management. ASN also observes numerous inadequacies in the intervention conditions (incomplete documents, equipment unavailability, etc.). Finally, the organisation in place in the NPPs for skills, qualifications and training management is on the whole satisfactory, even if there are gaps in the training proposed and problems with anticipating staff departures in certain disciplines.

Finally, ASN checks the analysis of operating experience feedback concerning reactor design, construction and operation. In the NPPs, ASN checks EDF's organisation for analysis of events, the methodology employed and the depth of the analyses carried out to ensure that the underlying causes of events are looked for (organisational and human) and, finally, for the definition and implementation of the action to be taken in response to the analyses, whether, short, medium or long term.

ASN considers that the organisation and the specific actions to improve how OHF are integrated into operational activities differ from one site to another, which means that on some of them, the way they assimilate the OHF approach could be improved.

12.4.2 Organisational and human factors in research reactor operations

The organisation put into place at CEA in recent years has helped make the responsibilities and duties of the units more comprehensible, specifically with regard to continuity of the specified plan of action, independence of the check function and identification of a facilities assistance function.

More particularly with respect to integration of human factors, CEA set up an expertise centre, with a workforce distributed among the head office departments and the operational units (called Human Resources and Social Relations Division since 1st January 2016, see Appendix 3 § 3.2. It provides support and assistance for the operational units and contributes to the drafting of internal directives. Although ASN considers this initiative to be satisfactory, it does feel that the actions taken need to be added to and better structured in order to create a real strategy for taking organisational and human factors into account in the safety policy.

ASN nonetheless observed with satisfaction the OHF integration into the design process for the JHR.

In 2011, ASN adopted a position with regard to the file concerning safety and radiation protection management at CEA, which had been assessed by the Advisory Committees of experts in 2010. The follow-up to this assessment and its operational implementation in the CEA centres will be inspected in 2016.

12.4.3 Work done on organisational and human factors within the framework of the stress tests

Following the assessments conducted during the stress tests, three priorities were identified:

- the renewal of the licensees' workforce and skills;
- the organisation of subcontracting, which is a major and difficult issue;
- research into these subjects, for which programmes must be initiated.

ASN has set up a pluralistic working group on these subjects called the CoFSOH (Social, organisational and human factors steering committee). In addition to ASN, this committee includes representatives of institutions, environmental protection associations, personalities chosen for their scientific, technical, economic, legal or social, or information and communication expertise, persons in charge of nuclear activities, nuclear industry professional federations and representative employees' unions.

Since 2012, this committee has been meeting regularly, with two plenary sessions per year. Work is done by thematic working groups:

- the contribution of subcontracting to installations safety in normal working situations;
- the legal aspects of the use of subcontracting;
- management of emergency situations;
- the interface between “managed safety” and “regulated safety”.

Moreover, in addition to the above-mentioned elements, the ASN resolutions of 26th June 2012 asked CEA for additional information on:

- the human actions required for extreme situation management;

- the list of skills required for emergency management, including those provided by the contractors;
- training and preparation for accident situations;
- social and psychological care given to respondents in accident situations.

In 2016, ASN will complete the review of the answers submitted from 2012 to 2015.

13. 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 ASN requests

The BNI order contains provisions to be implemented by a BNI licensee to define, obtain and maintain the quality of its facility and the conditions necessary to ensure operating safety.

The licensee must also implement an integrated management system specifying the provisions applied in terms of organisation and resources of all types (see chapter 10), and must maintain it, assess it and improve its effectiveness.

This order requires that the licensee define quality requirements for each activity concerned, utilise appropriate skills and methods in order to achieve them and, finally, guarantee quality by checking satisfactory compliance with these requirements.

It also requires that:

- detected deviations and incidents be dealt with strictly and that preventive measures be taken;
- suitable documents provide evidence of the results obtained;
- the licensee supervises its contractors and checks that the organisation implemented to guarantee quality does indeed operate satisfactorily.

13.2 Measures taken for nuclear power reactors

Quality assurance policy and programme for nuclear power reactors

It is up to EDF to guarantee design, construction and operation of its NPP fleet that is safe and efficient, both technically and economically. The quality management policy, which primarily focuses on activities important for safety, contributes to this.

There are three resulting objectives:

- to consolidate acquired knowledge and experience, and improve results where required, as part of a continuous improvement process;
- to bring the quality system personnel on-board by involving them in its implementation and improvement;
- to have a quality system in place that is compliant with French regulatory requirements, international quality recommendations, and best practices and methods as confirmed by operating experience feedback (see § 19.7). As part of this approach, indicators are used to monitor trends and define preventive measures.

Developing the quality system on the basis of acquired knowledge

The need to guarantee safety has led EDF to develop a quality system based on personnel skills, work organisation and formally documented methods. Acquired experience leads to changes to the quality system on the following points: the overview of activities, prior consideration before each step in the process, the need to apply the requirements of the quality system to activities that are important for safety and the involvement of each stakeholder in obtaining quality.

F – Safety of installations – Articles 17 to 19

Adjusting the quality assurance requirements to the importance of the activities

Each activity is the subject of a preliminary analysis. This analysis concerns the difficulties inherent in the activity and the consequences resulting from possible failures at each step in performance.

The quality characteristics essential for the activity are thus highlighted, in particular the quality level required. The result is appropriate quality assurance provisions. Through a questioning attitude, risk assessments and improvement proposals, a responsible player can contribute to improving these provisions.

Appropriate organisation and resources

Achieving the required quality objectives means that the activities must be clearly allocated and that the duties, responsibilities and coordination between players is defined at all levels of the company.

Relations with contractors

To ensure the quality of its services, EDF first of all ensures that its contractors are capable of performing the services in good conditions. 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 in particular concerns the quality of interventions, contracts which accord more importance to the "best bidder" and the facilitation of the intervention conditions in the field.

The stipulation of a subcontracting system with a maximum of three tiers, including the contract holder, must apply to any contract, in compliance with EDF's undertakings for new calls for bids and for currently ongoing contracts.

The social specifications were examined by the performance working group of the nuclear sector strategic committee set up by the Government in January 2012. The social specifications comprises rules common to all players in the sector, designed to guarantee know-how, skills, training and qualification, as well as the adoption of nuclear safety, radiation protection, occupational risk prevention and quality of life at work as fundamental, essential criteria.

These social specifications and the proposals for regulatory changes were sent to the Prime Minister, the Minister for Industrial Renewal and the Minister for Ecology on 20th July 2012. It was also presented to the CoFSOH, chaired by ASN, on 9th November 2012.

The Social Specifications (CCS) are now systematically applied for contract renewals and new contracts

Guaranteeing quality by means of appropriate checks

The quality of an activity depends first and foremost on those performing it. Check processes can guarantee this quality.

As necessary, these processes comprise:

- self-assessment;
- checks by another qualified person capable of providing a critical vision;

- verifications, with the necessary distance and independence, to ensure correct implementation of the quality requirements.

All of the above contribute to defence in depth.

Certification of quality through traceability

Documents prepared and checked at all stages of an activity, from preliminary analyses to final report, certify that quality has been achieved. These documents are preserved, thereby ensuring the traceability of operations, particularly in the field of nuclear safety.

13.3 Measures taken for research reactors

13.3.1 CEA reactors

The CEA Chairman sets in-house policy for the programming of its activities as well as in the functional fields, more specifically with regard to safety (including nuclear safety). He defines the organisation needed for the successful implementation of this policy by means of general instruction notes (NIG), applicable to all CEA entities. The operational organisation and safety organisation are each the subject of such a NIG.

Each centre and each operational division thus defines its quality 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 by the centre in which their facility is located and the operational division to which they report. In accordance with the regulatory provisions in force, for research reactors, the activities important for safety are formally identified in this local system and the quality assurance provisions designed to ensure that the corresponding requirements are met are formally laid out in the facility's baseline safety requirements. These baseline safety requirements and their updates and implementation are checked by the safety unit in the centre and during inspections by the regulatrory body.

The Nuclear Energy Division (DEN), which manages research reactors, also organises regular audits of its units or their contractors in order to:

- measure the progress achieved as part of an approach to ensure continuous improvement of the quality of these activities and define new areas for progress as necessary;
- assess the ability of the suppliers and contractors to meet CEA's quality requirements.

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

The management systems of the DEN and its centres (where all the research reactors are installed), include quality, health/safety and environment (QSE). They hold ISO 9001, ISO 14001 and OHSAS 18001 certification.

13.3.2 The ILL high-flux reactor (RHF)

The Reactor Division is responsible for operating the reactor and its auxiliaries. Given the particular importance of these operational activities in terms of safety, and in accordance with the provisions of the BNI order, a quality assurance organisation is put into place in order to guarantee that the level of quality required is obtained and maintained and to provide the necessary evidence.

Six guiding principles underpinned the creation of this organisation:

- **Principle I:** The licensee defines the scope of the quality organisation, by identifying the safety-related activities and equipments important for the protection of the interests defined by the order BNI (AIP and EIP) and then defining the requirements for each of them;
- **Principle II:** Persons qualified to carry out an AIP are designated by the Head of Operation. These persons are referred to as “accredited”;
- **Principle III:** All AIPs are performed following written documentation prepared in advance, and this performance is written up in reports. These documents are subject to either a technical inspection or an internal check, and either management or external checks;
- **Principle IV:** Monitored-quality documentation is updated and kept for a defined time depending on the document’s importance;
- **Principle V:** The results of an AIP are verified both technically (quality check) and as regards management (quality monitoring). The verification is formalized;
- **Principle VI:** The “performance” and “verification” functions are separate and assigned to different persons. The quality-monitoring function is independent of the operational functions;
- **Principle VII:** A minimum of two supplier audits are programmed each year.

13.4 ASN analysis and oversight

13.4.1 Quality assurance in the construction and operation of nuclear power reactors

13.4.1.1 General oversight of quality in construction and operation

During its inspections on sites under construction or already in operation, regardless of the field to be checked, ASN verifies that the quality assurance principles are respected. The adequacy of resources for tasks, staff training, working methods and the quality of the documentation associated with the operations, and procedures for internal monitoring of operations can thus be checked.

ASN considers that the integrated management system (IMS) put into place by EDF on the whole meets the requirements of the BNI order. Through its inspections, ASN however observes that the organisations involved in the processes subject to the IMS are experiencing difficulties with assimilating the requirements specified in this system owing to its complexity and frequent adaptations. Even if the steps taken in particular enable deviations from the defined requirements applicable to equipment and organisations to be identified, the number of tools involved and the players concerned make a significant contribution to the problem with building an accurate picture of the true state of the installations and their operating baseline requirements. The areas for progress are increased use of operating experience feedback on a few sites and greater compliance with the time to complete measures to remedy the deviations detected.

Quality aspects related to the use of contractors

The maintenance of French reactors is to a large extent subcontracted by EDF to outside contractors. The decision to implement this industrial policy lies with the licensee.

The role of ASN is to verify that EDF assumes its responsibility for the safety of its facilities by implementing a quality approach and in particular by monitoring the condition in which this subcontracting takes place.

A system of prior contractor qualification was put into place by EDF. It is based on an evaluation of the technical know-how and quality organisation of the subcontractor companies and is formally written up in the "progress and sustainable development charter" signed by EDF and its main contractors.

13.4.1.2 Contractor selection and monitoring

In the NPPs, ASN conducts inspections on the implementation of and compliance with the EDF baseline contractor monitoring requirements. With regard to regulation of the construction of the Flamanville 3 reactor, ASN also conducts inspections on this subject within the various engineering departments responsible for the design studies.

More generally, it conducts a number of inspections every year at the suppliers of the reactors in service.

In principle, the contractor qualification and assessment system is satisfactory and meets the regulatory requirements. In fact, there would appear to be room for improvement in EDF's monitoring of its contractors and its assessment of its industrial policy for maintenance and use of outside contractors and ASN ensures that this aspect is given full consideration in the approaches mentioned in § 11.2.

13.4.2 Quality assurance in the operation of research reactors

The quality requirements specified in the BNI order apply without restriction to research reactors.

Within this context and primarily by means of inspections, ASN checks licensee application of the quality assurance principles during the operation and maintenance of its reactors. In recent years, ASN has observed an improvement in the contractual documentation of the safety requirements applicable to outside contractors.

ASN pays particular attention to the check and management, by the reactor licensee, of the activities carried out by the common technical services in a CEA centre, to ensure that this check is carried out with the same degree of stringency as for outside contractors. ASN notes that this is the subject of a formal internal contract between the units of the centres, thus contributing to improved visibility of the distribution of responsibilities and to clarification of each party's tasks.

Exceptional maintenance or renovation operations are the subject of particularly close monitoring by ASN, which adapts its inspection programme to ensure the performance quality of these operations.

In addition, the structure put into place within the CEA centres, as referred to in chapter 11, has contributed to improving operational quality in research reactors. The centres have set up structured management systems and assimilation and adoption efforts by the various stakeholders have been observed. However, ASN considers that such efforts must be continued, especially with regard to the sharing of experience feedback and the effectiveness of its integration. The action of the safety cells, which are in charge of carrying out the second level checks on behalf of centre managers, was reviewed and reinforced with a view to improving the detection of weak points and selecting objectives such as to correct them. Coordination between the various action, support and check levels, whether local or national, must continue to progress in order to make the actions more consistent and more effective.

14. Article 14: Safety assessment and verification

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 Safety assessment before the construction and commissioning of a BNI

14.1.1 ASN requests

14.1.1.1 Regulatory framework

The environment code provides for a creation authorisation procedure, which may be followed by other authorisations during the operation of a BNI, from its commissioning to its final shutdown and decommissioning, including any changes made to the facility. These aspects are detailed in § 7.2.

The preliminary safety analysis report (PSAR), incorporated into the authorisation application file, informs ASN of and substantiates the measures taken at each step in the life of the facility to comply with the regulations and guarantee safety. It contains all information able to verify that all risks (whether or not nuclear) and all possible hazards (internal or external) have indeed been taken into account and that in the event of an accident, the personnel, the population and the environment are adequately protected by the means put into place. This report takes account of the specific characteristics of the site and its environment (meteorology, geology, hydrology, industrial environment, etc.).

Commissioning corresponds to the first use of radioactive substances in the facility or the first utilisation of a particle beam. In preparation for commissioning authorisation, the licensee sends ASN a file comprising the updated safety analysis report for the facility "as-built", the general operating rules (RGE), a waste management study, the on-site emergency plan, the impact analysis and the decommissioning plan. These aspects are reviewed by ASN with the support of IRSN and the Advisory Committees of experts (GPE).

14.1.1.2 Stress tests

The stress tests (see § 14.1.4.2), carried out by the licensees at ASN's request, following the accident which occurred in the Fukushima Daiichi NPP, were extended to include facilities under construction (EPR and RJH).

There are a few differences between the European and French stress tests. This is the reason for two reports which differ in format, even if the basic content is the same: The scope of the French stress tests is broader. They cover not only reactors, but also research facilities and fuel cycle plants. A chapter devoted to subcontracting was added at the request of the French High Committee for Transparency and Information on Nuclear Security.

With regard to the stress tests and their extension to the French stress tests, also see § 14.2.1.6.

ITER was also included within the scope of the stress tests, according to specifications identical to those for reactors in operation.

14.1.2 Measures taken for nuclear power reactors

With regard to the Flamanville 3 EPR reactor, following the granting of the creation authorisation decree, dated 10th April 2007, the next major regulatory step in the project schedule is the commissioning authorisation, corresponding to the first loading of nuclear fuel into the reactor.

EDF sent its commissioning authorisation application in March 2015, along with the start-up authorisation application file. This file was considered acceptable, enabling ASN and its technical support body to commence its examination. EDF was however asked for additions, corrections and substantiations.

The Advisory Committee for reactors (GPR) held meetings on various topics of the safety analysis report, in particular the safety classification, probabilistic safety assessments, the consideration of accidents with core melt in the design and the safety case for fuel storage and handling. Other GPR meetings are scheduled before the commissioning authorisation, concerning accident, system and hazard studies. ASN is also examining the other items transmitted by EDF as required by the regulations, along with the commissioning authorisation application.

14.1.3 Measures taken for research reactors

The JHR underwent the stress tests process. The reactor is currently under construction and the results of this assessment indicated no need for any changes to the civil engineering.

14.1.4 ASN analysis and oversight

14.1.4.1 Detailed design review of the Flamanville EPR reactor

Without waiting for the complete commissioning authorisation application file to be transmitted ASN, together with IRSN, has in recent years carried out a review to prepare the examination of the commissioning authorisation application file:

- technical baseline requirements necessary for the safety demonstration and for finalising the reactor's detailed design;
- the detailed design of certain systems important for safety presented in the safety analysis report;
- certain elements of the commissioning application file or used to assist with determining the contents of the file.

Following the stress tests, EDF proposed a number of measures to reinforce the robustness of the Flamanville 3 EPR reactor. ASN estimates that these propositions are relevant and considers that they should be implemented.

In the spring of 2015, ASN received the commissioning authorisation application for Flamanville 3. It reviewed the acceptability of the items transmitted and asked EDF for additional information. Pending the arrival of this additional information, it began the technical review of a part of the file.

The details of this review as well as the monitoring of the construction of the Flamanville 3 EPR reactor are presented in chapter 18.

14.1.4.2 Stress tests

Nuclear Power reactors

ASN's opinions and prescriptions resulting from the stress tests on the nuclear power reactors are presented in § 6.3.1.3.

Research reactors

The ASN opinions and requirements following the stress tests on the research reactors under construction are presented in § 6.3.2.1 and § 6.3.2.2.

14.2 Safety assessment and verification during operation

14.2.1 ASN requests

The regulations ask the licensee to set up an integrated safety management system (IMS) able to maintain and continuously improve safety, notably during operation of the nuclear facilities. The assessment methods for the processes related to the IMS and the performance of improvement measures resulting from these assessments are checked by ASN.

14.2.1.1 Correcting anomalies

Deviations are detected in the nuclear reactors through the proactive attitude of the licensees and through the systematic checks requested by ASN. The periodic safety reviews and the deviation searches continuously performed by the licensee play an important role in maintaining an acceptable level of safety.

Systematic checks are performed by the licensee every ten years on the occasion of the periodic safety reviews (see § 14.2.1.3 and § 14.2.3). The licensee then compares the actual condition of the facilities with the applicable safety requirements and lists any deviations.

"Continuous" checks are also performed by the licensee as part of the periodic test and preventive maintenance programmes carried out on the equipment and systems (see § 19.3).

ASN requires that deviations with an impact on safety be corrected within a time-frame compatible with their degree of severity. ASN thus examines the remediation procedures and deadlines proposed by EDF. In 2015, it in particular published a guide on the correction of conformity deviations affecting equipment important for the protection of the interests of nuclear power reactors (guide n° 21, see Appendix 2, § 2.3.4). This guide in particular helps EDF define the time-lines for correction of the deviations, taking account more specifically of their severity in terms of safety.

14.2.1.2 Examining events and operating experience feedback

The regulations require that the licensees notify ASN of any significant events (see § 19.6 and § 6.2). These events are the subject of detailed analysis. The lessons that EDF learns from the analysis of significant events are assessed by ASN. This analysis more specifically concerns the root causes of the events, most of which reveal problems with the EDF organisations and with the interfaces between EDF and its contractors.

Integrating experience feedback and processing of significant events are also subjects of particularly close attention during ASN inspections.

Finally, the Advisory Committees (GPE) periodically review national and international experience feedback from the facilities in operation.

14.2.1.3 Periodic safety reviews

In addition to the procedures applicable to changes to the installations or their operating mode, the Environment Code requires that the licensee carry out a periodic safety review of its installation every 10 years (see Figure 4 below). This system is in response to the requirements of the European directive on nuclear safety.

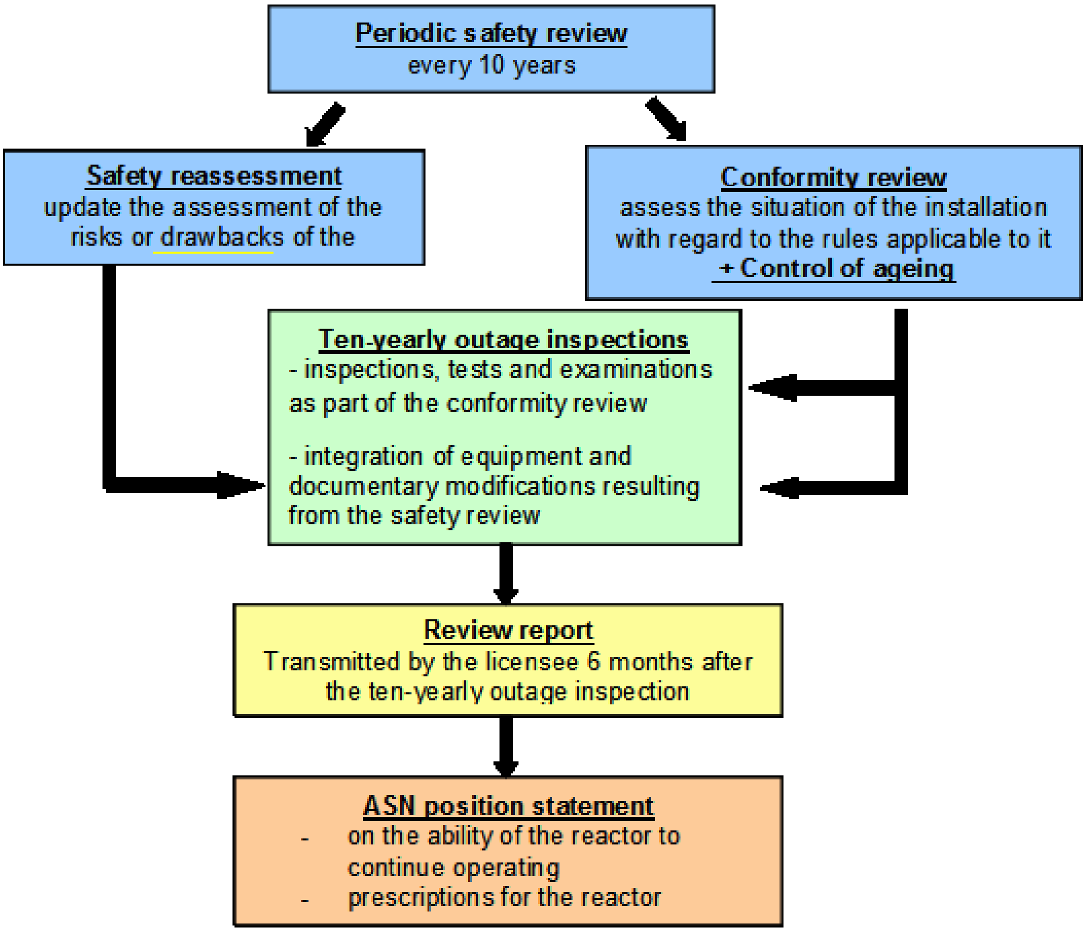

Figure 4: Periodic safety review process

The periodic safety review is an opportunity to conduct a detailed, in-depth examination of the condition of the facilities, to check that they are in conformity with the applicable baseline safety requirements. Its aim is also to improve their level of safety. The requirements applicable to the existing facilities are therefore compared with those to be met by the most recent installations, and the improvements which could reasonably be implemented are proposed by the licensee. The conclusions of these reviews are submitted to ASN, which may issue new demands to reinforce the safety requirements.

After consulting the IRSN and the Advisory Committees (GPE) when necessary, depending on the facility concerned, ASN rules on the list of topics chosen for safety reassessments, during the phase referred to as the periodic safety review orientation. Following these reassessments, a batch of modifications to improve safety is defined. ASN then issues a decision on the list of these modifications. For the reactors, they will be deployed during the reactor ten-yearly outages. For some of them, ASN clarifies the deployment time-lines in its resolutions.

The conclusions of the nuclear power reactor reviews are presented in § 6.3.1

With regard to the research reactors, these facilities are of an older design and their equipment is ageing. They have also undergone modifications during the course of their operation, sometimes without an overall safety review being conducted. As of 2002, ASN had informed the licensees that it considered that a safety review of the old facilities was required every 10 years. This provision is now written into the environment code.

The periodic safety reviews on the CEA facilities have been scheduled according to a calendar approved by ASN. All of the facilities should undergo a first review no later than 2017.

14.2.1.4 Ageing phenomena

The phenomena linked to ageing must be taken into account in order to maintain a satisfactory level of safety for the entire operating life of the facilities.

Control of ageing must be demonstrated, relying on operating experience feedback, the maintenance provisions and the possibility of either repairing or replacing the equipments.

To understand the ageing of an NPP, quite apart simply from the time elapsed since its commissioning, other factors must be taken into account, in particular physical phenomena which can modify the characteristics of the equipment, depending on their function or their conditions of use. Consideration must therefore be given to the deterioration of replaceable items, the lifetime of non-replaceable items and the obsolescence of equipment or its components.

EDF has implemented an ageing control 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.

For research reactors, new facilities are built to replace the older ones which no longer meet the new regulatory requirements. The construction of the RJH should make up for the ageing of the European irradiation reactors currently in service, which are scheduled for shutdown in the short to medium term. It will for example be able to carry out activities similar to those of the Osiris reactor. In addition, apart from the structures, many equipment items installed on the research reactors can be replaced.

ASN observed that ageing is an important cause of equipment failure in the significant events notified in 2013. As in previous years, the ageing mechanisms (corrosion, wear, fatigue, etc.) behind these events vary widely in nature. The licensees therefore need to take greater account of the ageing mechanisms affecting the equipment in their facilities. The periodic safety review is a particular opportunity for an in-depth examination of the effects of ageing on the equipment.

Controlling the obsolescence of equipment, including I&C and PLCs, is a key challenge for the safe operation of research reactors, more specifically owing to the fact that they are all different.

14.2.1.5 Modifications made to equipment and operating rules

In accordance with the principle of continuous improvement of reactor safety levels, but also to improve the industrial performance of its production tool, the licensees periodically made modifications to the equipment and the operating rules. These modifications are for instance the result of processing of deviations, periodic safety reviews or the integration of operating experience feedback.

The BNI procedures decree defines the requirements concerning the implementation of changes by the licensees and their review by ASN. The procedures for managing and notifying hardware modifications were specified in ASN resolution 2014-DC-420 of 13/02/2014.

14.2.1.6 The stress tests following Fukushima Daiichi NPP accident and their follow-up

In France, the stress tests approach (initiated in the wake of the Fukushima Daiichi NPP accident) was implemented at two levels.

Firstly, within a European framework, with the organisation of stress tests of nuclear power plants by seventeen European countries, as requested by the European Council. These tests consisted in checking the robustness of the NPPs to exceptional situations such as those which led to the Fukushima Daiichi NPP accident.

Secondly, within a national framework, with the performance of a safety audit on the French civil nuclear facilities, requested by the Prime Minister. This study was conducted in accordance with the specifications produced at a European level, but with two extensions:

- the study carried out in France concerned all nuclear facilities (including research and fuel processing facilities);
- the specifications were supplemented by points concerning the use of subcontracting.

In addition to the stress tests, 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 end of these national assessments, ASN stated that the safety level of the French facilities examined was such that it would not request the immediate shutdown of any of them. At the same time, ASN considered that their continued operation required that their robustness to extreme situations be increased beyond their existing safety margins, as rapidly as possible.

At the European level, the results of these stress tests were examined by a peer review carried out under the supervision of the European Nuclear Safety Regulators Group (ENSREG[6]) in April 2012.

Following this review, ASN adopted 32 resolutions, each one setting some thirty complementary prescriptions. These resolutions concern the facilities examined in 2011, including the 59 EDF nuclear reactors (including the Flamanville 3 EPR) and the four highest-priority CEA research reactors (OSIRIS, Phénix and Masurca, RJH). These measures will significantly reinforce the safety margins of the facilities beyond their design-basis levels.

Concerning nuclear power reactors:

To ensure monitoring of the implementation of these post-Fukushima measures (which will take several years, see § 6.3.1.3) and also to take account of the recommendations arising from the second extraordinary meeting of the Contracting Parties to the CSN, held in August 2012, ENSREG asked that each safety regulator draft and publish a national action plan by December 2012.

These national action plans underwent an initial European peer review in April 2013 and were then updated in December 2014, for a further review in April 2015.

Concerning the research facilities and other facilities regulated by ASN:

These installations are of widely different types, ASN defined priorities for submission of the stress test reports concerning the nuclear facilities other than power reactors.

The ASN opinions and requirements for research reactors in the stress tests have been presented in § 6.3.2 above.

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[6] ENSREG was created in March 2007 and brings together the heads of the safety regulators and Government representatives of the 28 countries of the European Union, along with representatives of the European Commission.

14.2.2 Measures taken for nuclear power reactors

Periodic safety review

The safety review of the reactors, carried out by means of periodic safety reviews or reviews of particular thematics, leads in a certain number of cases to nuclear reactor modifications. In most cases, these modifications are made in batches, each batch being implemented on all the reactors of the plant series concerned, with an initial reactor, referred to as the “first off”, playing the role of prototype. This grouping of modifications allows greater consistency and industrialisation by facilitating scheduling, documentation updates and operator training.

These batches are generally implemented during the ten-yearly outages in order to minimise the impact of the work on reactor availability.

EDF conformity check

The conformity of the facilities with the safety requirements is a major aspect of the exercise of the responsibility of a nuclear licensee, at several levels.

At the design stage, the designer defines a reference facility (plant series) meeting these requirements and ensures construction according to predetermined rules able to verify the conformity of the facilities up to industrial commissioning.

During operation, the licensee ensures that the conformity of the facilities with the safety requirements is maintained by means of permanent or periodic surveillance processes.

During the periodic safety review, EDF identifies the points requiring:

- additional analysis, with regard to the safety case of the reference facility;
- specific checks to be carried out on the actual reactors, in addition to the surveillance measures that already exist.

The reactors’ conformity check programme (ECOT) consists of a range of specific checks or targeted actions concerning topics relating to the requirements and, in certain fields, enabling a baseline for the state of the installations to be established. Implementation of this programme is a means of identifying findings for which processing is important in safety terms, to adopt a position on the conformity of the reactors, but also to help identify lessons of use in strengthening the conformity of the facilities, with the aim of prolonging their service life. Any conformity deviations observed during this review are analysed and become the subject of a correction programme.

Ageing phenomena

EDF has implemented a strategy based on three lines of defence: designed-in ageing prevention, surveillance and anticipation of ageing phenomena, and the repair, modification or indeed replacement of equipment liable whose ageing would not be under control.

These analyses are carried out as of the VD3.

14.2.3 Measures taken for research reactors

14.2.3.1 CEA reactors

All of the research reactors operated by CEA have now undergone a periodic safety review. This first review phase began in 2002 and ended in 2010 with the Eole and Minerve facilities.

The stress test reports for the 5 CEA facilities, including the Osiris, JHR, Masurca and Phénix reactors, were transmitted to ASN by CEA on 15th September 2011. They were reviewed at a joint meeting of the Advisory Committees in November 2011.

In 2012, CEA conducted stress tests on nine other facilities, including the Cabri and Orphée reactors, as well as on the general resources of the Cadarache and Marcoule centres.

The reports were sent to ASN on 15th September 2012. Following their review, ASN issued additional prescriptions in resolutions adopted in January 2015.

14.2.3.2 The ILL high-flux reactor (RHF)

Following the first periodic safety review held in 2002, the RHF set up a special project organisation, the "*Refit Management Committee"* which, together with the reactor division, carried out work between 2002 and 2006 on the seismic resistance of the buildings, fire detection and the seismic qualification of certain equipment.

In 2007, a meeting of the Advisory Committee confirmed that the undertakings made had been satisfactorily met. The next periodic safety review is scheduled for 2017.

Between 2009 and 2011, the RHF also strengthened its defence in depth, by adding a new backup system to prevent and mitigate the consequences of a core melt accident.

Since 2012, the ILL has been continuing to reinforce its defence in depth with the performance of work defined following the post-Fukushima stress tests to create a "hardened safety core" of backup equipment (see § 6.3.2.2).

14.2.4 ASN analysis and oversight

14.2.4.1 Nuclear power reactors

14.2.4.1.1 Next periodic safety reviews

Following the stress tests, ASN asked EDF to include an assessment of the seismic robustness of the facilities beyond the design baseline. This assessment will aim on the one hand to periodically analyse the risks of a beyond baseline cliff-edge effect, on the basis of updated data and, on the other, to identify the works, structures and equipment necessary for safe shutdown of the reactor and requiring further reinforcement.

The methods for assessing the seismic robustness beyond design-basis levels, to be used by the licensee during the forthcoming generic review phases, are analysed by ASN before being utilised in the facilities.

14.2.4.1.2 Assessment and verification of nuclear power reactor safety for the period 2013 – 2015

Every year, ASN gives a general assessment of the performance of EDF as a whole and of each individual NPP in terms of safety, radiation protection, environmental protection and labour inspection.

This assessment is itself based on the result of regulations carried out by ASN during the course of the year, in particular by means of inspections, oversight reactor outages and analysing the processing of significant events by EDF, as well as on the inspectors' familiarity with the sites they control.

ASN considered the years 2014 and 2015 to be satisfactory for EDF in terms of nuclear safety.

F – Safety of installations – Articles 17 to 19

The overall assessment of each site represents ASN’s viewpoint for the years 2013 to 2015. These data help guide ASN’s regulation works for the subsequent years.

Belleville-sur-Loire

In 2013, 2014 and 2015, ASN considered that the performance of the Belleville-sur-Loire site was on the whole in line with its general assessment of EDF concerning nuclear safety and radiation protection. The management and processing of deviations, the management of documentation and the performance of periodic tests on the equipment are areas for improvement on this site.

In 2013, ASN considered that environmental protection performance once again fell short. On 17th December 2013, ASN adopted a resolution regulating the key measures of the environmental stringency plan implemented by the site. In 2015, improved performance in this field was observed by comparison with 2014.

Blayais

ASN considers that between 2013 and 2015 nuclear safety performance was on the whole in line with ASN's general assessment of EDF performance.

ASN observed the satisfactory general performance of the maintenance operations carried out during the reactor outages held during this period, which were marked more particularly by the replacement of the steam generators of 3 of the 4 reactors on the site, and which included 3 ten-yearly outage inspections.

ASN does however observe persistent difficulties in the preparation for and performance of maintenance work.

Bugey

With regard to nuclear safety, ASN notes that after a year 2013 and early 2014 which were marked by a drop in operational rigorousness, the Bugey NPP in 2015 confirmed the progress observed in late 2014. ASN also carried out an in-depth inspection in September 2015 which confirmed that the site was moving in the right direction: the licensee has initiated a number of fundamental safety management measures to ensure progress in the satisfactory configuration of systems and the monitoring of maintenance activities. The organisation of the NPP remains vulnerable with regard to the monitoring of activities in the control room.

The partial inspection of reactor 5 began in the summer of 2015 and confirmed that the reactor building containment was suffering from a loss of tightness. In Resolution 2015-DC-0533 of 1st December 2015, ASN asked EDF to submit its metal liner repair processes to it for approval and to carry out the repairs prior to reactor restart.

On 10th July 2012, 25th July 2013 and 23rd December 2014, ASN considered that reactors 2, 4 and 5 of the Bugey NPP were able to function for a further period of 10 years following their periodic safety review. In a resolution, ASN imposed a number of additional prescriptions on EDF in order to reinforce the safety of these reactors. ASN is currently examining the continued operation of reactor 3.

Cattenom

ASN considers that for the period 2013-2015, the nuclear safety performance of the Cattenom site is on the whole in line with its general assessment of EDF’s NPPs and is generally speaking satisfactory.

Even if the site’s radiation protection and environmental protection performance over the period 2013-2014 fell short, ASN considers that in 2015 the environmental protection situation, in particular radioactive waste management, is once again satisfactory. With regard to radiation protection of workers, ASN notes the efforts made by the licensee and the progress achieved, even though improvements are needed concerning the personnel's approach to radiological cleanness and the containment of radioactive materials.

On 28th May 2015, a valve on the secondary system of reactor 1 was blocked in the open position owing to a hardware fault, which led to the site's on-site emergency plan being activated. This event was rated level 1 on the INES scale. ASN considers that this event was well managed by the licensee.

Chinon

Between 2013 and 2015, ASN considered that the performance of the Chinon site had progressed and was in line with ASN's general assessment of EDF in the fields of safety and environmental protection, after ASN's reinforced monitoring from 2010 to 2014. The approaches adopted by the site to integrate error-reduction practices into its activities need to be continued.

The site's radiation protection performance stands out positively with respect to the general assessment of EDF, with constant progress between 2013 and 2015.

Chooz

In 2013, 2014 and 2015, ASN considered that the nuclear safety, radiation protection and maintenance performance of the site was on the whole in line with its general assessment of EDF. However, in 2013, ASN considered that the site fell slightly short in environmental protection. This situation was gradually corrected in 2014 and 2015 but ASN considers that these efforts must be continued.

In 2013 and 2014, system line-up errors and lock-out errors had led to an increase in significant events. In the same way, the expected progress in radiation protection of workers to improve the site's performance in terms of radiological cleanness on maintenance worksites failed to prevent recurring deviations in 2015, such as non-compliance with dressing and self-check rules for access to or exit from zones considered to be contaminated.

Monitoring of pressure equipment was considered to be a positive point. Finally, succession planning remains a sensitive subject on the site.

In June 2013 and June 2015, IAEA carried out an operational safety review (OSART mission) of the Chooz NPP, which on the whole confirmed ASN's opinion of this site.

Civaux

In 2013, ASN considered that the performance of the site fell short of ASN's general assessment of EDF. In 2014 and 2015, ASN considered that this performance was on the whole in line with its assessment of EDF.

In 2013, ASN observed deficiencies in the application of the reactor operating rules and several shortcomings in the processing of the maintenance files. The site management undertook to remedy these shortcomings rapidly through the implementation of a dedicated action plan. In 2014 and 2015, ASN observed increased operational rigorousness. Efforts must however be continued in this field. Spares management also needs to be improved.

Cruas-Meysse

In 2014, the Cruas-Meysse NPP entered a 4-year period during which EDF will be carrying out the VD3 third ten-yearly outage inspections of the plant's four reactors and will be replacing two steam generators.

In the light of this extremely intense maintenance workload, the Cruas NPP is underperforming in terms of maintenance reliability and nuclear safety performance with respect to ASN's general assessment of EDF performance.

ASN in particular observes a lack of operating rigorousness marked by vulnerability in compliance with technical specifications and unsatisfactory control of foreign material exclusion from the systems and pools. This latter point is illustrated by the presence during a cycle of a 300 g metal part in the tube bundle of a steam generator on reactor 3, leading to significant damage of 2 tubes.

ASN considers that the environmental protection performance of the Cruas-Meysse NPP falls short of its general assessment of the EDF fleet. ASN observes that the Cruas-Meysse NPP made considerable efforts in 2014 and 2015 and improved the rigorousness of its waste management. However, a number of events notified in the second half of 2015 raise further questions concerning the site's containment of liquids.

Dampierre-en-Burly

In 2013, 2014 and 2015, ASN considered that the site's performance was on the whole in line with its general assessment of EDF concerning nuclear safety and radiation protection. The weak points identified in 2013 in the application of procedures by the operating personnel or in 2014 in the preparation and performance of maintenance work, have been corrected by the site. Weaknesses were however identified in the management of the equipment periodic checks in 2015.

The site still stands out positively in relation to the control of the impact of the facilities on the environment, with the environmental issues being satisfactorily addressed by the various departments.

Fessenheim

ASN considers that for the period 2013-2015, the nuclear safety, radiation protection and environmental protection performance of the Fessenheim site is on the whole in line with its general assessment of EDF's NPPs and is generally speaking satisfactory.

Few inappropriate practices were detected during this period and ASN considers that the operational level is good. However, a number of deviations in the configuration of the installations with respect to the baseline safety requirements were observed and the licensee must make further improvements in documentation management, where a few deviations were noted. The work done concerning the continued operation of the reactors, within the time set by ASN, has improved the safety level of the installations.

With regard to radiation protection, the recovery plan implemented in 2012 improved the situation and it is now satisfactory.

On 9th April 2014, internal flooding of the non-nuclear part of the installation damaged the backup electrical systems, leading to shutdown of reactor 1 for a period of seven weeks. ASN considers that this incident, rated level 1 on the INES scale, was well managed by the licensee.

Flamanville

In 2013, 2014 and 2015, ASN considered that the nuclear safety, radiation protection and environmental protection performance of the Flamanville site was on the whole in line with its general assessment of EDF. ASN noted that the site was continuing with its efforts to make up for a long-standing and significant delay in the handling of numerous maintenance operations and that the site situation in this respect had improved in 2014.

F – Safety of installations – Articles 17 to 19

In 2015, ASN considered that the occurrence of a number of incidents required particular attention. ASN considered that the management of the operating instructions needed to be improved, more specifically the rigorousness with which these documents are filled out and checked prior to application. ASN also considers that efforts are needed concerning the analysis, characterisation and processing of conformity deviations.

Golfech

Although in 2013 ASN considered that the site's performance stood out positively with respect to its overall assessment of EDF, it felt that this performance was no more than average in 2014 and 2015.

During the course of 2014, marked by a particularly intense maintenance programme, ASN found that the quality of oversight by the control room teams had deteriorated and that there were quality deficiencies in the maintenance operations. ASN considers that the site must improve its preparation of maintenance work and its oversight of the contractors carrying out it.

Gravelines

In 2013 and 2014, ASN considered that the performance of the Gravelines site was on the whole in line with ASN's general assessment of EDF performance. However, in 2015, ASN considered that its nuclear safety performance fell short of that of the other sites. The site must take steps concerning error-reduction in practices, operating rigour, rapid detection of deviations and the application of instructions.

In 2013 and 2014, EDF continued the programme of the third ten-yearly outage inspections (VD3) on the Gravelines site. ASN reviewed the results of the inspections carried out on reactors 2 and 4.

From 2013 to 2015, ASN examined the results of the inspections on reactor 1 which had suffered cracks in a bottom-mounted instrumentation penetration. These inspections did not reveal any development of these defects. The reactor 1 bottom-mounted instrumentation penetration repair file is currently being reviewed by ASN. Final repair is scheduled for 2016.

On 20th August 2015, ASN adopted a resolution setting prescriptions concerning the control of risks relating to the methane tanker terminal at Dunkerque.

Nogent-sur-Seine

In 2013, 2014 and 2015, ASN considered that the nuclear safety, radiation protection and environmental protection performance of the site was on the whole in line with its general assessment of EDF.

Contractor oversight and the quality of the maintenance documents remains an area in which progress is still required. In 2013 and 2014, good performance was recorded in the field of radiation protection, at a time of limited maintenance work, but the contamination of an individual worker with exposure of the skin in excess of one quarter of the annual regulation dose limit in 2015 demonstrated the need for the site to reinforce its radiation protection culture.

The shortcomings observed in 2012 and 2013 on deviations monitoring led ASN to serve formal notice on the licensee in January 2014 to correct this situation. A corrective action plan was produced and an internal audit carried out by the licensee.

Progress was observed in 2014 in monitoring of the pressure equipment and in maintenance. Similarly, good management of refuelling and maintenance outages was observed in 2015.

Paluel

In 2013, 2014 and 2015, ASN considered that the nuclear safety, radiation protection and environmental protection performance of the Paluel site was on the whole in line with its general assessment of EDF.

ASN considered that the site had made progress in the areas of reactor operation and management, in the application of the general operating rules and in the control of the fire risk. ASN observed an improvement in the management of the safety aspects of the reactor outages, even if the monitoring and quality control of maintenance operations still requires vigilance given the large number of deviations observed further to deficiencies in the performance of such operations.

ASN considered that in 2015, the site confirmed its satisfactory reactor control performance. ASN did however note that error-reduction practices concerning the preparation for and subsequent verification of operation, radiation protection and maintenance are inadequately implemented by the personnel involved. ASN noted an improvement, which needs to be sustained, in the integration of the analyses produced by the plant department in charge of independent safety oversight.

Penly

Between 2013 and 2015, ASN considered that the nuclear safety and radiation protection performance of the Penly site stands out positively with respect to its assessment of EDF as a whole. The site's environmental protection performance is in line with ASN's general assessment of EDF performance.

ASN nevertheless considers that the site must maintain its efforts to strengthen the way it organises the monitoring of outside contractors during reactor outages, and significantly increase the resources allocated to this topic in the field.

ASN considers that particular attention must be paid to the preparation of operational management in order to reinforce the implementation of error-reduction practices during work on the equipment.

Saint-Alban/Saint-Maurice

ASN had considered that between 2009 and 2011 the overall performance of the Saint-Alban/Saint-Maurice NPP fell short of its general assessment of EDF performance as a whole, which was relatively satisfactory. Since 2012, ASN considers that the nuclear safety performance of the Saint-Alban/Saint-Maurice NPP is, on the whole, in line with its general assessment of the EDF plants. The quantitative indicators for the year 2015 would seem to be in the right direction and confirm the fundamental approach initiated since 2011 to ensure a long-term turnaround in the performance of the site.

With regard to maintenance, the latest maintenance and refuelling outages by EDF were on the whole successful. ASN did however identify weak points regarding application of the maintenance programmes schedule.

ASN considers that the NPP must consolidate these results in the run-up to the ten-yearly outage inspections of two reactors in the installation which will take place in 2017 and 2018.

Saint-Laurent-des-Eaux

In 2013 and 2015, ASN considered that the site's performance was on the whole in line with its general assessment of EDF concerning nuclear safety and radiation protection. In 2014, with a lower maintenance and refuelling outage programme workload, the site stood out positively with respect to the general assessment of EDF, including in radiation protection, despite the unfavourable conditions created by a cladding defect linked to the presence of loose parts in the main primary system.

Environmental performance was considered to be better than the EDF NPP fleet average, in particular with good management of liquid and gaseous discharges. The site set up an independent process competent in environmental matters based on the model of the process that exists in the area of safety.

Tricastin

ASN considers that the nuclear safety performance of the Tricastin site is on the whole in line with ASN's general assessment of EDF performance and is comparable to the performance obtained by the Tricastin NPP since 2012. Although EDF has made progress in the field of periodic tests, ASN does however observe a deterioration in the results concerning system configuration (line-up and lock-out) which reflects shortcomings in organisational and human factors.

With regard to maintenance, ASN finds that the Tricastin NPP's performance in the management of reactor outages remains good on the whole, even if technical difficulties linked to work quality deficiencies sometimes occurred during the restart phases.

On 27th May 2011, 27th January 2015 and 2nd June 2015, ASN considered that Tricastin reactors 1, 2 and 3 respectively were cleared for a further 10 years of operation after their third periodic safety review. In a resolution, ASN imposed a number of additional prescriptions on EDF in order to reinforce the safety of these reactors.

14.2.4.2 Research reactors

14.2.4.2.1 Periodic safety reviews of research reactors

The main problem identified is linked to the fact that each research reactor is a special case, for which ASN must adapt its regulation, while ensuring that safety practices and rules are applied. In this respect, the last few years have seen the development of a more generic approach to the safety of these facilities, inspired by the rules applicable to power reactors, and more particularly the method of safety analysis by "postulated initiating events" and safety classification of the associated equipment. This has led to significant progress in terms of safety. This approach is now used for the periodic safety reviews of the existing facilities as well as for the design of new reactors.

14.2.4.2.2 Stress tests

For the facilities considered to be high priority, the stress test reports were submitted on 15th September 2011 by CEA and the ILL. At the request of ASN, these reports were analysed by IRSN and were presented to the Advisory Committees in November 2011. Following this analysis, ASN completed by resolution the requirements to be applied to installations operation.

14.3 Application of probabilistic risk assessment methods

The safety case for these facilities is primarily based on a deterministic approach, whereby the licensee designs the facility on the basis of reference accidents. This approach is supplemented by probabilistic safety assessments (see § 3.1, point 4) based on a systematic investigation of accident scenarios enabling the safety level of a facility to be assessed in terms of the frequency of feared events and their consequences.

14.3.1 ASN requests

14.3.1.1 Nuclear power reactors

The PSAs are used to estimate whether the steps taken by the licensee are satisfactory, by incorporating equipment reliability and operator behaviour into their scenarios. The PSAs are used to:

- highlight any installation weak points, for which design and operational changes may be considered necessary;
- determine the systems which play an important safety role, by identifying the main contributions to the sought-after frequency.

Two types of PSAs are produced for nuclear power reactors:

- Level 1 PSAs (PSA 1) which identify the sequences leading to core melt and determine their frequency;
- Level 2 PSAs (PSA 2) which assess the nature, importance and frequency of releases outside the containment.

The PSA 1 were in particular developed in compliance with basic safety rule (RFS) 2002-01 concerning the use of PSAs. The rule covers the following aspects:

- French PSA doctrine;
- the scope of PSA coverage;
- the acceptable methods for performance of level 1 PSAs – internal events;
- the PSA applications.

The PSAs are developed both at the design stage, for new installations and, during operation, for the periodic safety reviews of reactors in service.

In the case of projects for new installations, the PSAs are developed so as to highlight situations for which steps are needed to reduce the frequency of a severe accident or mitigate its consequences. For the periodic safety reviews, the PSAs are developed to:

- assess the changes to the level of safety in relation to the assessment made following the previous review, to take account of operating experience feedback (for example, changes to system characteristics), the measures adopted for more recent reactors and new knowledge. Within this framework, the overall probabilistic core melt frequency target is consistent with the recommendations of INSAG 12.

For new installations, for example the Flamanville 3 EPR, PSA 2 is used to verify that the safety objectives are reached, in particular the significant reduction in radioactive releases that could result from all conceivable accident situations, including accidents with core melt.

For each type of accident, the technical directives set the following objectives:

- for accident situations without core melt, there should be no need for measures to protect the populations living in the vicinity of the damaged plant (no evacuation, no sheltering);
- the accidents with low-pressure core melt should be dealt with so that the maximum conceivable associated releases only require population protection measures that are limited in terms of scope and duration;
- the accidents with core melt which would lead to large-scale, early releases must be practically precluded.

14.3.1.2 Research reactors

Pursuant to Article 3.3 of Part I of the BNI order, whereby "*the nuclear safety case shall also include probabilistic assessments of accidents and their consequences unless the licensee demonstrates that this is irrelevant* ", ASN will request that the licensees of research reactors also produce probabilistic safety assessments.

14.3.2 The PSA types developed for nuclear power reactors

The table below shows the PSAs developed for each series of similar reactors.

Plant series	Events considered for the level 1 and 2 PSAs
900 MWe reactors	PSA 1 and 2 for failures (or events) inside the reactor; PSA 1 for fire. For the safety review associated with the 4th 10-yearly outage (VD4), the following shall also be considered: • PSA 1 for events affecting the fuel building pool; • PSA 1 for internal fire and flooding; • a probabilistic assessment of the frequency of formation of an explosive atmosphere.
1300 MWe reactors	• PSA 1 and 2 failures (or events) inside the reactor For the safety review associated with the 3rd 10-yearly outage (VD3), the following shall also be considered: • PSA 1 for events affecting the fuel building pool; • PSA 1 for internal fire and flooding; • the earthquake PSA for the Saint-Alban site.
1450 MWe reactors	PSA 1 for failures (or events) inside the reactor. For the safety review associated with the 2nd 10-yearly outage (VD2), the following shall also be considered: • level 1 PSA for internal flooding; • level 1 PSA for events affecting the fuel building pool; • levels 1 and 2 PSAs for fire; • level 2 PSA for internal events.
1650 MWe reactors (EPR) under construction	For the commissioning authorisation application, the PSAs take account of: • the events within the reactor (PSA 1 and 2); • the events affecting the fuel building pool (PSA 1); • earthquakes (simplified PSA 1); • fire and internal flooding (PSA 1 reactor and fuel building pool); • internal explosion (ATEX frequency assessment); • specific probabilistic assessments concerning an airplane crash or external industrial risks are also available.

Table 6: PSAs currently available and the main categories of initiating events considered for each French reactor plant series

PSA contribution to the technical operating specifications

The PSAs help shed light on how to respond better to unavailability of an equipment item required by the technical operating specifications and how to rank the requirements in the light of the importance for safety of the postulated unavailabilities.

They can be used to assess the increased core melt frequency for all reactor states, in the light of the unavailability(ies) concerned, and during transients between states.

They can also be used to support the licensee when requesting authorisation to perform a particular intervention and/or for operation in a reactor state that is not in conformity with the technical operating specifications, in order to justify that that resulting increased core melt frequency is limited, taking account of any mitigating measures it intends to implement.

Finally, they can be used to analyse the possible failure modes of certain systems and improve the technical operating specifications, the periodic tests and the equipment maintenance programmes.

Moreover, the results of the equipment reliability assessments with failure modes analysis (FMECA) can influence the preparation of the equipment periodic test and maintenance programmes.

14.3.3 Measures taken for research reactors

14.3.3.1 CEA reactors

The regulations[7] require that since July 2013, the nuclear safety demonstration shall also include probabilistic assessments of accidents and their consequences, unless the licensee demonstrates that this is irrelevant. These assessments comprise the technical, organisational and human aspects.

With regard to research reactors, the performance of probabilistic safety assessments (PSA)[8] is not required by the regulations[9]. Moreover, the specificity of each of these facilities makes it harder to conduct such assessments, so for the time being they are not carried out.

14.3.3.2 The ILL high-flux reactor (RHF)

In the light of the forthcoming periodic safety review scheduled for 2017 and more specifically for the revision of its safety analysis report, the ILL proposed a methodology for conducting the safety assessments, based on an approach that is deterministic, but also probabilistic. On the advice of ASN, the methodology and corresponding analysis are currently being adjusted.

14.3.4 ASN analysis and oversight

For the 3rd periodic safety review of the 1300 MWe reactors, the licensee carried out a level 1 PSA on the internal events, PSAs on hazards (fire, internal flooding and earthquake) and a PSA on the fuel building pool.

ASN's assessment of the changes made by EDF to the level 1 PSAs during the 1300 MWe periodic safety reviews is on the whole positive, but it underlines the interest of the PSAs with respect to hazards, more specifically those concerning fire and internal flooding.

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[7] Article 3.3 of the Order of 7th February 2012 setting general rules for BNIs.

[8] Basic safety rule (RFS) 2002-01, concerning the use of probabilistic assessments for the safety of BNIs.

[9] Article 8.1.2 of the Order of 7th February 2012 setting general rules for BNIs.

They in particular highlighted the need for design or operating changes to the facilities to reduce the risks linked to core melt and fuel melt.

ASN considers that the methods and hypotheses adopted for the “internal events” PSA on the whole comply with the recommendations of the RFS n° 2002-01. However, ASN observed that the reliability data for some equipment had been produced from old experience feedback, even though the PSAs must take account of changes to system characteristics. ASN considers therefore that the PSAs must use reliability data that are representative of the most recent operating experience feedback and this data has to be analysed regularly and updated if required.

The “spent fuel pool” PSA does not currently cover all scenarios liable to lead to a loss of cooling or rapid emptying. ASN asked the licensee to complete its assessment in order to allow a final ruling to be made on the modifications to be carried out for the VD3 1300 MWe periodic safety review.

ASN considers that the “fire” PSA represents a significant contribution to risk assessment. It considers that the approach adopted by EDF is appropriate but that certain hypotheses and data must be further improved in order to rule on the modifications to be selected.

ASN considers that the “internal flooding” PSA is state of the art and represents significant progress in the PSA utilisation approach. ASN more specifically considers that this assessment highlighted the preponderance of scenarios which could lead to core melt following rupture of a fire extinguishing system in the electrical building.

The “earthquake” PSA exercise carried out for the Saint-Alban NPP comprises the steps essential for its production. However, additional analyses are necessary, notably for the seismic hazard and for definition of the various equipment and structure failure modes and the fragility curves taking account of these various modes. The assessment concerning the feasibility and benefits of performing PSAs for extreme climatic conditions and external flooding, highlighted the difficulties in estimating the probability of hazards linked to natural phenomena. However, ASN considers that complete PSAs, complementary probabilistic assessments or margin assessments must be carried out for these hazards for the next periodic safety reviews.

With regard to the level 2 PSAs, the first assessments of this type were carried out on the 1300 MWe reactors, considering the status prior to the VD3 and the status incorporating the changes requested for the VD3. A comparison of the results of these two assessments showed a significant reduction in the frequency of major releases, in particular in the case of total loss of electrical power supplies. ASN did however ask for changes to these PSAs in order to realistically reflect the condition of the facilities, their operation and the risk of releases in the event of an accident.

For the safety review of the 900 MWe reactors, ASN asked for the coverage of the level 2 PSAs to be extended to accidents without fuel melt and for a statistical assessment of their radiological consequences according to local meteorological conditions on each site.

Level 1 PSA for the Flamanville 3 EPR

The development of level 1 PSAs as of the beginning of the design of the Flamanville 3 EPR reactor was of considerable benefit in addition to the deterministic assessments, more specifically leading to the definition of several important improvements to the design of this reactor. ASN considers that the performance of the PSAs enabled a structured analysis of the EPR reactor design to be carried out, with identification of the technical subjects that needed to be taken further. One of these subjects is the concept of “balanced safety design” and, in this respect, when transmission of the end of start-up file was due, ASN asked for a reassessment of the frequency of core melt, taking account of the results of the ongoing reviews and the finalised design.

Changes to the level 2 PSA for the Flamanville 3 EPR

The PSA 2 for the Flamanville reactor 3 comprises a major change with respect to that of the other French nuclear reactors. It is primarily based on the technical directives, which set the main objective of a significant reduction in radioactive releases that could result from all conceivable accident situations, including accidents with core melt (see § 14.3.1.1 above).

The Advisory Committee of experts for reactors considers that the PSA 2 for the Flamanville 3 EPR sheds valuable light on the safety level and on the robustness of the design of the installation. However, in the probabilistic assessment of the “practical preclusion” of pressurised core melt situations, ASN underlines the significant weight of the probability of hot leg rupture of the primary system.

Research reactors

At present, no PSAs are run on the research reactors.

15. 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 Regulations and ASN requests

The legal framework of nuclear activities has been extensively modified in recent years. The legislative system is now relatively complete and the publication of the application documents is well advanced, even if not as yet complete.

The European Commission has started work on merging into a single text several Euratom directives, including those concerning basic radiation protection standards, protection of patients against medical exposure and the regulation of high-level sources. The new Euratom directive 2013/59, published on 5th December 2013, must be transposed into French Law before February 2018. The transposition work is in progress and the legislative modification of the Public Health, Labour and Environment Codes was the subject of an ordinance published on 11th February 2016 (Ordinance 2016-128 of 10th February 2016 constituting various nuclear provisions).

15.1.1 The Public Health Code and the general principles of radiation protection

Chapter III dealing with ionising radiation of Title III of Book III of the legislative part of the Public Health Code defines all "nuclear activities", that is, all activities involving a risk of human exposure to ionising radiation resulting either from an artificial source (whether a substance or a device) or a natural source, when natural radionuclides are or have been processed because of their radioactive, fissile or fertile properties. They also include "interventions" aimed at preventing or reducing a radiological risk following an accident, due to environmental contamination.

Article L. 1333-1 of the Public Health Code defines the general principles of radiation protection (justification, optimisation, limitation), which have been laid down at the international level by the International Commission on Radiological Protection (ICRP) and reiterated in EURATOM's Directive No. 96/29. Those principles are recalled below and guide all regulatory activities for which ASN is responsible.

The *Code* institutes the Radiation Protection Inspectorate to be set up and chaired by ASN, with a view to regulating the application of its radiation-protection provisions. The code also defines a system of administrative or criminal penalties.

15.1.1.1 The justification principle

"A nuclear activity or intervention may only be undertaken or carried out if justified by the advantages it procures, particularly in health, social, economic or scientific terms, with respect to the risks inherent in the exposure to ionising radiation to which the individuals are likely to be subjected".

Assessment of the expected benefit of a nuclear activity and the corresponding health drawbacks may lead to prohibition of an activity for which the benefit does not seem to outweigh the risk.

15.1.1.2 The optimisation principle

"Human exposure to ionising radiation as a result of a nuclear activity or an intervention must be kept as low as reasonably achievable, given current techniques, economic and social factors and, as applicable, the medical purpose."

This principle, commonly referred to as ALARA (as low as reasonably achievable), leads for example to a reduction in the discharge licences of the quantities of radionuclides permitted in radioactive effluents discharged from nuclear installations or mandatory monitoring of exposure at work stations in order to keep them to the strict minimum.

15.1.1.3 The limitation principle

"Exposure of a person to ionising radiation as a result of a nuclear activity cannot raise the sum of the doses received beyond limits set by the regulations, unless this person is exposed for medical purposes or for biomedical research."

The exposure of the general public or workers as a result of nuclear activities is subject to strict limits (see § 15.1.2.1 and § 15.1.3.1). If these limits are exceeded, this situation is considered to be unacceptable and can lead to administrative or criminal penalties.

15.1.2 General protection of the population

In addition to the particular radiation protection measures taken for the individual authorisations concerning nuclear activities, for the benefit of the general public and the workers, several more general measures incorporated into the Public Health Code help protect the public against the dangers of ionising radiation as a result of nuclear activities.

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 equivalent 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 cm² area of skin). The method of calculating effective and equivalent doses, and the methods used to estimate the dose impact on a population, are defined by the order of 1st September 2003.

15.1.2.2 Radiological monitoring of the environment

15.1.2.2.1 The objectives of radiological monitoring of the environment

The Environment Code requires that the licensees of nuclear facilities carry out radiological monitoring of the environment around their facility. The objectives of this monitoring of the various components of the environment (surface waters, ground waters, air, biological matrices: grass, milk, plants, fisheries products, etc.) are to:

- contribute to the knowledge of the radiological and radio-ecological state of the environment of the installation, and its evolution;
- contribute to estimating the impact of the facility on health and the environment;
- detect any abnormal increase in radioactivity as early as possible;
- ensure that the facility is not malfunctioning;

- contribute to transparency and information of the public through the transmission of these data to a national monitoring network (RNM).

15.1.2.2.2 The French national network of environmental radioactivity measurements (RNM)

The RNM was created by the Public Health Code and its aim is to provide the public with the results of environmental radioactivity monitoring and information concerning the health impact of nuclear activities nationwide in France.

The ASN resolution of 29th April 2008, modified by the ASN resolution of 26th February 2015, describes the working of the RNM and defines the laboratory approval procedures. ASN thus determines the RNM guidelines and issues approval of the laboratories taking the measurements. In this respect, it chairs the RNM steering committee and the measurement laboratories accreditation commission. This network is managed by IRSN.

The non-regulatory measurements taken by accredited laboratories can also be made available to the public. On average, nearly 20,000 measurements are transmitted every month. The database currently contains more than 1.7 million measurements, representing more than 1.1 million samples.

15.1.2.2.3 ASN duties concerning regulatory radiation protection monitoring

The Environment Code gives ASN the task of *"organising a permanent watch regarding radiation protection across the country*", of which radiological and environmental monitoring form an integral part.

In this capacity, ASN issues technical regulatory resolutions, either of a general scope, if they apply to all BNI operators, or of a more individual scope, if they regulate a specific installation. ASN thus sets the minimum prescriptions for monitoring radioactivity in the environment with a view to ensuring subsequent compliance with these prescriptions.

ASN also plays a major role in public information notably by ensuring that environmental information is available to the public.

Lastly, ASN helps the Ministry of Health to develop technical provisions applicable to health monitoring of the radiological quality of waters intended for human consumption and for the accreditation of laboratories performing these health monitoring.

15.1.2.2.4 Other monitoring players

BNI licensees

In France, the licensees are responsible for monitoring the environment around their facilities, in accordance with their individual prescriptions (creation authorisation decree, discharge license orders or ASN resolutions) which define the measurements to be taken and at what intervals, regardless of any additional measures that can be adopted by the licensees for the purposes of their own monitoring.

The minimum content of this monitoring is defined in the Order of 7th February 2012 which sets the general rules for BNIs and in ASN regulation 2013-DC-0360 concerning the control of nuisances and the impact of French BNIs on health and the environment.

IRSN

Operational radioactivity monitoring nationwide is the responsibility of various players: the licensees (EDF, CEA, AREVA, ANDRA, French Navy, etc.), for monitoring in the vicinity of the facilities, IRSN (for measurements at all points nationwide) and other players belonging to non-governmental organisations (ACRO, CLI, ALQA, universities, etc.).

The results of the measurements submitted to RNM are accessible to the public via various Internet platforms, including that of the RNM (http://www.mesure-radioactivite.fr/) and those of IRSN (https://sws.irsn.fr/ and http://teleray.irsn.fr/).

The environmental radiological monitoring data are periodically analysed by IRSN and made public either in the form of summaries, both national (radiological summaries) or regional (radiological findings and results of radiological monitoring in French Polynesia), or in the form of thematic syntheses (e.g. radiological findings on the remanence of artificial radioactivity).

Two approaches are used for this:

- continuous on-site monitoring by self-contained systems (remote monitoring networks) with real-time transmission of results, including :
  - the recently refurbished Téléray network, based on 450 measurement detectors (see Appendix 4, § 4.3);
  - the Hydrotéléray network, which comprises 7 monitoring stations on the major rivers;
  - the OPERA[10] continuous sampling network with measurements in the laboratory.
- laboratory processing and measurement of samples taken in various compartments of the environment in the vicinity of or at a distance from installations likely to discharge radionuclides.

15.1.2.2.5 Radioactive waste and effluent

BNI waste management

The underlying principles for waste management are: limiting the quantity produced, sorting according to type and to level of activity, packaging immediately after production, storage guaranteeing the integrity of the packages, transportation then disposal.

In practice, waste management is checked more specifically when reviewing the waste studies for each site and the zoning plans, with analysis of the annual waste management reports. In addition, since 1st July 2015, the BNIs must have a waste zoning plan which clearly shows the boundaries of the zones in which nuclear waste could be produced, the methods for declassifying or reclassifying the waste zones and the traceability and records-keeping for those zones in which the structures and soils are liable to have been contaminated or activated.

Finally, French regulations do not include the notion of a clearance level, neither for effluents, nor for solid waste.

BNI discharges

The Environment Code empowers ASN to define the prescriptions concerning BNI water intake and discharges.

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[10] http://www.irsn.fr/FR/Larecherche/outils-scientifiques/installations-moyens-experimentaux/Opera/Pages/reseau-Opera-Air.aspx

When renewing or modifying these prescriptions, ASN sets limit values for emissions, water intake and discharge of effluents on the basis of the best available technologies in technically and economically acceptable conditions, taking into consideration the characteristics of the facility, its location and the local environmental conditions.

The process of reduction of BNI discharges at source aims to reduce their quantity. The optimisation efforts implemented by the licensees lead to, for "equivalent operation", sometimes significantly, reduced discharges. Setting discharge limit values should encourage the licensees to maintain their optimisation and their discharge control efforts.

In its resolutions, ASN defines prescriptions concerning water intake and effluent discharge methods for each BNI and others which set their environmental discharge limits (resolutions requiring approval by the ministers responsible for nuclear safety).

Since 1st July 2012, any BNI modification project that could cause a significant increase in its water intakes or effluent discharges to the environment is now made available to the public for examination.

15.1.2.3 Protection of persons in a radiological emergency situation

The steps taken to protect persons in an accident or radiological emergency situation are detailed in chapter 16.

15.1.2.4 Reference and intervention levels

Intervention levels were updated in 2009 by an ASN resolution[11]. This resolution improves the protection of the most sensitive populations (foetus and children up to 18 years old). From now on, the protective actions to be set in place in the event of an emergency and the corresponding intervention levels are the following:

- sheltering, if the forecast effective dose exceeds 10 mSv ;
- evacuation, if the forecast effective dose exceeds 50 mSv;
- administration of stable iodine tablets, if the forecast dose to the thyroid is liable to exceed 50 mSv.

The reference exposure levels for persons intervening in a radiological emergency situation are also defined; two groups of intervention personnel are thus defined:

- the first group includes all members of staff forming special technical or medical intervention teams, which have been constituted in advance to deal with a radiological emergency;
- the second group is comprised of members of staff that do not belong to special teams, but who intervene in the course of missions within their competence.

15.1.2.5 Protecting the population in the event of long-term exposure

Some sites are contaminated with radioactive materials due to a past or obsolete nuclear activity, or an industrial activity calling upon the use of raw materials containing non-negligible quantities of natural radioelements. The majority of these sites are listed in the inventory issued and periodically updated by ANDRA and can be consulted on its website www.andra.fr.

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[11] ASN resolution of 18th August 2009.

A new guide on the management of potentially polluted sites, drafted under the coordination of ASN and the Ministry of the Environment, was published in December 2011 and describes how to deal with the various situations that could be encountered when rehabilitating sites (potentially) contaminated by radioactive substances.

15.1.3 Protection of workers

The Labour Code contains specific provisions for the protection of workers, whether or not salaried, liable to be exposed to ionising radiation. It transposes into French law the Euratom directives concerning the protection of external workers liable to be exposed to ionising radiation during their work in limited access areas.

There are links between the Public Health Code, the Environment Code and the Labour Code, with regard to the provisions for the collective protection of workers within BNIs.

For all workers (salaried or otherwise) liable to be exposed during their professional activity, the Labour Code also sets provisions more specifically concerning:

- worker dose limits;
- the technical rules for outfitting of working premises;
- the training and dosimetric and medical follow-up of workers;
- abnormal working situations (exceptional exposure);
- the functional organisation of radiation protection within the establishment (in particular the department with competence for radiation protection).

15.1.3.1 Dose limits for workers

Limits are set for the exposure levels induced for workers by nuclear activities. Worker dose limits have been reduced to 20 mSv over 12 consecutive months, except for specific waivers being granted to account for exceptional exposure or emergency professional exposure. In addition to this dose limit, referred to as the “effective dose” there are the following specific dose limits, known as the “equivalent dose” for individual organs or tissues:

- 500 mSv for hands, forearms, feet, ankles and skin, in which case the limit applies to the average dose over a total surface of 1 cm^2, irrespective of the exposed surface;
- 150 mSv for the crystalline lens of the eye.

A significant change should take place with the transposition into French law of the Basic Safety Standards (BSS) of Euratom directive 2013/59, of which article 9 paragraph 3 a) requires that the EU Member States modify the exposure limits for the lens of the eye for exposed workers: “*3 … the following dose equivalent limits apply: a) the dose equivalent limit for the lens of the eye is set at 20 mSv per year or at 100 mSv for a period of five consecutive years, provided that the dose received during the course of one year does not exceed 50 mSv, as stipulated in the national legislation.”*

There is also a dose limit for the unborn child (1 mSv for the period between the declaration of pregnancy and the actual birth).

The Labour Code prohibits the employment of temporary contract staff for the performance of work in areas where the hourly dose rate is liable to exceed 2 mSv.

If a temporary contract worker is exposed to ionising radiation and if at the end of his or her contract, this exposure exceeds the annual limit as calculated by comparison with the duration of the contract, the employer must propose an extension of the contract for a time such that the exposure observed at expiry of the extension is no higher than the annual limit value calculated by comparison with the total duration of the contract.

EDF also applies these requirements to staff under contract for the duration of the worksite, provided that their seniority within the company is less than six months.

15.1.3.2 Zoning

The regulations[12] set stipulations for definition of monitored, controlled and specifically regulated areas (particular controlled areas) and also defines health, safety and upkeep rules which must be applied in these areas.

The demarcation of regulated areas is defined on the basis of an evaluation of the level of external exposure (effective or equivalent doses), and internal exposure as applicable. The regulations set reference values.

15.1.3.3 Person Competent in Radiation protection (PCR)

The duties of the person competent in radiation protection (PCR) are carried out under the responsibility of the employer. They are in particular consulted for the demarcation of areas, for the prior workplace risk assessments and for definition of the protection measures designed to keep exposure to a level that is as low as reasonably achievable (optimisation).

The regulations[13] make provision for 3 levels of training and 5 activity sectors, including a "nuclear reactor" sector, covering all nuclear reactors, regardless of what they were designed for.

Training comprises a theoretical module and a practical module specific to each sector. The training organisations carrying out "PCR" training must be certified by an organisation accredited by the French Accreditation Committee (COFRAC).

15.1.3.4 Dosimetry monitoring of workers[14]

The procedures for certifying organisations in charge of worker dosimetry and those for the medical follow-up of workers and the transmission of individual dosimetry data, are defined by the regulations[15]. ASN examines the approval requests concerning the conditions for issue of the certificate and the approval for organisations in charge of individual monitoring of worker exposure to ionising radiation.

The external exposure monitoring system for persons working in facilities in which ionising radiation is used has been in place for several decades. It 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.

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[12] Order of 15th May 2006 amended.

[13] Order of 6th December 2013 relative to the training conditions for the person competent in radiation protection and the certification of the training organisations.

[14] Information taken from the summary "Radiation protection of workers – Occupational exposure to ionising radiation in France: summary 2011" published by IRSN. Reference PRP-HOM/2012-007.

[15] Orders of 6th December 2003 amended and of 30th December 2004.

The data recorded indicate the total exposure dose over a given period. They are collated in the SISERI system managed by 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 PCRs;
- 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.

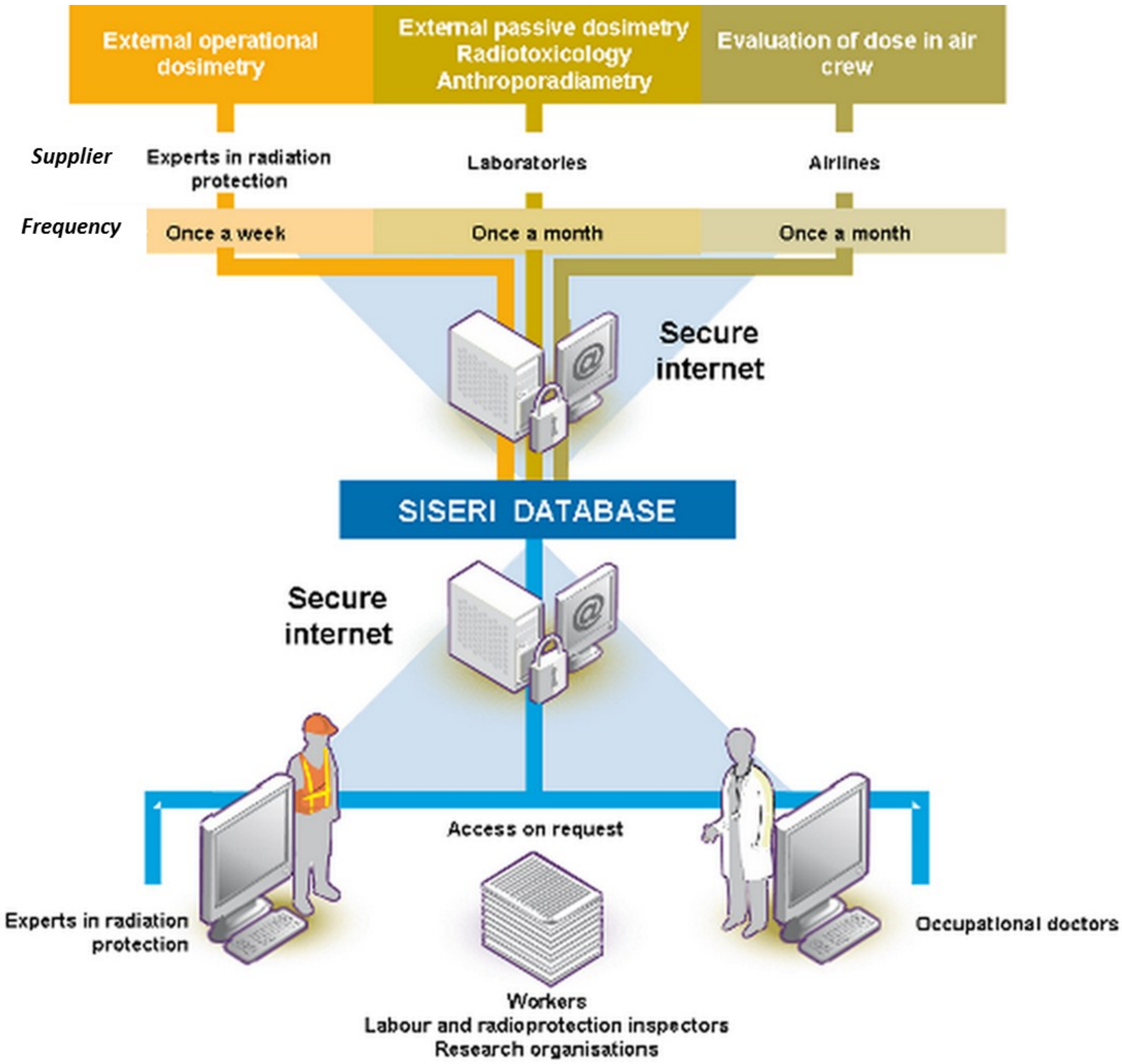

Figure 5: Working of the SISERI system (source IRSN)

If one of the limit values is exceeded, the occupational physician and the employer are immediately informed. The occupational physician notifies the employee concerned.

15.1.3.5 Radiation protection technical checks

The radiation protection external technical checks are performed by IRSN, or by approved organisations[16]. The internal technical checks can be performed by the PCR or entrusted to IRSN, or to approved organisations. The nature and frequency of the radiation protection technical checks are defined by the regulations[17].

The technical checks concern sources and devices emitting ionising radiation, the environment, measuring instruments and protection and alarm devices, source management and any waste and effluents produced.

15.2 Measures taken for nuclear power reactors

15.2.1 Radiation protection of workers

Occupational dosimetry must be optimised prior to performance of the operations. The doses received by workers can result from internal contamination or external exposure to radiation. EDF's "radiological cleanness" policy and the systematic use of breathing apparatus in the event of a suspected risk of internal contamination, mean that cases of occuaptional internal contamination are rare and not serious. Virtually all the doses received can be attributed to external irradiation, which EDF is endeavouring to reduce in various ways.

During the period 2013-2015, ASN was notified of two events in which the regulation dose equivalent limits for the skin were exceeded (events of 24th April 2013 and 18th August 2015 in the Le Blayais NPP). During this same period, ASN was notified of several events during which one quarter of the regulation whole body dose and the equivalent dose for the skin were exceeded.

In order to optimise and further reduce the doses received by exposed individuals, EDF launched its ALARA 1 policy in 1992, which was given fresh impetus in 2000. Considerable gains were then obtained, with the collective dose per year and per reactor falling from 2.4 man.Sv in 1992 to 0.71 man.Sv/reactor in 2015.

With regard to the individual dose, the doses received by the most exposed workers have been significantly reduced. In 2015, no workers (EDF and contractor personnel) had an annual dose between 16 and 20 mSv (as against 2 at the end of 2011). As at the end of 2015, there were 2 workers with an annual dose of > 14 mSv (as against 20 at the end of 2011) and there are 204 workers with an annual dose of > 10 mSv (as against 424 at the end of 2011).

This dose optimisation approach is based on three fundamentals:

Reduced contamination of systems

Contamination of primary systems is the origin of exposure. Steps are therefore being taken to optimise the operation of systems and the facility outages (periods during which the main maintenance work is carried out) by modifying the chemical conditions or optimising the purification of the primary system water.

Foreign experience feedback shows that the controlled injection of zinc into the primary system reduces the contamination of the systems. At present, 14 French reactors use this system, which has not yet

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[16] The list of approved organisations is available on www.asn.fr (in French).

[17] Order of 26th October modified by the order approving the ASN resolution of 4th February 2010.

proven its effectiveness in reducing Dose Equivalent Rates (DeD) but results are expected on the reactors which inject it continuously.

In addition, as in any NPP fleet, there are differences between the dosimetry results from the reactors. Since 2004, clean-out of the RRA (residual heat removal system) and RCV (Chemical and Volume control system) systems has been carried out on the reactors with the highest doses (Chinon 2 in 2004, Flamanville 1 in 2006, Gravelines 3 in 2007, Bugey 2 in 2008 and Le Blayais 4 in 2009, Gravelines 2 in 2010, Civaux 1 in 2011, Bugey 3, Cruas 4 and Civaux 2 in 2012, Bugey 4 in 2014 and Tricastin 1 in 2015). A multi-year programme has now been drawn up.

Operating experience feedback from the ten or so reactors cleaned-up shows a dosimetric gain demonstrating the effectiveness of this clean-up in order to reduce worker dosimetry.

Preparation for interventions and dose optimisation

The process, common to all nuclear sites (EDF and contractor staff) is as follows:

- perform a forecast dosimetry evaluation for each operation (collective and individual dose);
- rank these operations according to the dosimetric implications;
- carry out an optimisation analysis of these operation according to the potential dosimetry. For work with the highest potential dosimetry, the operation is studied phase by phase, post by post, to determine the most appropriate protection, tooling and intervention methods;
- set a collective and individual dosimetry target for each operation as a result of this optimisation analysis;
- carry out real-time measurement of the changing collective and individual dosimetry of these operations, analyse and process any deviations;
- carry out experience feedback work, with analysis of deviations and good practices to be used for the benefit of future operations.

The measured dose received by workers on certain sites with potentially high dosimetry can now be retransmitted to a supervisor in real-time via a system of teledosimeters. This supervisor advises the worker and checks that any changes in the dose received are in compliance with the forecasts.

An experiment has been carried out since 2010 on the central monitoring station on three sites. The decision to extend it to all the sites was taken in 2012. Deployment to all sites will take place between 2016 and 2018.

Use and dissemination of experience feedback

To limit the doses received by the workers, EDF set up alert thresholds in the application for managing operational doses common to all EDF nuclear sites. These thresholds are set at 14 mSv for the pre-alert and 18 mSv for the alert. If these values are reached, special consultation procedures involving workers, doctors and radiation protection specialists are triggered. They lead to an assessment and detailed optimisation of subsequent doses, as well as enhanced follow-up to prevent regulatory limits from being exceeded.

The jobs subject to the highest exposure are given specific follow-up which is bearing fruit, as the individual doses are falling significantly and the individual dosimetric average has been dropping continuously over the past fifteen years and stood at 0.93 H x mSv per worker in 2014 (2.17 in 2000).

Activities involving a significant risk of exposure to radiation are subject to a specific process

These specific activities comprise means of access to prohibited areas (dose rate higher than 100 mSv/h), to a lesser extent access to limited stay areas (dose rate higher than 2 mSv/h), and gamma radiography operations. If not managed, these activities could lead to occasional irradiation in excess of the forecast or greater than a regulatory limit. Specific organisations were formally defined and documented so that all the sites implement them in the same way. These organisations are periodically assessed by teams from the Nuclear Inspectorate, which is independent of the sites and which assesses all the sites on the same basis. These sites are then classified according to a rating system which is monitored particularly closely by DPN. Any significant event concerning gamma radiography operations and the means of access to the prohibited areas is particularly closely monitored by the centralised engineering service and is the subject of a presentation by the site itself to the risk prevention committee dealing with radiation protection. This committee is chaired by the Deputy director of DPN.

15.2.2 Radiation protection of the public

15.2.2.1 Radioactive effluent discharges

For several years now, EDF has maintained efforts to reduce and control discharges. The management of "radioactive discharges" is based on the licensee's firm desire to mitigate the environmental and dosimetric impacts of their activities and facilities, more particularly endeavouring to minimise discharges, acting primarily to improve the effluent collection and treatment systems and to implement rigorous effluent management based on reducing its production at source.

All the actions described above more specifically led to an highly significant reduction in the activity of the liquid effluents discharged (excluding tritium and carbon 14) for which the discharged activity has now reached a baseline level of about 0.3 GBq/reactor/year (division by 100 of the discharges activity (except for tritium & carbon 14) since 1985, and division by 10 since 1994), with recent discharge values fluctuating very slightly (owing to the number and duration of outages, equipment unavailability, etc.). Tritium and carbon 14 discharges, which are directly correlated with the power output by the units, remain stable:

- at about 18 TBq/reactor/year for liquid tritium, 0.5 TBq/reactor/year for tritium gas;
- at about 12.5 GBq/reactor/year for liquid carbon 14 and 0.17 TBq/reactor/year for carbon 14 gas.

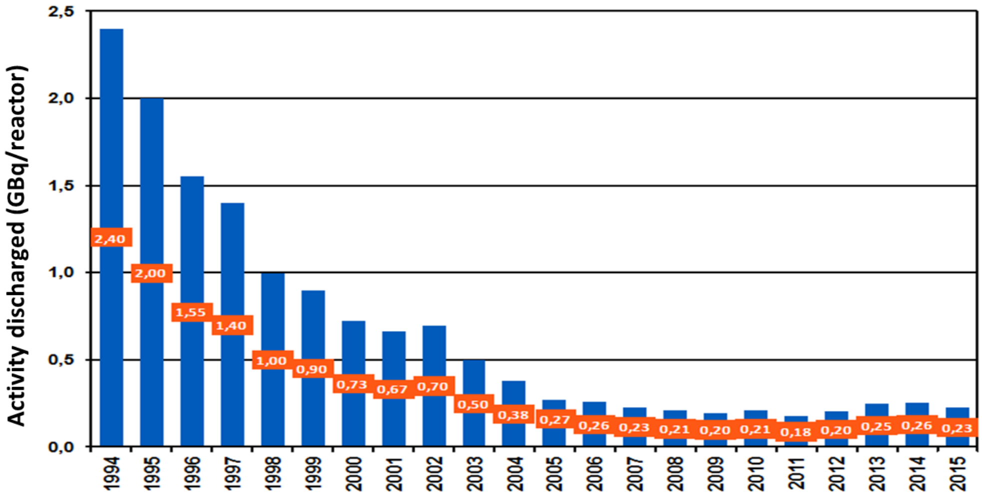


Figure 6 : Liquid discharges activity trends (excluding tritium and carbon 14) from 1994 to 2015

For 2014, the annual average discharge values of liquid and atmospheric radioactive effluents per reactor, all plant series included, were those given in the following table:

Activity released annually in GBq per reactor	Discharges of liquid radioactive effluents	Discharges of gaseous radioactive effluents
Carbon 14	12.9	170
Iodine	0.005	0.020
Tritium	17 700	500
PF-PA	0.3	0.002
Noble gas	Purposeless	600

Table 7: Average annual liquid and gaseous radioactive discharges per reactor

The dosimetric impact that can be attributed to discharges of radioactive effluents from the sites is today primarily that caused by tritium and carbon 14, two radionuclides with low radiotoxicity and for which there is at present no means of treatment appropriate to the activity of the effluents encountered on a site in operation. This dosimetric impact of about one µSv/year, is more than 2,000 times lower than the average dose that can be attributed to naturally occurring radiation alone in France (≈ 2 400 µSv/year on average). It should be noted that the impact due to these radionuclides is below the threshold of 10 µSv/year, a threshold below which a possible "health" risk is considered to be negligible by the international organisations (ICRP, IAEA[18]).

Figure 18 of § 4.1.3 in Appendix 4 (Environmental monitoring) gives figures for liquid and gaseous discharge from NPPs.

15.2.2.2 Environmental monitoring

In order to check on compliance with the regulatory provisions, EDF has set up a programme for environmental monitoring appropriate to each of its facilities. This programme, established in agreement with ASN, is conducted under the licensee's responsibility. It comprises a fixed programme of periodic measurements (daily to annual, representing more than 40,000 measurements per year for each NPP) directly related to the nature and frequency of the authorised discharges.

This regulatory monitoring is voluntarily supplemented by the licensee 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 an overview of the radiological environmental impact of our facilities in terms of both space and time. The sites also produce ten-yearly radio-ecological results comparable to the "zero point" benchmark produced prior to commissioning of the first reactor of a site:

- in the various matrices characterising the terrestrial environment (cultivated or other land, milk, freshwater (groundwater, drinking water, irrigation, etc.), traces of ^{137}Cs are observed throughout the territory. The activity levels measured are influenced by airborne nuclear weapons tests which

[18] IAEA Safety series 89, International Basic Safety Standards (IAEA 96); European Commission – Radiation Protection 113; Annals of ICRP – The scope of radiological protection regulation. 2006 Jack Valentin.

introduced ^{137}Cs (but also tritium) into the atmosphere, supplemented by the caesiums (^{134}Cs & ^{137}Cs) from the Chernobyl accident, which are continuing to decay. The contamination of the terrestrial environment by gaseous radioactive effluent discharges remains barely perceptible despite the very low detection limits of the analytical techniques used. Only the influence of discharges of carbon 14 can be detected. This is however very low, with an average difference of 2 to 3% (or about the same order of magnitude as the uncertainty) by comparison with areas not subject to the influence of the discharges.

- the continental aquatic environment of the French sites is characterised by the detection of traces of artificial radionuclides the origin of which can be traced to the fall-out from nuclear weapons atmospheric testing and the Chernobyl accident (^{137}Cs), to discharges from hospitals (^{131}I), to discharges of radioactive effluents from EDF sites and discharges of radioactive effluents from French or European nuclear facilities belonging to other licensees. The operation of EDF's NPPs occasionally contributes ^{14}C, ^{137}Cs, ^{60}Co and ^{58}Co and ^{3}H. It is however apparent that the activity of the gamma-emitting radionuclides fell by a factor of 10 between the 1990s and 2000s and has stabilised since then. An occasional increase in the free tritium activity (i.e. in the form of tritiated water) can be observed in the biological matrices, in parallel with the occurrence of a discharge carried out in accordance with the regulation limits.
- in the marine aquatic environment (5 of the 19 sites), analysis of the results obtained since the implementation of annual radio-ecological monitoring in 1992 reveals low activity levels but also an overall fall in the activity of artificial gamma-emitting radionuclides in all the matrices studied, in particular in the algae sampled from the environment near the coastal sites of northern France. The measurements taken show that the impact of the facilities is only perceptible in the near field owing to the radioactive effluent discharges licensed.

The analyses made of environmental monitoring, incorporating the results of the annual and ten-yearly radio-ecological monitoring, help confirm the very low environmental impact of radioactive effluent discharges from the sites and a general reduction in the activity of artificial gamma-emitting radionuclides measured in the monitored environmental matrices. These results, in association with the drop in discharges recalled above, are the environmental reflection of the quality of site operations and the steps taken by EDF to optimise effluent discharges and minimise their impacts, both on the environment and on humans.

15.3 Measures taken for research reactors

15.3.1 CEA reactors

Dedicated teams monitor the facilities, the CEA personnel and, outside normal working hours, provide a duty or on-call system.

Radiological monitoring of the personnel is performed on each site by specialised teams. The external and internal passive dosimetry results are transmitted to the SISERI system by the dosimetry organisations. Every employee intervening within a controlled area is also equipped with an individual dosimeter to ensure continuous and real-time tracking of any doses received; the results from these dosimeters are sent to the SISERI system by the PCR.

The employees of contractor companies are monitored by approved organisations, which issue them with passive dosimeters. This monitoring is supplemented by individual operational dosimeters that can be made available to these contractor employees by CEA.

On the basis of the principle of equivalence, CEA clarified the steps taken to organise the radiation protection of operations entrusted to outside contractors. For these operations with a risk of exposure to ionising radiation, the outside contractor designate a PCR, in compliance with the regulations. Moreover, during the operations in the facilities, the radiation protection of the contractor's staff is guaranteed by a certified radiation protection technician, provided by and acting under the responsibility of the contractor company.

The effectiveness of the system in place is demonstrated by the log of the doses received by the personnel in the facilities and the personnel from outside contractors over the past three years (2012, 2013 and 2014): for example, in 2014, no CEA employee was exposed to an annual whole-body dose of more than 5 mSv; the collective dosimetry over this period is about 0.3 h.Sv, for the CEA staff, the average individual external dose is 0.11 mSv for the CEA staff and 0.08 mSv for the staff of outside contractors (operational dosimetry).

The environmental monitoring programme is drawn up and performed on each site under ASN regulation.

For all the CEA research reactors, gaseous and liquid discharges remain low and in any case below the discharge licence limits.

15.3.2 The ILL high-flux reactor (RHF)

The radiation protection department providing ILL and personnel monitoring comprises 10 persons. Outside normal working hours, an on-call duty service is provided on the ILL site

The effectiveness of the overall radiation-protection system in place is demonstrated by the dose history of BNI personnel, researchers and staff from outside contractors: over the past three years (2013, 2014 and 2015), no employee received an annual dose in excess of 2 mSv and the total dosimetry (personnel, researchers, contractors) over this period is below 0.05 h.Sv, for more than 2000 people wearing a dosimeter, or an average individual dose of less than 0.025 mSv.

For the years 2013, 2014 and 2015, gaseous releases remains below 25% of the carbon 14 authorisation, were about 10 to 20% of the tritium and noble gases discharge authorisation and about 1% for the other categories of radionuclides.

Liquid discharges were 25% lower than the authorised limits for tritium and 20% lower than the authorised limits other radionuclide categories.

15.4 ASN analysis and oversight

15.4.1 Exposure of workers

15.4.1.1 ASN regulation

One of ASN's duties is to check compliance with the regulations relative to protection of workers liable to be exposed to ionising radiation in BNIs. ASN focuses on all workers active on the sites, both in-house and external contractor staff, for the entire operating cycle of the facility.

This regulation takes two main forms:

- performance of inspections:
  - specific radiation protection inspections, 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 head office departments in charge of radiation protection doctrine.
- 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;
  - The in-depth reviews carried out by IRSN at the request of ASN and the opinions submitted by the GPR.

15.4.1.2 Nuclear power plants

Every year, ASN presents EDF with its assessment of the radiation protection situation on the sites. This summary is a means of comparing ASN's analysis with that of the licensee and of identifying possible areas for progress.

Periodic meetings are also held to check the progress of technical or organisational projects being considered or actually being deployed.

In the light of ASN's various findings during these inspections and analyses of significant events, it considers that the radiation protection organisation defined and implemented by the NPPs is on the whole satisfactory. The collective dose on all the reactors fell slightly in 2015 by comparison with 2014. At the same time, the average dose received by workers for one hour of work in a controlled zone has been falling since 2013.

However, ASN considers that the average situation in the NPPs could be improved on a small number of points and that areas for improvement identified in recent years still need to be addressed.

ASN observes that the collective doses have reached a plateau of about 0.65 man.Sv per reactor, depending on the volume of maintenance work.

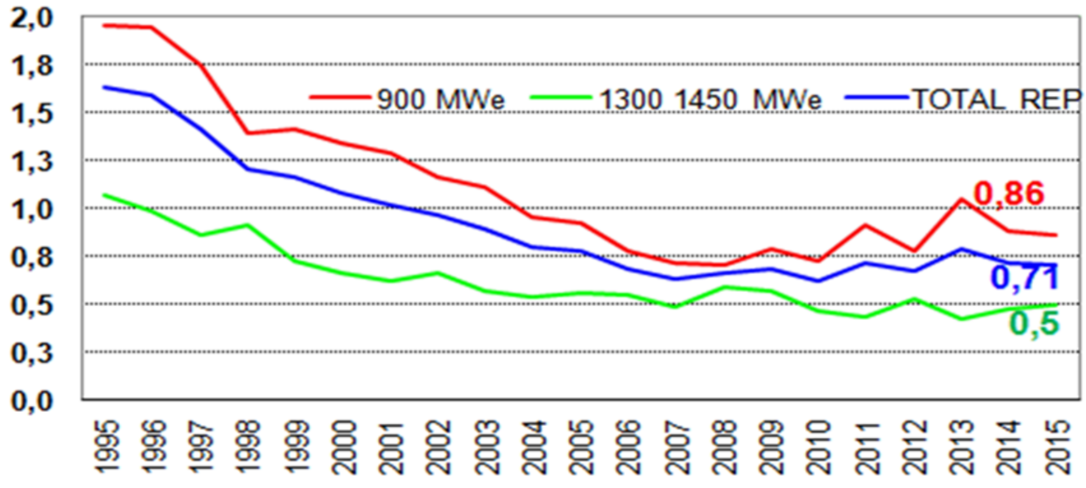


Figure 7: Mean collective dose per reactor (man.Sv per reactor)

In preparation for the project to renovate the major components of the NPPs, ASN considers that in its future reactor outage campaigns, EDF must increase its efforts to limit the expected rise in collective doses.

ASN considers that the average situation of the NPPs in 2015 concerning radiation protection could be improved on a small number of points:

- the management of industrial radiography worksites could be improved; ASN in particular observed two events in which the signs barring entry to operations areas were ignored. Progress is expected in the preparation of the worksites, more specifically the involvement of all stakeholders and the quality of the installation visits carried out when preparing these worksites;
- the management of contamination dispersal inside the reactor building is still insufficient, owing to inadequate worksite containment or contamination level signage errors. ASN repeatedly observes non-compliance with instructions for contamination checks on personnel exiting worksites, the lack of contamination inspection devices or devices that are unserviceable.

These inadequacies can contribute to delaying the detection of bodily contamination of the workers. ASN has observed numerous events relating to the failure of workers to wear individual dosimeters. The control of limited stay areas could still be improved further. ASN observes inadequacies in the identification and signposting of these areas.

15.4.1.3 Research reactors

At CEA, the organisation of radiation protection is dependent on application of the fundamental principles of radiation protection:

- justification of practices;
- optimisation of exposure levels;
- limitation of individual exposure.

As well as by:

- application of the principle of equity: for equivalent work, the distribution of individual doses must be equitable in order to minimise dosimetry disparities between the workers.
- application of the principle of equivalence: the radiological protection measures and the level of personnel monitoring are the same for all exposed workers (CEA and outside contractors).

The following table gives the external passive dosimetry results for staff subject to dosimetric monitoring.

	2012	2013	2014
Number of staff subject to dosimetric monitoring	7405	7310	7067
Dosimeters showing a dose < detection threshold	87%	89%	90%

Table 8: External passive dosimetry summary for the period 20012 – 2014

15.4.2 Exposure of the population and the environment

The monitoring of discharges and the environment around nuclear reactors is the responsibility of the licensee. The discharge authorisations stipulate minimum monitoring that have to be made by the licensee, in particular concerning effluents and environmental monitoring.

The results of regulatory measurements must be recorded in registers that are forwarded to ASN every month for monitoring purposes. With regard to the environment, they are also transmitted to the RNM (see § 15.1.2.2.2).

The results of nationwide radiological monitoring are published annually by IRSN. They are drawn up on the basis of IRSN's measurements and are published on the RNM website.

Moreover, the licensees regularly send liquid and gaseous radioactive effluent samples to IRSN for analysis. The results of these "cross-checks" are communicated to ASN.

Finally, ASN also carries out unannounced inspections. Since 2000, ASN carries out from 10 to 20 inspections with sampling per year (20 in 2012).

15.4.2.1 Monitoring of discharges in environment from NPPs

The nature of the environmental monitoring around the NPPs is presented in Appendix 4.

ASN completed its review of the effluent discharge and water intake files for the Belleville-sur-Loire and Cattenom NPPs in 2013 and those of Sain-Alban-Saint-Maurice, Saint-Laurent-des-Eaux and Bugey in 2014.

In 2014 and 2015, ASN reviewed the file concerning effluent discharges and water intake for the Chinon NPP and is continuing with its review of the files for Fessenheim and Cruas.

On all of these files, ASN ensured that discharge limits were set for these sites according to the best available techniques and taking account of experience feedback from the NPPs in operation.

15.4.2.2 Research reactors

With regard to the Marcoule site, the liquid discharges from the Phenix plant are currently being treated and discharged by the secret BNI (SBNI). In 2012, CEA was authorised to continue to discharge liquid and gaseous effluents and to intake and consume water for the operation of this Marcoule SBNI. For the Phenix plant decommissioning project, a file was presented to ASN to allow continued discharge of gaseous effluents and the transfer of liquid effluents to the SBNI. ASN completed its review in 2015 and in 2016 will set limit values and procedures for effluent discharge and water consumption.

The liquid effluents from the civil BNIs on the CEA site at Cadarache are transferred after treatment to a site installation classified on environmental protection grounds (ICPE). In 2015, CEA submitted a new file for continued water intake, discharge of gaseous effluents and transfers of liquid effluents for its Cadarache site. This file does not comply with the regulatory requirements and needs to be supplemented. ASN asked CEA to clarify and reinforce its organisation in order to take greater account of environmental aspects at the various stages in the life of these facilities (ten-yearly safety reviews, hardware modifications, etc.).

16. 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 General organisation for emergencies

The response organisation of the public authorities in the event of an incident or accident is defined by Prime Ministerial circular 5567/SG of 2nd 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 security.

Act 2004-811 of 13th August 2004 on the modernisation of civil security 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 a warning system. Several Decrees implementing this Act, codified in Articles L 741-1 to L 741-32 of the domestic security code, more specifically concerning the ORSEC plans and off-site emergency plans (PPI), clarified it in 2005.

The subject of radiological emergencies is clarified in the interministerial directive of 7th April 2005 on the action of the public authorities in the case of an event leading to a radiological emergency situation, which in particular describes the respective roles of the public authorities and the licensee.

Following the Fukushima Daiichi NPP accident, considerable thought was given nationally and internationally to consolidating and, as applicable, improving the response organisation measures adopted by the public authorities. This accident showed that it was necessary to improve preparation for the occurrence of a multi-faceted accident (natural disaster, accident affecting several facilities simultaneously), more specifically to be able to manage a large-scale emergency over the long-term. There must be greater anticipation of and preparation for interventions in a degraded radiological situation along with better international relations to enable effective support to be provided to the country affected.

At an international level, ASN is taking part in the experience feedback work being done by international bodies such as the International Atomic Energy Agency (IAEA), the OECD's Nuclear Energy Agency (NEA), or within regulator networks such as WENRA or HERCA, which are forums for the heads of European nuclear safety or radiation protection authorities.

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.

Independently of bilateral agreements on information exchanges in the case of an incident or accident with potential radiological consequences, France is committed to applying the Convention on early notification of a nuclear accident adopted on 26th September 1986 by IAEA and the Euratom decision of 14th December 1987 on community arrangements for the early exchange of information in the event of a radiological emergency. On 26th September 1986, France also signed the Convention adopted by IAEA on assistance in the event of a nuclear accident or radiological emergency.

Two interministerial directives of 30th May 2005 and 30th November 2005 specify the procedures for application of these texts in France and mandate ASN as the competent national authority. It is therefore up to ASN to notify the events without delay to the international institutions and the Member States, to rapidly provide the pertinent information for limiting the radiological consequences abroad and, finally, for providing the ministers concerned with a copy of the notifications and the information transmitted or received.

The HERCA/WENRA approach

During their joint meeting in 2014, the HERCA and WENRA associations adopted a common position aiming to improve cross-border coordination of protection measures during the first phase of a nuclear accident. The position of HERCA and WENRA aims, in the event of an accident, to promote the rapid transmission of information between the countries concerned and ensure consistency in the population protection recommendations issued by the nuclear safety and radiation protection authorities.

The approach thus recommends:

- outside emergency situations, exchanges between countries to promote improved mutual familiarity with and understanding of their emergency organisations;
- in an emergency situation:
  - 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 ensure alignment of the population protection measures in neighbouring countries with those decided on by the country in which the accident occurred;
  - in the even highly improbable situation which would require urgent measures to protect the population but in which very little information is available, predetermined "reflex" measures are defined.

In order to implement these principles, a minimum harmonised 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.

On this basis, the European safety and radiation protection authorities have been asked to initiate national level discussions with the authorities responsible for civil protection, with a view to implementing these recommendations. An evaluation of the implementation of this approach by the member States is to be presented to ENSREG in 2016. In France, work is in progress concerning the organisation of public protection measures in an emergency situation and their scope of application. The HERCA-WENRA approach was presented in this context within a working group in particular comprising the authorities In charge of civil protection.

Bilateral relations

Maintaining and strengthening bilateral relations with neighbouring and other European countries is one of ASN's major priorities.

In 2015, ASN thus continued regular exchanges with its European counterparts concerning the harmonisation of emergency management. Experience feedback from the Fukushima accident and the steps taken since then in each country were at the heart of the debate. Finally, in 2015, protocols concerning cross-border alert mechanisms and information exchanges in an emergency situation were signed with Belgium and Luxembourg.

ASN is continuing to develop bilateral relations in emergency management with many countries, Spain, Luxembourg, Germany, Switzerland and Belgium in particular. Meetings on specific emergency management topics were held with these five countries in 2015. In addition, Chinese and Japanese delegations visited ASN in 2015 for discussions on the management of emergency situations and took the opportunity to visit ASN's emergency centre. A United States delegation also took part in a national emergency exercise at ASN, as an observer.

Finally, during the course of 2015, the emergency exercise at the Gravelines NPP was able to test cross-border information exchanges in the event of an accident.

Multilateral relations

The Fukushima Daiichi NPP accident occupied a substantial amount of time for many of the ASN and IRSN staff, even though it was a remote accident for which the radiological consequences in France would appear to be limited. In addition, ASN’s actions were also limited, because it is not its responsibility to monitor the actions of the Japanese licensee.

This accident highlighted the problems that would be encountered by ASN, IRSN, but also their European counterparts, in managing a large-scale accident in Europe. The nuclear safety regulators confirmed the need for mutual assistance mechanisms and have already undertaken international work to improve their response organisations.

ASN and IRSN also take part in the IAEA's work to improve notification and information exchanges in radiological emergency situations. It participates in defining international assistance strategy, requirements and means and in developing the Response Assistance Network (RANET).

In addition to the four traditional committees which draft its safety standards, IAEA created a new committee in 2015 called EPReSC, to deal with emergency situations. The standards in this field had hitherto been monitored by the other existing committees. The most fundamental document in this field is the GSR Part 7, published in November 2015. The first meeting of the new committee was in early December 2015 and ASN represented France on it, with IRSN providing technical assistance.

ASN also collaborates with the NEA, under whose supervision it will organise the INEX 5 exercise in 2016 (with the participation of the various French emergency management players) and is taking part 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 Heads of European Radiological Protection Competent Authorities Association (HERCA). 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 accident. This group also comprises a number of members appointed by the European Nuclear Regulators Association (WENRA).

International assistance

The interministerial directive of 30th November 2005 defines the procedures for international assistance when France is called on or when it itself calls on assistance in the case of a radiological emergency situation. It requires that each ministry keep an up-to-date inventory of its intervention capabilities in terms of experts, equipment, materials and medical resources, and to communicate it to ASN. As coordinator of the national assistance resources (RANET database), ASN takes part in IAEA work devoted to the provision of international assistance, from the technical and operational viewpoints, with IRSN taking part in the RANET activities.

Since 2008, France has been called upon on several occasions to assist a foreign country in the context of a radiological emergency. For example, ASN has been contacted regularly in recent years for assistance requests concerning persons accidentally exposed to high-level radioactive sources.

16.1.1 Local organisation

Several players are authorised to take decisions in emergency situations:

- the licensee of the affected nuclear facility deploys the response organisation and the resources defined in its on-site emergency plan (PUI);

  NB: In 2015, ASN started work to draft a resolution concerning the obligations of the BNI licensees with respect to preparedness for and management of emergency situations and the content of the on-site emergency plan, in order to clarify the provisions of title VII of the Order of 7th February 2012 setting the general rules applicable to basic nuclear installations. This resolution, which should be approved in 2016, covers the use of human and material resources by departments over which it has no authority for the management of emergency situations.

- one of ASN's duties is to monitor the licensee's actions in terms of nuclear safety and radiation protection. In an emergency situation, aided by IRSN's assessments, it can at any time instruct the licensee to perform assessments and take the necessary measures;

- the Prefect of the *département* in which the facility is situated 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 disaster and emergency response organisation plans (ORSEC). As such, the Prefect is responsible for coordinating the public and private, human and material resources engaged in the PPI. He or she ensures that the populations and mayors are kept informed. Through its regional division, ASN assists the Prefect in drawing up the plans and managing the situation;

- IRSN mobilises the experts from its mobile unit, the size of which can be modulated in order to assist the public authorities with their decision-making. This implies deployment of resources in the field, but also the monitoring networks and laboratories;
- owing to his or her local role, the mayor has an important part to play in anticipating and supporting the population protection measures. To this end, the mayor of a *commune* included within the scope of application of an off-site emergency (PPI) plan must draw up and implement a local safeguard plan to provide for, organise and structure the measures to accompany the Prefect's decisions. The mayor also plays a role in passing on information and heightening population awareness during the iodine tablet distribution campaigns.

16.1.2 National organisation

In the event of a severe accident, an interministerial crisis committee (CIC) is set up. The relevant departments of the Ministries concerned, together with ASN, work together to advise both the Prefect at the local level and the Government, through the CIC, on the protective measures to be taken. They provide the information and advice to enable the state of the facility, the seriousness of the incident or accident, its possible developments, and the measures required to protect the general public and the environment to be assessed.

ASN in particular relies on its technical expert, IRSN, whose Emergency Technical Centre assesses the situation. Its experts propose and regularly update the diagnosis and prognosis of the damaged facility, the dosimetric impact of the accident and the radiological consequences for the populations and the environment.

The Prime Minister, who is responsible for managing any major emergency, activates the CIC and places it under the authority of the Minister for the Interior, to coordinate governmental action in the event of a radiological or nuclear emergency situation.

The CIC can comprise:

- **the Ministry for Health** (which ensures the health protection of individuals against the effects of ionising radiation);
- **the Ministry responsible for nuclear safety:** the Minister responsible for ecology takes part in national communication in the event of an incident or accident affecting a nuclear installation under his or her responsibility or occurring during the transport of radioactive materials;
- **the Ministry for foreign affairs:** is responsible, without prejudice to the responsibilities of ASN and the Ministry of the Interior, for transmitting information as necessary to the partner countries and the international organisations concerned. As required, with the support of ASN and IRSN, it also transmits the measures adopted with respect to protection of the populations to the French embassies abroad and the foreign embassies in France;
- **the Ministry for the Environment;**
- **the Ministry for Defence** through the Defence Nuclear Safety Authority (ASND) is the competent authority for monitoring the safety of secret basic nuclear installations (SBNIs), of military nuclear systems (SNM) and defence-related transport operations. ASN and the ASND signed an agreement on 26th October 2009 to coordinate their efforts in the event of an accident affecting an activity controlled by the ASND and to facilitate the transition from the emergency phase

managed by ASND to the post-accident phase which is the responsibility of ASN (this agreement is currently undergoing revision);

- **the General Directorate for Civil Security and Emergency Management** (DGSCGC) manages the Operating Centre for Interministerial Emergency Management (COGIC) and calls on the Nuclear Risk Management Aid Committee (MARN), which in particular ensures that the Prefect is provided with suitable material and human resources to protect the public and property;
- **ASN:** for management of radiological emergency situations. Its duties are detailed in § 16.2.

Other Ministries and administrations or establishments involved (such as IRSN, Météo-France), and the heads of the national nuclear licensees concerned (for example EDF, CEA or AREVA) as applicable. IRSN and Météo-France act as public expert appraisal organisations in a nuclear emergency situation.

16.1.3 The emergency plans

16.1.3.1 The BNI emergency and contingency plans

The PUI relative to accidents occurring at a BNI define the measures necessary to protect the site personnel, the general public and the environment, and to control the accident.

The purpose of the on-site emergency plan (PUI), drawn up by the licensee, is to bring the facility to a safe state and to mitigate the consequences of the accident. It describes the organisation and the means to be deployed on the site. It also includes the provisions for rapidly informing the public authorities. Pursuant to decree 2007-1557 of 2nd November 2007, the PUI is one of the items to be included in the file sent by the licensee to ASN prior to commissioning of its facility. The licensee's obligations in terms of preparedness and management of emergency situations are determined by the order of 7th February 2012 setting the general rules for basic nuclear installations (Title VII). These obligations will be clarified by an ASN resolution currently under preparation.

The off-site emergency plan (PPI) is drawn up by the Prefect of the *département* concerned, pursuant to decree 2005-1158 of 13th September 2005, "to protect the populations, property and the environment, and to cope with the specific risks associated with the existence of structures and facilities whose coverage area is localised and fixed. The PPI implement the orientations of the policy of emergency preparedness and civil protection in terms of mobilisation of resources, information, alert, exercises and training". This decree also clarifies the characteristics of the facilities or structures for which the Prefect is required to define a PPI.

The PPI specifies the first population protection measures to be implemented, the duties of the various services concerned, the alert broadcasting arrangements and the human and material resources likely to be engaged to protect the populations.

The PPI falls within the framework of the ORSEC system, which specifies 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.

More broadly, the interministerial directive of 7th April 2005 concerning the actions of the public authorities in the case of an event leading to a radiological emergency situation determines the framework of the organisation of the public authorities and the steps to be taken by the authorities in the case of an event liable to lead to a radiological emergency situation and to triggering of the ORSEC or PPI-ORSEC plan.

16.1.3.2 The “Major nuclear or radiological accident” national response plan

ASN took part in drafting the “Major nuclear or radiological accident” national response plan under the supervision of the General Secretariat for Defence and National Security (SGDSN), a department reporting to the Prime Minister. This plan, published in February 2014, describes the governmental organisation 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).

This national response plan takes account of changing modelling and measurement technology and is better able to anticipate the possible consequences of an accident, to mitigate them and measure their consequences more rapidly. It also includes elements of post-accident doctrine established by the CODIRPA, the international nature of emergencies and the mutual assistance possibilities in the case of an event.

In 2015, the local implementation of this plan began in the French *départements*, under the supervision of the defence and security zone Prefects. It must take account of the diversity of local situations and will first of all entail updating of the existing planning measures in accordance with the method proposed by the guide issued by the Ministry of the Interior at the end of 2014.

16.1.3.3 The response plans for radioactive substances transport accidents

Radioactive substance transport represents nearly a million packages carried in France every year. The dimensions, weight, radiological activity and corresponding safety implications can vary widely from one package to another.

Pursuant to the international regulations on dangerous goods, those involved in the transport of dangerous goods must take steps appropriate to the nature and scale of the foreseeable hazards, in order to avoid damage or, as applicable, to mitigate the effects. These steps are described in a management plan for events linked to the transport of radioactive substances. The preferred content of these plans is defined in ASN Guide No. 17 (see Appendix 2, § 2.3.4).

In order to deal with the eventuality of a radioactive materials transport accident in their *département*, each Prefect includes a part devoted to radioactive substances transport accidents in their implementation of the “Major nuclear or radiological accident” national response plan. Faced with the diversity of possible types of transport operation, this part defines the criteria and simple measures enabling the first respondents (departmental fire and emergency service (SDIS) and law enforcement services in particular) to initiate the first reflex response measures to protect the general public and sound the alert, based on their findings on the site of the accident.

16.1.3.4 The response to other radiological emergency situations

In addition to incidents which would affect nuclear facilities or a radioactive substances transport operation, the following radiological emergency situations can also occur:

- during operation of a nuclear activity for medical, research or industrial purposes;
- in the event of intentional or unintentional dissemination of radioactive substances into the environment;
- following the discovery of radioactive sources in places not designed to accommodate them.

It is then necessary to intervene to put an end to all risk of exposure of individuals to ionising radiation.

Jointly with the Ministries and respondents concerned, ASN drafted interministerial circular DGSNR/ DHOS/DDSC n° 2005/1390 of 23rd December 2005. This supplements the provisions of the interministerial directive of 7th April 2005 and defines the organisation of the State services for radiological emergency situations not covered by an Orsec, PPI-Orsec or PIRATE-NRBC (nuclear, radiological, bacteriological, chemical) plan.

Given the large numbers of those who could possibly issue an alert and the corresponding alert circuits, all the alerts are centralised in a single location, which then distributes them to the parties concerned: this is the fire brigade's centralised alert processing centre CODIS-CTA (operational *département* fire and emergency centre – alert processing centre), that can be reached by calling 18 or 112.

16.1.3.5 ASN's role in the preparation and monitoring of emergency plans

Review of emergency plans for nuclear facilities or activities

ASN reviews the on-site emergency plans before authorising the commissioning of basic nuclear installations or licensing the possession and utilisation of high-level sealed sources (article R.1333-33 of the Public Health Code), as well as the management plans for events linked to the transport of radioactive substances.

Participation in drafting of contingency plans

Pursuant to the decrees of 13th September 2005 concerning the PPI and Orsec plans, the Prefect is responsible for drafting and approving the off-site emergency plan (PPI). ASN assists the Prefect and, with the help of its technical support organisation IRSN, analyses the technical data to be provided by the licensees, in particular the nature and scope of the consequences of an accident.

Contingency plans such as the PPIs identify the population protection measures that mitigate the health and environmental consequences of a possible accident. The Prefect decides on the implementation of these actions on the basis of the predicted radiation dose that would be received by a one-year old child situated in the open air when the accident occurs.

The intervention levels associated with the implementation of population protection measures in a radiological emergency situation, mentioned in article R.1333-80 of the Public Health Code, are thus defined by ASN resolution 2009-DC-0153 of 18th August 2009:

- an effective dose of 10 millisieverts (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 time adopted for the calculation does not exceed one week.

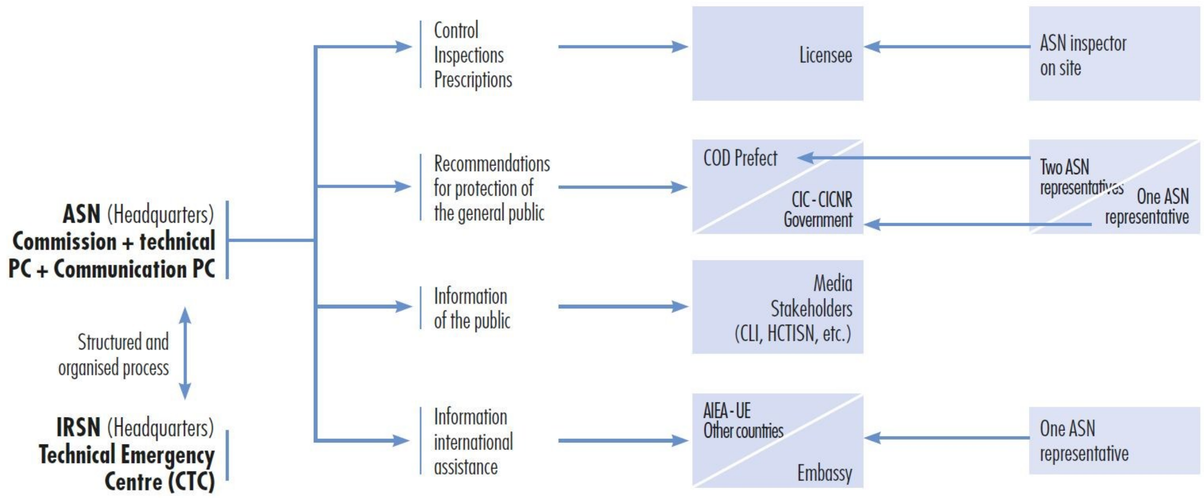
The Fukushima Daiichi NPP accident showed that a severe accident can have consequences that affect a radius of several tens of kilometres around an NPP. In France, PPI planning makes provision for civil protection of the population residing within a 10 km radius around the affected reactor in the initial hours of the accident. The effectiveness of this organisation thus requires the preparation and, as applicable, the implementation of measures beyond the PPI perimeter as part of the ORSEC planning process. ASN considers that it is today essential to continue with the harmonisation effort so that concrete results are achieved to ensure consistent population protection measures across Europe following an accident. An accident occurring in a European country could simultaneously affect several countries, which reinforces the need for effective cross-border coordination.

ASN also assists the General Directorate for Civil Security and Emergency Management (DGSCGC) at the Ministry of the Interior, in order to supplement the PPIs with regard to aspects relating to post-accident management.

16.2 ASN role and duties

In an emergency situation, ASN, supported by the IRSN, has the following duties:

- to oversee the steps taken by the licensee and ensure that they are pertinent;
- to advise the Government and its local representatives;
- to help disseminate the information;
- to act as competent Authority within the framework of the international agreements on early notification and assistance.



COD: Departmental Operations Centre
CIC: French Inter-ministerial Crisis Committee
CICNR: Inter-ministerial Committee for Nuclear or Radiological Emergencies
CLI: Local Information Committee
HCTISN: High Committee for Transparency and Information on Nuclear Security
PC: Command Post

Figure 8: The role of ASN in a nuclear emergency situation

16.2.1 Checking the measures taken by the licensee

In the same way as in a normal situation, ASN acts as the regulatory authority in an accident situation. In this particular context, ASN checks that the licensee is fully exercising its responsibilities to control the accident, mitigate its consequences and inform the public authorities rapidly and regularly. On the basis of IRSN's assessments, ASN can at any time instruct the licensee to perform assessments or take the necessary measures, without substituting itself for the licensee in the technical operations.

In 2016, ASN will continue its work to draft a resolution concerning the obligations of the BNI licensees with respect to preparedness for and management of emergency situations and the content of the on-site emergency plan, in order to clarify the provisions of title VII of the Order of 7th February 2012 setting the general rules applicable to basic nuclear installations. This resolution will cover subjects including accidents on a site comprising several nuclear facilities.

16.2.2 Advising the Government and the Prefect

The Prefect's decision on the population protection measures to be taken in radiological emergency and post-accident situations depends on the effective or foreseeable consequences of the accident around the site. 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.

16.2.3 Dissemination of information

ASN is involved in several ways in the dissemination of information:

- **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 and 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 bodies**.

16.2.4 Function of competent authority under the international conventions

The Environment Code requires that ASN fulfil the role of competent Authority under the international agreements on early notification and assistance. As such, it collects and summarises information in order to make or receive the notifications and transmit the information required by these agreements to the international organisations (IAEA and European Union) and to the countries concerned by potential consequences on their territory.

16.2.5 ASN Organisation

16.2.5.1 Preparedness for BNI accidents

The ASN emergency response organisation set up for an accident or incident in a BNI more specifically comprises:

- at the national level, an emergency centre in Montrouge, consisting of three command posts (PC):
    - a strategy command post, set up by the ASN Commission, which could be called on to issue resolutions and impose prescriptions on the licensee of the installation concerned in an emergency situation;
    - a technical command post (PCT) that is in constant contact with its technical support organisation - IRSN, and with the ASN Commission. Its role is to adopt positions to advise the Prefect, who is the emergency operations director;
    - a communication command post (PCC), situated close to the PCT. The ASN Chairman or his representative acts as the spokesperson, separately from the duties of head of the PCT.

This emergency centre is regularly tested during national emergency exercises and is activated for actual incidents or accidents.

- at the local level:
  - ASN representatives assisting the Prefect in his/her decisions and communications;
  - ASN inspectors present on the affected site.

More specifically in the event of accidents in a BNI, the IRSN's Technical Centre is activated. The IRSN experts regularly produce a detailed status of the facility and the probable development of the accident according to the operator's actions. They also assess the impact on the populations and the environment. IRSN also mobilises experts and resources in the field, monitoring networks and laboratories in order to consolidate the calculations of the radiological consequences for the population and the environment.

Experience feedback from the Fukushima Daiichi NPP accident also leads ASN to envisage sending one of its representatives, if necessary, to the French embassy in the country where the accident occurred. In this case, IRSN may be called on.

ASN's alert system allows rapid mobilisation of its emergency centre staff and the IRSN experts. This automatic system sends an alert signal to the staff equipped with appropriate reception devices, as soon as it is remotely triggered by the BNI licensee originating the alert. It also sends the alert to the staff of the DGSCGC, the interministerial emergency management operations centre (COGIC), Météo-France and the ministerial operational monitoring and alert centre of the Ministry of the Environment, Sustainable Development and Energy.

Figure 8 summarises the role of ASN in a radiological emergency situation. This functional diagram illustrates the importance of the ASN representative to the Prefect, who relays and explains the recommendations being sent by the ASN emergency centre.

	DECISION	ASSESSMENT	ACTION	COMMUNICATION
Public authorities	Government (CIC) Prefect (COD)	-	Prefect (PCO) Civil protection	Prefect (COD)
	ASN (Emergency Centre) and representative at Prefecture	IRSN (CTC) Météo France	IRSN (mobile units)	ASN IRSN
Licensees	National and local level	National and local level	Local level	National and local level

Table 9: positions of the various players in a radiological emergency situation

Table 9 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 public and media are given coherent information.

16.2.5.2 Preparedness for all other radiological emergency situations

A radiological emergency toll-free number (0 800 804 135) enables ASN to receive calls notifying incidents involving sources of ionising radiation used outside BNIs or during the transport of radioactive materials. It is accessible 24/7. The information given during the call is transmitted to the locally competent division or to the ASN duty staff outside working hours. Depending on the severity of the accident, ASN may activate its emergency centre in Montrouge. If not, only the ASN local level (division concerned) intervenes to provide its Prefect assistance and communication duties, if necessary calling on the expertise of the headquarters offices. In order to enhance the graduated nature of the ASN response and organisation in the event of an emergency, for situations not warranting activation of the emergency centre, the system has been adapted for the creation of a national level support unit to assist the division concerned. The format and duties of this unit are tailored to each situation.

Once the public authorities have been alerted, the response generally comprises four main phases: care for the persons involved, confirmation of the radiological nature of the event, safeguarding of the zone and reduction of the emission and, finally, clean-up.

The Prefect or the Mayor coordinates the response teams, taking account of their technical competence, and decides on the protection measures to be taken, on the basis of the plans they have drawn up (Orsec and PPI for the Prefects, local safeguard plans for the mayors). At the local level, the mayors can also call on the mobile radiological intervention units (CMIR) of the fire and emergency services.

In these situations, responsibility for decision-making and implementing the protection measures lies with:

- the head of the facility carrying out a nuclear activity (hospital, research laboratory, etc.) who implements the PUI stipulated in Article L. 1333-6 of the Public Health Code (if the risks presented by the facility so warrant) or the owner of the site with regard to the safety of persons within the site;
- the Mayor or the Prefect with regard to the safety of persons in areas accessible to the public.

16.2.5.3 Activation of the ASN emergency response centre in real situations

In 2015, the national emergency centre was activated for six national exercises as well as on three occasions when the licensee triggered the on-site emergency plan for the Cattenom NPP on 28th May 2015, the Flamanville NPP in the night of 26th August 2015 and the former Brennilis NPP decommissioning site on 23rd September 2015. These three real situations led to no releases of radioactive substances. In all three cases, the licensees brought the situation under control within a few hours, which meant that ASN was able to authorise them to lift the PUI. The ASN emergency centre was also activated for several hours in standby mode, for an event in the Flamanville NPP in the evening of 9th October 2015.

Since 2013, the emergency response centre has been deployed in real emergency situations on several occasions, the details of which are given in the following table:

Date	Site	Alert	Event
15th July 2013	Tricastin NPP	General	Intrusion by Greenpeace militants
18th March 2014	Fessenheim NPP	General	Intrusion by Greenpeace militants

28th May 2015	Cattenom NPP	General	Valve leak creating a pressure difference between the steam generators.
26th August 2015	Flamanville NPP	General	Release of smoke in the NAB (nuclear auxiliaries building) of shut down reactor 2. The installation concerned carries out treatment of radioactive effluents.
23th September 2015	Brennilis	By telephone because BNI without PPI	Fire in reactor undergoing decommissioning during waste cutting.

Table 10: Activation of the ASN emergency response centre in real situations

On the occasion of ASN's relocation to new premises in 2013, the emergency response centre was modernised, in particular taking into account ASN's internal experience feedback on its organisation during the Fukushima Daiichi NPP accident.

The emergency centre is connected not only to the public telephone network but also to several independent restricted-access networks that provide direct or specific secured lines to the main nuclear sites. ASN's PCT also has a videoconference system that is used chiefly to communicate with IRSN's emergency technical centre (CTC). It also uses IT equipment tailored to its functions, in particular to transmit technical information from IRSN (continuous environmental radioactivity monitoring) and exchange information with the European Commission and the Member States (WebECURIE, USIE).

16.3 Role and organisation of the reactor licensees

16.3.1 Role and organisation of EDF

16.3.1.1 Organisation

The emergency response organisation adopted by EDF as the nuclear operator fully meets the objective of covering situations presenting a significant risk for the safety of the facilities, and which can lead to releases of radioactive substances into the environment.

Outside this area, there are also many situations at an installation that require a rapid response.

Consequently, the following areas are covered by the emergency organisation:

- situations triggering the PUI (safety and radiological emergency, management of a multi-unit reactors accident …);
- the other situations covered, for which an appropriate internal organisation (Support and Mobilization Plan) must be set up in advance in order to prevent the development of an emergency and to provide a suitable response, by bringing together the necessary and appropriate resources for the situation, such as:
    - accidents with injuries and/or in the event of fire. In this case, the first actions are dependent on the teams from the 24-hour duty services. The external emergency services are always called before this plan is implemented;

- certain situations such as climatic or man-made external hazards.

The emergency organisation adopted by EDF since the start of operation of its NPP fleet to cope with such situations is based on human and material resources that can be mobilised 24 hours a day and 7 days a week, if an NPP calls the national emergency situation director.

The emergency organisation deployed following triggering comprises a national level and a local level. This organisation is structured in teams (or command posts - PC) covering the four broad areas for crisis necessary for emergency management (appraisal, decision, action and communication).

EDF's emergency structure and the missions of the different units are described below:

At local level

The unit manager or his/her representative is responsible for managing the emergency response. The emergency response manager directs the local strategic management command post (PCD) and ensures the implementation of the PUI.

Restoring the situation is primarily the responsibility of the operating team in charge of the affected reactor, which constitutes the local command post (PCL), under the responsibility of the shift operations supervisor in charge of the operating manoeuvres in accordance with the procedures in force.

The local PCD is assisted by two appraisal teams:

- the local emergency response team (ELC), more specifically in charge of the analyses of 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.

All the technical information concerning the installation is sent to the local emergency response team (ELC), while the technical information concerning environmental monitoring is available at the PCC.

Environmental monitoring in accident situations is based largely on the monitoring resources used during normal operation (namely a network of radiation detectors and laboratory vehicles equipped with measuring and sampling equipment).

Meteorological data are provided by the weather station situated on or near the site.

In accordance with the specific agreement between EDF, ASN and IRSN, these two teams – ELC and PCC – 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 local PCD is also assisted by a resources command post (PCM), whose mission is to ensure all logistic actions on the site for managing the emergency. Its actions also cover the following areas:

- personnel protection and the management of assembly points;
- management of telecommunications for all the PCs;
- organisation of work and specific tasks on equipment, and;
- logistic support to external emergency services and to emergency-response teams.

At national level

The national strategic management command post (PCD-N) is directed by the head of the DPN (EDF's nuclear operations division); Working in permanent contact with the local PCD, 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 Executive Board, to the national public authorities and to other NPPs.

The PCD-N is in contact with the Executive Board of the EDF group which can also mobilise its emergency management unit. It is also in contact with the experts of the national emergency technical team (ETC-N).

The ETC-N has two main missions:

- providing technical support to the PCD-N which consists in giving an analysis of the situation and a prediction of how it will evolve. In continuous contact with the local emergency response team and the IRSN emergency response team, it compares its results to supplement the PCD-N's information;
- providing on-site technical assistance in collaboration with the ELC and the PCC. The ETC-N issues opinions and recommendations for the management of the installation and in respect of environmental aspects.

The telecommunications resources available to those involved are an essential aspect of the organisation. Installation status parameters are relayed to the emergency response teams by automatic means and by telecommunication means. The information exchanged between the various command posts (PCs) is supported by a telephone network dedicated to EDF and the emergency situations, thereby guaranteeing that the networks do not become saturated.

The response to an emergency situation requires appropriate mobilisation, ranging from customised mobilisation to automatic mobilisation both locally and nationally.

In the NPP, 24h/24 and 365 days per year, the emergency organisation must be operational within 1 hour and mobilise 70 people.

At the national level, the National Emergency Organisation must be operational in its Paris premises within two hours, mobilising 50 people and alerting 300 others.

In addition to the premises used by the emergency teams, the sites have assembly stations (LR) in which the personnel assembles if the PUI is triggered, and a fallback centre, located off the site and not under the prevailing winds, to accommodate the persons present on the site at the time of the accident in order to protect and inform them. Application of the procedures by the operators in the control room remains possible in the event of an external hazard (earthquake, flooding), as the control room is robust to the design-basis hazards. The emergency management centre will be replaced by a local emergency management centre protecting firstly the emergency response protagonists and their equipment against the hazards targeted by the stress tests, and secondly the persons involved if there is a problem of radioactivity on the site.

In the event of total loss of the electrical power supply, the required actions in the facilities will have to be rendered secure, particularly if building lighting is lost. Specific intervention means are currently being acquired by the sites.

The procedures put in place for the management of severe accidents, the training and the exercises form part of the Severe Accident Management Guidelines (SAMG) and baseline requirements of the PUI of the sites.

The skills and capabilities of the persons and organisations involved are maintained by training and by performing periodic exercises. To this end, exercises are performed regularly. The internal PUI exercises held by EDF cover all the domains, including design accidents, fuel building (BK) incidents and severe accidents.

Experience feedback from actual emergency situations and all the exercises is used to improve emergency preparedness and the emergency response organisation, as well as the necessary coordination between the public authorities and the licensee.

EDF continues its analysis of the sizing of the operating teams for application of the current severe accident management procedures, particularly for events affecting several reactors, postulating in particular the impossibility of the on-call response teams getting to the site during the first 24 hours following an unpredictable large-scale hazard affecting the entire site. Further to these analyses, the sizing of the operating teams in conformity with the current baseline requirements will have to be adapted to the implementation of the hardened safety core equipment.

16.3.1.2 Setting up of the Nuclear Rapid Intervention Force (FARN)

The emergency baseline requirements incorporated experience feedback from the accident in the Fukushima Daiichi NPP in late 2014, taking account of extreme situations and local disaster situations by deploying the FARN, the rapid response force situated at a distance from the site and permanently on-call to assist the shift crew.

The FARN is a national EDF entity which is part of EDF's emergency organisation and capable of rapidly providing material and human aid to a site in difficulty, following the decision of the national emergency director (PCD-N). The FARN is now fully operational for the entire EDF NPP fleet.

Thus, in accordance with the ASN prescriptions, the FARN can now:

- intervene within 24 hours, to assist the site crews that will have carried out the emergency measures for the site concerned, for which the access infrastructures may be partially destroyed;
- work autonomously for several days on a partially destroyed site (non-seismic-design tertiary buildings, for example), whose environment could be radioactive, and - on some sites - possibly affected by chemical pollution;
- deploy heavy-duty protection or intervention means within a few days;
- ensure a permanent link with site management and teams;
- prepare for continuation of the intervention beyond the first days of autonomy in the event of a long-duration emergency.

16.3.2 Role and organisation of the CEA

The CEA’s emergency organisation forms part of the general organisation described in § 16.1.

If an emergency occurs at an installation operated by the CEA, an emergency response organisation is set up to supplement the arrangements made by the public authorities.

As shown in the diagram in § 16.2, the CEA plays a role at local and national level.

The site affected by the emergency (local level):

- manages the response inside the establishment;

- 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 and with IRSN emergency technical centre.

The CEA's administration (central level):

- directs the 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 national levels are assisted respectively by a local strategic management command post (PCD-L) and an emergency coordination centre (CCC).

- the PCD-L is under the responsibility of the director of the centre or his/her representative. It comprises a decision-making unit, a local technical emergency team (ETC-L), a control team, an operational team, a communications unit and a press unit;
- the CCC is under the responsibility of the general administrator of the centre or his/her representative. It comprises a decision-making unit, a central emergency technical team (ETC-C), a communications unit and a press unit.

The communication and press units, in agreement with the PCD-L or the CCC, prepare press releases, answer external calls and manage interviews.

It is the responsibility for the director of the site or his/her representative to assess the seriousness of the event, based on predetermined criteria for triggering the PUI and determining its level.

In the case of an important event, the initial notification is given to the CEA’s 24-hour alert organisation.

Depending on the severity of the event, the General Administrator or his/her representative may decide to activate the CCC.

As indicated in § 14.2.3.1, stress tests have also been carried out on the general emergency response resources for the Marcoule and Cadarache centres further to the Fukushima Daiichi NPP accident.

The Marcoule centre has an emergency management centre whose functions are preserved, including in the event of the seismic hazard considered for the "hardened safety core". The Cadarache centre will be equipped with a new building housing the local command post (PCL).

For the two centres, complementary measures are envisaged with regard to:

- fire-fighting water reserves,
- fuel reserves,
- means of preventing the flood risk,

The stress test report for the Saclay centre was submitted to ASN in June 2013.

After analysis, ASN issued additional prescriptions in early 2016. With regard to Organisational and Human Factors, the content of the training courses and the operational documentation will be adapted to consolidate the preparation for and training in emergency management situations further to the stress tests.

16.3.3 Role and organisation of the Institut Laue-Langevin (ILL)

The ILL emergency organisation forms part of the general organisation described in § 16.1.

If an emergency occurs at an installation operated by ILL, an emergency response organisation is set up to supplement the arrangements made by 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 for the site affected by the emergency, in collaboration with the prefecture;
- is responsible for relations with the prefecture and with the IRSN emergency 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 centre (ETC), a technical command post (PCT), a communications unit (delegated to communication 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 queries from outside.

It is the responsibility of the Head of the Reactor Division or their representative to assess the seriousness of the event, based on predetermined criteria for triggering the PUI, and to determine its level.

The ILL is equipped with an emergency control station (PCS) which remains functional even in the event of the seismic, flooding and chemical hazards considered for the “hardened safety core”.

The ILL ECS was transmitted to ASN in September 2011. After analysis, ASN issued prescriptions in July 2012. The principles adopted are mainly the deployment of redundant prevention and mitigation systems, along with a command post and reinforced organisational measures to allow management of all types of emergencies. 80% of these prescriptions have now been met. The work will be completed in 2017 with the commissioning of the additional cooling systems.

16.4 Emergency exercises

16.4.1 National nuclear emergency exercises

Jointly with the SGDSN, DGSCGC and 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.

Generally speaking, these exercises enable the highest-level decision-making circles to be tested, along with the ability of the leading players to communicate, sometimes with simulated media pressure on them.

For example, table 11 describes the main characteristics of the national exercises carried out in 2015.

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 performance of a national nuclear and radiological emergency exercise, at maximum intervals of 5 years on the nuclear sites subject to a PPI, and at least one annual exercise concerning the transport of radioactive substances, would seem to be a fair compromise between the training of individuals and the time needed to effect changes to organisations.

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.

In 2015, the objectives chosen in the annual instruction of 15th December 2014 concerning the national nuclear or radiological emergency exercises include:

- testing of international relations;
- setting up an organisation to simulate the Government level;
- holding exercises in real meteorological conditions as often as possible;
- testing the response plan for a major nuclear or radiological accident and implementing it if effective.

With regard to the nuclear safety aspects, the main objectives were:

- to continue to train experts with a focus on technical aspects;
- to carry out an exercise involving several installations on the same site;
- to bring in the licensees' national response forces as stipulated by the statutory resolutions;

With regard to civil security aspects:

- on the occasion of the exercises, to develop the ties between the authorities of the Prefect and the local authorities;
- to promote greater anticipation of civil protection measures to ensure protection of the population;
- to implement and coordinate thematic workshops separated from the technical scenario.

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 authorities (IAEA, European Commission, Nuclear Energy Agency - NEA);
- the Ministries (Health, Interior, etc.).

F – Safety of installations – Articles 17 to 19

With regard to defence-related installations, two exercises were organised by the ASND in 2015, in compliance with the interministerial instruction. One of them was carried out jointly with ASN, as it concerned several installations, both civil and defence-related, on the same site.

Pursuant to the ASN/ASND protocol of 26th October 2009, ASN takes part in some of these exercises:

- in the ASND national emergency centre: an ASN representative goes to the ASND's emergency centre to act as the interface between ASN and the ASND, to advise the ASND on aspects relating to the environmental impact of releases and to prepare for post-accident management of the emergency by ASN;
- in the prefecture: a representative of the ASN division concerned goes to the prefecture to advise the Prefect pending the arrival of the ASND's representative.

The ASN personnel draw on the experience acquired during these many exercises in order to respond more effectively in real emergency situations. Thus, during the real situations in 2015 concerning the NPPs of Flamanville and Cattenom, the organisation set up among all the stakeholders, who had become used to cooperating with each other during the exercises, was found to be efficient and effective.

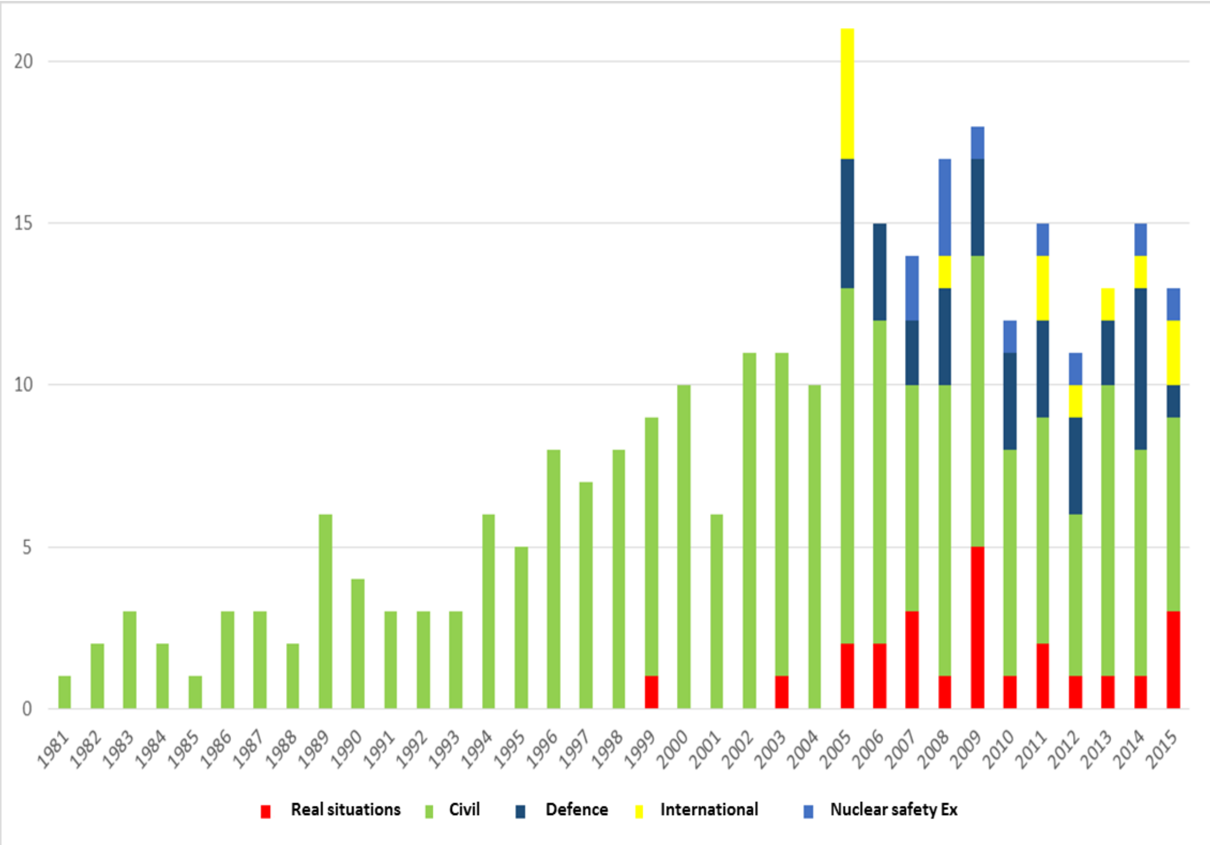


Figure 9 : Number of exercises and emergency situations

Nuclear site	Date of exercise	Main characteristics
Gravelines NPP	10th February 2015	Health aspect, post-accident aspect Involvement of SEVESO industrial firms Inter-*département* and inter-region aspect (exchanges with Belgium, etc.)
Chinon NPP	28th May 2015	Alert aspect Protection of populations aspect
Cadarache Site	23rd June 2015	Events simultaneously affecting several BNIs and SBNIs on the same site Deployment of means from another CEA site Definition of an environment measurements strategy and output of results
Civaux NPP	22nd September 2015	Tests to check understanding of instructions by the public Activation of the general public information unit Communication aspect
Transport of radioactive substances (Doubs)	1st October 2015	Organisation of radiological emergency management in a *département* without a nuclear facility Communication aspect
Penly NPP	13th October 2015	Activation of the PPI reflex phase Inter-communes dimension

Table 11: Main characteristics of the national exercises carried out in 2015

Evaluation meetings are organised immediately after each exercise in each emergency centre and at ASN a few weeks after the exercise. Along with the other players, ASN endeavours to identify the 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.

Twice a year, ASN also brings all the players together to review best practices in order to improve the response organisation as a whole. These meetings enable the players 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.

Of the objectives identified, some will be mentioned in the 2016 interministerial instruction on exercises:

- test the regional implementation of the national plan for response to a major nuclear or radiological accident, in particular in all the *départements* which do not contain a nuclear facility (half-day “transport” exercises);
- prepare the Prefectures for implementing public protection measures or post-accident actions, by following up slow-development accident exercises with a phase focusing on civil security;
- test the ability of the entities involved to provide the interministerial level with information linked to the national plan for response to a major nuclear or radiological accident, on the occasion of the SECNUC major exercise;
- involve the Prefects of the defence and security zones in certain exercises.

The exercises and the actual situations which occurred have demonstrated the importance of communication in emergency situations, particularly to inform the public and foreign authorities sufficiently early and avoid the spread of rumours that could lead to movements of panic in the population, both in France and abroad.

16.4.2 International exercises and cooperation

ASN maintains international relations in order to exchange the good practices observed during exercises held in other countries. Thus, during the course of 2013 and 2015, ASN therefore:

- took part in 2013 in the organisation and holding of the three-nation exercise simulating an accident on the Cattenom NPP site and involving Luxembourg, Germany and France. This exercise was the 3rd phase of a large-scale exercise, the first two phases of which were carried out in 2011 and 2012, coordinated by Germany and Luxembourg respectively;
- received foreign delegations attending exercises organised by France as observers;
- participated as an observer in many exercises organised by foreign safety authorities.

ASN is a member of the IAEA’s National Competent Authorities Co-ordination Group (NCACG) and notably participated in the work aiming at implementing an action plan by competent authorities to improve international information exchanges in the event of a radiological emergency. ASN also plays an active part in the “ConvEx” exercises held by IAEA pursuant to two international conventions, one on notification and the other on assistance, in the event of a radiological or nuclear emergency.

In addition, with regard to international assistance, ASN has set up data bank listing all the technical and human resources available in the event of an accident or radiological emergency and, since August 2008, it is one of the competent authorities having registered the French means of international assistance with the Response Assistance Network (RANET). ASN is involved in defining the strategy for international assistance needs and resources, and in the development of RANET.

16.5 Developments in nuclear emergency management

The steps to protect the populations that can be taken during the emergency phase, as well as the initial actions as part of the post-accident phase, aim to protect the populations from exposure to ionising radiation and to any chemical and toxic substances that may be present in the releases. These actions are part of the PPIs.

16.5.1 Population protection measures

In the event of a severe accident liable to lead to releases, a number of preventive measures can be considered by the Prefect in order to protect the population:

- sheltering and waiting for 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: when ordered by the Prefect, the persons liable to be exposed to releases of radioactive iodines are instructed to take the prescribed dose of potassium iodide tablets;
- evacuation: in the event of an imminent threat of large-scale radioactive releases, the Prefect may order evacuation. The populations are then asked to prepare a bag, secure their home, leave it and go to the nearest assembly point.
- In the event of actual release of radioactive substances into the environment, measures are taken to prepare for management of the post-accident phase; they are based on the definition of area zoning to be implemented on exiting the emergency phase and including:
  - a population protection zone (ZPP) within which action is required to reduce both the exposure of the populations to ambient radioactivity and the consumption of contaminated food to a level that is as low as reasonably achievable (ALARA);
  - a heightened territorial surveillance zone (ZST), which is larger and more concerned with economic management, within which specific surveillance of foodstuffs and agricultural produce will be implemented;
  - if necessary, an evacuation zone is created within the population protection zone, defined according to the ambient radioactivity (external exposure). The residents must be evacuated for a length of time that will vary according to the level of exposure in their living environment.

16.5.2 Stable iodine tablets

Taking stable iodine tablets is a means of saturating the thyroid gland and protecting against the carcinogenic effects of radioactive iodines.

The circular of 27th May 2009 defines the principles governing the responsibilities of a BNI licensee and of the State with regard to the distribution of iodine. The licensee has responsibility for the safety of its facilities. 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.

In 2016, a new national campaign for the distribution of iodine tablets, supervised by ASN, concerns the populations situated in the zone covered by the PPIs around the NPPs operated by EDF and other nuclear facilities liable to release radioactive iodine in the event of a severe accident (Saclay site, Cadarache site, ILL in Grenoble for example). The aim of this distribution is to ensure that as high a proportion of the population as possible is covered, but also to make the populations and the local elected officials (mayors) aware of the potential risk and the instructions to be followed when necessary, through specific communication media and local information meetings initiated in the second half of 2015.

Outside the area covered by the PPI, stocks of tablets are constituted to cover the rest of the country. In this respect, the Ministries in charge of health and the interior decided to create stocks of iodine tablets, positioned and managed by the health emergency preparation and response organisation (EPRUS). Each Prefect organises the procedures for distribution to the population in their own *département*, relying in particular on the mayors for this. This arrangement is described in a circular dated 11th July 2011. Pursuant to this circular, the Prefects have drawn up plans to distribute iodine tablets in a radiological emergency situation, which can involve exercises being held for the local implementation of the major nuclear or radiological accident national response plan.

16.5.3 Care for contamined persons

In the case of a radiological emergency situation, a large number of persons could be contaminated by radionuclides. This contamination could make it difficult for the emergency response teams to provide the necessary care.

Circular 800/SGDN/PSE/PPS of 18th February 2011 specifies national doctrine for the use of emergency response and care resources in the face 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 would need to be adapted to the specific situations encountered.

The "Medical intervention in the case of a nuclear or radiological event" guide, published in 2008 and the drafting of which was coordinated by ASN, accompanies circular DHOS/HFD/DGSNR n° 2002/277 of 2nd May 2002 on the organisation of medical care in the case 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. Under the supervision of the SGDSN, a working group comprising the authors of this guide was set up at the end of 2015 to begin its revision in order to take account a number of changes to practices that have taken place since 2008.

16.6 Understanding the long-term consequences

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 varied 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 conditions for reimbursement for the damage resulting from a nuclear accident are currently covered by Act 68-943 of 30th October 1968, amended, concerning civil liability in the field of nuclear energy. France has also ratified the protocols signed on 12th February 2004, reinforcing the Paris convention of 29th July 1960 and the Brussels convention of 31st January 1963 concerning civil liability in the field of nuclear energy. These protocols and the measures necessary for their implementation are now codified in the Environment Code (Section I of chapter VII of Title IX of Book V). The energy transition for green growth Act (TECV Act) of 17th August 2015 makes provision for the entry into force in February 2016 of these provisions and of new liability thresholds set by the two protocols, without waiting for their ratification by all the signatory States.

Pursuant to the Interministerial Directive of 7th April 2005, and in association with the ministerial departments involved, ASN was tasked with establishing the framework, and defining, preparing and contributing to implement the necessary provisions in response to post-accident situations following a nuclear accident. In order to draw up the corresponding aspects of doctrine, ASN in June 2005 created the steering committee for managing the post-accident phase of a nuclear accident or radiological emergency situation (CODIRPA). Post-accident management of a nuclear accident is a complex subject involving numerous aspects and players. The response must benefit from a pluralistic structure which in particular involves all the stakeholders involved in the preparation of post-accident management.

In November 2012, ASN sent the Prime Minister elements of the doctrine drafted by the CODIRPA, covering the emergency exit, transition and long-term phases, accompanied by an opinion from the ASN Commission. These elements were then posted on http://www.french-nuclear-safety.fr/ and widely circulated at the local, national and international levels.

In its opinion, the Commission considers that drafting and publishing the first elements of the doctrine is a first and important step in preparing for post-accident management and underlines the importance of continuing with and intensifying the implementation process.

The CODIRPA, coordinated by ASN, carries out work to take account of the lessons learned from the post-accident management carried out in Japan in the wake of the Fukushima Daiichi disaster, but also to ensure support for the preparatory work to be organised at the regional level. Whereas thought has so far only been given to accidents with releases on a moderate scale and of short-duration, this has now been expanded to consider the management of the consequences of an accident with long-duration releases.

In this context, three orientations were adopted:

- test and supplement the elements of doctrine with respect to the different accident situations;
- assist with regional implementation of the elements of post-accident management;
- participate in the international actions on the post-accident theme, share and take into consideration the results of these actions.

In 2015, the new duties of the CODIRPA, officially laid out in a letter from the Prime Minister on 29th October 2014, giving ASN a new five-year mandate, focused on watching over, supporting and analysing the various post-accident preparation processes with the aim of periodically proposing updates to the doctrine.

Three working groups were set up in 2014, one concerning long-duration releases doctrine, another concerning the involvement of the regional stakeholders in preparing for post-accident management and the third on the involvement of the health professionals. The working group for long-duration releases submitted its report in 2015.

In conjunction with the experience feedback from the Fukushima Daiichi NPP accident, a new working group was set up in 2015 on waste management in a post-accident situation, involving members of the CODIRPA and of the National Radioactive Materials and Waste Management Plan (PNGMDR). Furthermore, subjects for which more detailed doctrine will be envisaged in 2016 have already been identified. These mainly concern the management of manufactured products, management of water and marine environments, and radiological measurements in a post-accident situation.

The report from the pluralistic seminar on the economic assessment of the nuclear accident risk organised by ASN in October 2014 was released in 2015. ASN initiated the necessary steps to promote the development of research on this subject, nationally and internationally.

F – SAFETY OF INSTALLATIONS

17. 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 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 ASN requests

17.1.1 Evaluation of relevant site-related factors

Section 7.2 specifies the different authorisation procedures in effect for the creation, commissioning, modification, shutdown and decommissioning of a BNI.

Well before applying for a BNI creation authorisation, the prospective licensee must inform the administration of the site(s) on which it plans building the installation. ASN analyses the safety-related characteristics of the sites: seismicity, hydrogeology, industrial environment, cold water sources, etc. The characterisation of the risks associated with the site and the design of the installations to counter these risks form the subject of basic safety rules (RFS – see Appendix 2, § 2.3).

The safety options, which include the accident and hazard situations considered in the design and the methods of dealing with them must then be presented in the preliminary safety report.

The stress tests carried out further to the Fukushima Daiichi NPP accident concerned all the French nuclear installations (see § 14.2.1.6). The assessment have supplemented the initial assessments with a characterisation of the extreme natural phenomena and their effects on the safety of the installations. The case of multiple accidents was also studied.

17.1.2 Evaluation of the impact of a BNI on the local population and the environment

As indicated in § 7.2.2, the BNI creation authorisation application is accompanied by a file comprising a number of items, including the impact study and the risk control study.

17.1.3 Reassessment of the relevant factors

The external hazards are reassessed in the periodic safety reviews conducted every 10 years. The ASN resolution relative to the BNI periodic safety reviews will specify that at each review the licensee will reassess the intensity of the external hazards considered in the nuclear safety demonstration of the installation, along with their frequency of occurrence in the light of any new knowledge.

The external hazards, particularly earthquakes and flooding, were the subject of a targeted review as part of the stress tests (see § 14.1.4.2).

17.1.4 Consultation of neighbouring countries

In application of the regulations, authorisation to create a BNI cannot be granted until the European Commission, including the neighbouring countries in particular, has been consulted (see § 7.2.5).

ASN associated the civil society in the stress tests and the corresponding targeted inspections. Foreign experts were thus able to participate in inspections and meetings of the GPE.

17.1.5 Public consultation

In application of articles L. 121-1 and following 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 (excluding nuclear power production) involves an investment cost exceeding €300 M. The public debate focuses on the appropriateness, the objectives and the characteristics of the project. Furthermore, as indicated in § 7.2.3, the BNI creation authorisations and the decommissioning decree are issued following a public inquiry.

A public debate was held in 2010 before taking the decision to build an EPR nuclear reactor at Penly. Smaller-scale projects can also give rise to a "local consultation" approach. This was the case for example in 2005 with the Jules Horowitz research reactor (RJH) project on the CEA Cadarache site.

For the other resolutions which are not subject to public inquiry (or public debate), and if these resolutions could have a direct and significant impact on the environment, the draft resolutions are made available for consultation by the public who can express their observations and proposals. This procedure involves firstly making the file submitted by the licensee available to the public, and secondly consultation of the public on the draft resolution produced by ASN.

With regard to the stress tests and the targeted inspection campaigns, ASN involved the CLI (see § 8.2.4) in the inspections and members of the HCTISN (see § 8.2.3.1) in the meetings of the GPE.

17.2 Measures taken for nuclear power reactors

The safety analysis reports (SAR) feature a "Site and Environment" chapter that covers the following themes: industrial environment and communication routes, population, meteorology, geology, hydrogeology, radiological situation, natural environment and rural economy.

By examining these themes, the relevant site-related factors that could affect the safety of the installation can be identified and the impact of the installation on safety, individuals, society and the environment can be assessed.

These themes take account of the requirements of the RFS concerned (see Appendix 2, § 2.3.1): namely site geology (RFS 1.3.c), seismic conditions (RFS I.2.c5 and RFS 2001-01), flood risks of external origin (RFS 1.2.e), climatic risks and risks relating to the industrial environment and communication routes (RFS 1.2.d). They also take into account the requirements of the new guide on protection against the external flood risk for nuclear facilities published by ASN in 2013 (see § 17.4.1.1.2) which is intended to replace basic safety rule RFS 1.2.e.

These themes are re-assessed at each periodic safety review and the chapters of the safety report are updated accordingly.

In the framework of the stress tests, the robustness of the installations beyond the requirements of the safety report was assessed, particularly for earthquakes, external flooding and climatic hazards. The risk associated with the industrial environment was also reviewed.

17.2.1 External events – Earthquake

The deterministic approach used to define the seismic loads to be considered in the design of the installations involves determining for each site the maximum historically probable earthquake (MHPE) and the safe shutdown earthquake (SSE) with the addition of a further degree of intensity. The NPP is then designed so that it can be restored to and maintained in safe shutdown conditions after an earthquake corresponding to an intensity at least equivalent to that of the SSE.

An "envelope" design-basis earthquake (DBE) is taken into consideration in the standardised plant series for the design of the nuclear island. Besides this, the other structures, known as the "site structures" are specifically designed for each site. The site structures include the other buildings and facilities necessary for operation of the plant, including the heat sink and the intake channel.

The design approach for determining seismic motion to be considered for the safety of the facilities is based on basic safety rules RFS I.2.c and RFS 2001-01.

Methodology used to evaluate the design-basis earthquake during the periodic safety reviews

The ten-year periodic safety reviews provide the opportunity to perform an in-depth examination of compliance with the seismic design requirements in effect and to reassess the SSE levels in the light of the most recent data and any new knowledge.

Reinforcements may be decided, not only on the basis of a reassessment of the seismic hazard, which constitutes input data for the calculation of structures and equipment, but also on the basis of developments in paraseismic engineering (calculation methods and means).

Special measures have been taken for sites with seismic characteristics outside the envelope of the standardised plant series (due to local particularities, especially geological).

The deviations observed when performing conformity checks during the stress tests do not directly call into question safety. These deviations have been notified to ASN as significant events and are being dealt with in this context.

Identification of systems, structures and components which must remain available after an earthquake

Depending on the role items of equipment play in safety, they are placed in safety classes that comprise seismic classification requirements defined by the regulations or basic safety rules. The seismic classification requires justification either by calculation or by testing on a vibrating table or through case-by-case analysis.

EDF points out in its stress test reports that it sets seismic classification requirements in particular for the items important for safety (“IPS classified for safety") and, on a case-by-case basis, for certain items that are not “IPS classified for safety", as well as for the post-accident surveillance measures.

Items which, if they fell, could lead to the loss of an item IPS and seismic-classified, are the subject of seismic verification.

Assessment of the safety margins in the stress tests

EDF reviewed the seismic resistance margins of the structures and items important for safety, in order to determine the level of acceleration for which the installation has a very low probability of failure.

In addition, EDF carried out the seismic inspection of a sample of the equipment needed to operate the reactor in the event of total loss of off-site and on-site power supplies, whether seismic-classified or not, for all the plant units in service. For some of these equipment items EDF has defined additional improvement measures for a hazard beyond the design-basis earthquake (DBE).

EDF concludes that the seismic capacity of the containment and of the structures and equipment which, in the event of failure, would compromise the safety functions, would enable them to withstand an earthquake with a spectrum 1.5 times greater than that of the SSE. EDF considers that this spectrum level corresponds to hazard values that are relatively to completely implausible for the sites in question.

EDF has defined the extreme seismic hazard levels (Earthquake Hardened Safety Core) for all the sites of the nuclear fleet in operation. These levels are currently being examined by ASN.

Main operating provisions

In order, following an earthquake, to be able to rapidly take appropriate steps to bring to and maintain the power plant reactors in the safest shutdown state, or to continue operation, basic safety rule RFS I.3.b recommends installing seismic instrumentation for pressurised water reactors. The action to take depends on the level of the earthquake with respect to an inspection threshold (SDI):

- if the SDI threshold is not exceeded, each reactor can continue to operate provided that a visual inspection of the structures and equipment is carried out.
- if the SDI threshold is exceeded, the reactors must go to the shutdown state considered for each one to be the safest. The resumption of operation may only be initiated with the approval of ASN.

The operation of this seismic instrumentation was the subject of a series of targeted inspections by ASN in 2011.

The results of the conformity checks performed on the 19 NPPs reveal no findings that could call into question the requirements of RFS I.3b.

In response to an ASN requirement, EDF studied the advantages and drawbacks associated with the installation of an automatic reactor trip system (AAR) in the event of a seismic stress. EDF concluded that an earthquake-triggered reactor trip (AAR) function was justified from the safety aspect on the fleet in operation. This earthquake-triggered reactor trip is beneficial for rod drop and clarifies the initial conditions of the reactors following an earthquake. ASN is currently examining this method.

"Seismic interaction" procedure

The "seismic interaction" procedure aims to prevent equipment that must remain operational after an earthquake from being damaged by non-seismic classified equipment or structures.

This approach, which is implemented in the context of the periodic safety reviews and can lead to modifications on a plant series or local ones.

In response to the ASN requirement concerning the measures to take to prevent potential damage by other equipment of items which, on account of safety, must remain available following an earthquake, EDF has decided to reinforce its organisation to control hazard risks during operation.

The EDF management guide of the "seismic interaction" hazard on the nuclear power plants is applicable. It defines the organisational measures to put in place on the sites and details the roles and responsibilities of the players and the prevention measures to implement.

The training of "seismic interaction" experts ended at the end of 2015. Likewise, courses targeting the representatives and awareness-raising for all the personnel will be integrated in EDF's DPN (nuclear operations division) training syllabus.

An initial list of "target hazard" pairs was drawn up at the end of 2015; the conformity deviation pairs (in the sense of the "seismic interaction" approach" defined above) will be processed in accordance with the regulations in effect (speed of processing dependent on harmfulness).

Loss of off-site electrical power supplies

The PWR safety demonstration studies the simultaneous occurrence of a major earthquake and the loss of off-site power supplies, insofar as they are not designed to withstand a major earthquake.

The total loss of on-site and off-site electrical power supplies to a single reactor on the site is taken into account in the baseline safety requirements. In the event of failure of the plant unit diesel generators (emergency power supplies) to start or connect, it is possible to connect a site ultimate backup generator or a diesel generator set belonging to a neighbouring reactor. There is an ultimate backup generator set per site which is not designed to withstand an earthquake.

In the event of a failure affecting several of the site's diesel generator sets simultaneously, one of the site's reactors could thus be backed-up.

The design-basis autonomy of the batteries used in the event of loss of the electrical power supplies was 1 hour. The autonomy of the batteries of train A has been increased to 2 hours as part of the stress test actions.

EDF is taking the following measures in response to ASN requirements and with a view to reinforcing the electrical power supply resources:

- an additional electrical power supply ("ultimate backup diesel generator set - DUS) will be built to supply the hardened safety core systems and components, among other things. EDF communicated the design principles to ASN in early 2013 and the work has begun. The ultimate backup diesel generator sets are planned to be put in place on the entire French nuclear power fleet by the end of 2018.
- In the interim, EDF has equipped each reactor with a generator set that can supply electrical power for the necessary instrumentation and control and lighting of the control room in the event of loss of the on-site and external power sources. This modification has been in place since the end of June 2013, in accordance with the ASN prescription.

Conditions of site access following an earthquake

In the event of major disruption to roads and structures, the emergency response organisation calls on the public authorities who, in addition to triggering the off-site emergency plan (PPI) if necessary, deploy specific measures to restore site access. These measures allow on-call personnel to be brought in.

The stocks of fuel and oil and their replenishment under all circumstances are guaranteed in order to ensure an autonomy in accordance with the following organisational arrangements:

- minimum autonomy of oil of 15 days for the 1300 MWe and 1450 MWe plant series, and of 4.5 days for the 900 MWe plant series. In addition, an oil supply contract with a reserve stock of 32 m^3 is intended to cover the needs of a nuclear power plant in case of "long term" (15 days) operation of the emergency diesel generator sets;
- minimum autonomy of fuel of 72 hours with a supply contract based on a minimum dedicated stock: hedging contract signed with the FARN, and beyond this, requisition of stocks under action sheet No.12 of the governmental plan;
- refuelling and oil replenishment by the FARN: this capability was validated (excluding flood conditions) during FARN tests carried out at the Chinon NPP in September 2015.

Earthquake-induced fire risk

The buildings have fire protections designed in application of defence in depth (prevention of fire outbreaks, detection of fire outbreaks and rapid extinction to limit development and propagation of the fire), which are subject to seismic resistance requirements. These provisions are originally designed to withstand the OBE (operating-basis earthquake) (excluding the N4 plant series).

To respond to an ASN prescription, EDF undertook a study of the resistance to the safe shutdown earthquake (SSE) of the structures and equipment contributing to nuclear safety, to fire sectoring, to fire detection and the fixed extinguishing systems, which are subject to an operating basis earthquake resistance requirement. A works and reinforcement programme has been started for the structures and components whose resistance to the SSE is not ensured.

Earthquake-induced explosion risk

In the context of the periodic safety reviews, application of the SSE design requirement to the hydrogen systems and inclusion of the "seismic interaction" approach for lines carrying hydrogen situated in the nuclear island, is in progress on the 900 MWe, 1300 MWe and N4 plant series.

In response to the ASN requirement, EDF has proposed more rapid implementation of this requirement on the various plant series than provided for in the 10-yearly outage schedule.

Seismic level leading to non-design-basis flooding

In its stress test reports, EDF took account of the topography of each of the sites and identified the water reserves above the site which are not considered robust to the SSE. The analysis did not reveal any risk not already covered by the existing or planned protection measures.

For those sites on which the off-site flooding risk created by an earthquake exceeding the design basis for the facility cannot be ruled out, EDF achieved a study to determine if there is a real risk of the nuclear island platform being submerged. Additional protection measures are currently being deployed on the sites in accordance with ASN prescriptions.

17.2.2 External events – Flooding

Floods are events liable to lead to failures that can impact all the facilities on a site.

Flooding is a risk that is taken into account in the design of the facilities and reassessed during the periodic safety reviews or further to certain exceptional events, such as the partial flooding of the Blayais nuclear power plant during the storm of 27th December 1999 (see § 6.3.1.2.1).

Floods for which the facilities are designed

For the sizing of protection against flooding, the sites use basic safety rule RFS I.2.e of 12th April 1984. This text defines a method for determining the water levels to be considered when designing the facilities. This method is based on the defining of the flood safety level and provides for three different cases: sites by the sea, sites on rivers and sites on estuaries.

Measures to protect facilities from the flooding risk integrated in the design process

EDF has conducted a safety analysis for each site, drawing up a list of the systems and equipment necessary to reach and maintain a safe state.

In order to reach a conclusion on the absence of water in the premises housing the equipment to be protected in the event of flooding, EDF has adopted a two-step approach:

- comparison of the water height liable to be reached at the various possible water entry (or by-pass) points;
- indication of the material and operating measures aimed at protecting the facility against the design-basis flood level.

Material provisions

The material provisions concern the civil engineering, specific equipment, modifications to existing equipment, electrical equipment and instrumentation and control equipment.

The work for protecting the facilities against flooding and integrating the lessons learned from the Blayais NPP event of December 1999 have been completed since the end of 2014.

Operating measures

During the stress tests, EDF also presented the operating measures for each site aiming at protecting the facility against the design-basis flood level. They include:

- warning systems in the event of a foreseeable hazard that could lead to flooding of the site;
- agreements with organisations within or outside EDF;
- special operating rules in the event of flooding;
- local procedures.

In response to an ASN prescription, measures for coping with NPP isolation in the event of flooding have been implemented on the Cruas and Tricastin sites.

Conformity of facilities with the current baseline safety requirements

The work to restore conformity of the protected volume and deployment of the structures and resources to maintain its effectiveness over time were carried out within the deadlines set by ASN.

At national level these measures resulted in the holding of a protected volume conformity check and updating of the protected volume management rules (see the definition in §17.4.1.1.2) for the sites.

Evaluation of safety margins

During the stress tests, EDF presented for each site the margins between the flood level reached and the level of the protections provided with the current design, and decided on the additional measures to be taken.

This assessment was based on increased scenarios also taking into account the flooding induced by a beyond design-basis earthquake and the structures present on or above the platform and liable to constitute potential sources of flooding following an earthquake of intensity exceeding the SSE, if the structure is not considered robust to a beyond design-basis earthquake.

EDF thus calculated the water level resulting from these increased scenarios, highlighting the protection measures implemented on the site in the framework of protection against design hazards.

The approach implemented leads EDF to define increased hazards covering all the phenomena that could lead to or contribute to flooding and examine additional scenarios for certain sites.

EDF envisages different solutions depending on the sites according to the identified cliff-edge effect and the increased scenario.

EDF has defined the extreme flooding hazard levels for all the sites of the nuclear fleet in operation. These levels are currently being examined by ASN.

Furthermore, the stress test analysis shows that the requirements resulting from the complete re-evaluation of how the flood risk is taken into consideration in the nuclear power plants, completed in 2007, offer the facilities a high level of protection against the risk of flooding, on condition that the measures for satisfying these requirements are implemented as planned.

17.2.3 External events – Extreme climatic conditions

Wind

At each periodic safety review, EDF checks that the IPS buildings and the buildings housing systems or equipment important for safety are able to withstand winds with characteristics conforming to the “Snow and Wind” Rules (1999 and 1984 editions, amended in 2000) and also integrating the experience feedback from the two storms that recently hit France in 1999 and 2010.

EDF considers that the projectiles generated by extreme winds cannot damage the structures or civil engineering works that constitute or house systems or items that participate in a safety function.

Nonetheless, on the occasion of the latest periodic safety reviews, EDF defined baseline safety requirements concerning protection against projectiles generated by extreme winds.

EDF considers that the design of the buildings for the off-site explosion risk guarantees their robustness to extreme winds. EDF has evaluated the existing margin by comparison with this event and concludes that for all its sites, all the buildings designed for the "off-site explosion" risk are robust to extreme winds with significant margins.

For buildings not covered by the "off-site explosion" design, EDF considers that the loads associated with extreme winds are not liable to have consequences for reactor safety.

EDF has analysed the behaviour of its facilities and the possible cliff-edge effects for a wind speed value of about 200 km/h. This order of wind speed is consistent with the objective of an annual frequency of occurrence of $< 10^{-4}$ for the wind values to be considered.

Moreover, EDF decided to use the tornado hazard in the definition of the hardened safety core and submitted draft baseline requirements for tornadoes to ASN at the end of 2015. These baseline requirements are currently being examined by ASN.

Hail

The hail hazard had not been considered in the design of the reactors. This is because hail is a relatively localised and brief meteorological phenomenon for which the majority of the equipment items important for safety are situated inside buildings and are therefore protected. With regard to the robustness of the buildings themselves to the effects of hail, EDF considers that the maximum impact could be pitting of the cladding, but without penetration. No incident related to a hail storm has been observed on the reactors in service. The targets identified with respect to hail are primarily those already considered in the analyses covering wind-generated projectiles.

Lightning

The protection of facilities against lightning-related risks is in conformity with the ministerial order of 19th July 2011. In the approach adopted by EDF, the lightning prevention and protection measures must ensure that the consequences of a lightning strike on safety are less than those defined in the initial design of the reactors with regard to category 2 incidents (frequency of less than 10^{-2} per reactor and per year).

In accordance with the order of 19th July 2011, an analysis of the lightning risk was carried out to demonstrate the acceptability of the consequences of a lightning strike. EDF stated that further to this study, preventive measures and protection systems were defined and were implemented on 1st January 2012. The direct effects (direct impact on the building structure) and secondary effects (impact in the vicinity of the building) of the lightning strike were taken into account.

EDF considers that there is no plausible cliff-edge effect liable to be created by lightning, given the high robustness to the lightning risk and its effects of the facilities and given the functional redundancy and diversity of certain systems, especially those associated with the electrical power supplies.

A turbine hall maintenance programme is currently being prepared to increase the robustness of the facilities.

The EPR for its part is designed in accordance with the "lightning safety baseline applicable to the EPR". Adequate steps are thus taken to ensure that the safety functions of the systems and equipment necessary to bring the reactor to a safe condition and to prevent and mitigate radioactive releases are not unacceptably affected.

EDF has decided to take an increased lightning level for the hardened safety core.

Snow

A working group with representatives from Météo France, EDF, CEMAGREF and IRSN contributed to the Flooding guide (see Appendix 2, § 2.3.4). This document also mentions other forms of precipitation such as snow. EDF considered that there was no direct correlation between snow and rain and that snow was not one of the extreme meteorological conditions linked to flooding. Nonetheless, the design of the structures in accordance with the latest revision of the “Snow and Wind” rules, does protect the safety-classified buildings from all snow-related cliff-edge effects.

17.3 Measures taken for research reactors

17.3.1 CEA reactors

The Safety Reports feature a dedicated "Site and Environment" chapter which covers the same themes as for nuclear power reactors.

These themes take into account the requirements of the basic safety rules concerned.

These themes are analysed at each ten-year periodic safety review and the chapters of the Safety Report are updated accordingly.

In the framework of the experience feedback (OEF) following the Fukushima Daiichi NPP accident, the robustness of the installations beyond the requirements of the Safety Report was assessed, particularly for earthquakes, external flooding and climatic hazards in relation with the hazards experienced at Fukushima Daiichi NPP. The risk associated with the industrial environment was re-analysed.

As a general rule, these assessments have shown the research reactors to display good robustness to these extreme hazards. More specifically, the susceptibility of the sites to flooding is extremely low. Research reactors, which have much lower power levels than in power reactors, are also very resistant to power supply and heat sink losses. They offer a large time allowance before intervention is necessary.

17.3.2 The ILL high-flux reactor (RHF)

The general safety presentation of the Laue Langevin Institute (ILL) describes all the external hazards that are taken into consideration in the design of the equipment items that are required according to on the operating situations. The stress tests of the ILL analyse the impact of concomitant external hazards and define the work necessary to ensure compliance with the safety perimeter even under these extreme conditions.

17.4 ASN analysis

17.4.1 Nuclear power reactors

As a general rule, the licensee has applied operating measures aiming to protect the sites against extreme meteorological conditions, including warning systems for predictable hazards and particular organisational and material prevention and protection provisions.

17.4.1.1 Change in the design basis for natural and human risks following the stress tests

For the different risks considered for each site, the licensee has highlighted the margins with respect to the design-basis risks and those going beyond the baseline requirement. It has decided, where applicable, on the additional measure to be taken. The licensee has also studied several situations which it considers representative for evaluating the cliff-edge effects.

As part of this approach, new requirements have been enacted for reactors in operation or under construction with the aim of reinforcing their robustness to such phenomena. The main requirements and demands that are a cross-cutting with respect to Articles 17, 18 and 19 of the Convention are described in chapter 6 and detailed below.

Besides this, ASN is also preparing the transposition, into the national regulatory framework, of the external hazard reference levels which WENRA has added or modified.

17.4.1.1.1 Earthquake

Earthquake hazard

With regard to earthquakes, the methodology currently used to determine the seismic risk in France is mainly deterministic and complies with the methodology and criteria prescribed by the IAEA.

ASN considers that the exercise conducted on the earthquake PSA (probability safety assessment) applied to the Saint-Alban NPP is worthwhile and needs to be continued and extended to the other NPPs.

This PSA brings out the initiating events and equipment items that contribute predominantly to the risk of core meltdown. Additional analyses are necessary, notably for the seismic hazard evaluation and the definition of the various equipment and structure failure modes and the extent of the equipment that must be covered by fragility curves taking into account these various failure modes. EDF must also provide elements to substantiate the applicability of the American approach developed by the EPRI to the French reactors.

Indirect effects of seismic events

The indirect effects of seismic events have been examined under the periodic safety reviews and the complementary studies in the stress tests which focused on:

- the "seismic interaction" approach[19] (see § 17.2.1);
- loss of off-site electrical power supplies;
- conditions of access to the site following an earthquake;
- the fire, explosion and flooding risks induced by an earthquake.

Seismic instrumentation

The conditions of utilisation of the seismic instrumentation installed on the sites were checked by ASN during the targeted inspections carried out in 2011 and were the subject of a request in the European peer review.

ASN is also going to examine the relevance of revising the basic safety rule in the light of the results of EDF's ongoing seismic instrumentation evaluation.

Other requests

The licensee submitted a review of the effective resistance of the facilities to the SSE and the envisaged modifications. Compensatory measures have been defined to ensure the SSE resistance of the Civaux, Cruas and Flamanville sites.

On the basis of the in-depth experience feedback from the Fukushima Daiichi NPP accident, ASN has planned to review the baseline safety requirements of the nuclear facilities, particularly with regard to the "earthquake" aspects.

17.4.1.1.2 Flooding

Following the flooding of the Blayais site in 1999, EDF put in place a protected volume perimeter[20] on all the sites. The conformity of this protected volume was specifically checked by ASN during the targeted inspections conducted in 2011, resulting in demands from ASN. In spring 2012 the licensee submitted an overall analysis of the responses to the observations raised by ASN, which ASN judged satisfactory. ASN has set the following requirements:

[19] The aim of the "seismic interaction" approach is to prevent an item that must remain functional in an earthquake situation from being damaged by an item or structure that is not classified for earthquakes.

[20] The protective volume perimeter, which encompasses the buildings housing items for guaranteeing reactor safety, has been defined by EDF so as to ensure that an influx of water that reaches the outside edge of this perimeter does not lead to flooding of premises situated inside this perimeter. Concretely, the protected volume consists of walls, ceilings, floors and structures to that close openings in these surfaces (doors, covers, etc.) that can constitute potential water ingress points in the event of flooding.

- works to integrate experience feedback from the Blayais flood in 1999 for the Blayais, Bugey, Cruas, Dampierre, Gravelines, Penly, Saint-Laurent-des-Eaux and Tricastin sites (requirement ECS-04). EDF met the 31st December 2014 deadline for completion of the modifications.
- restoring conformity of the protected volume and implementation of the appropriate organisation and resources to ensure that the effectiveness of the protected volume stipulated in the safety demonstration is maintained (requirement ECS-05. Work to restore conformity was completed on 30th June 2012).
- verification of the resistance of the emergency situation management rooms to the SSE and implementation of any modifications where necessary (requirement ECS-30. The licensee has given ASN an assessment of the effective resistance of the rooms to the SSE along with the planned modifications. EDF met the 31st December 2013 deadline for completion of the modifications).

In addition to the requirement on the hardened safety core (see § 6.3.1.3, requirement ECS-01), ASN has also issued a specific requirement to EDF relating to the protection of the facilities against flooding beyond the baseline requirement with the aim of increasing the robustness of these facilities in order to prevent the cliff-edge effects associated with heavy rainfall or the failure of on-site equipment due to an earthquake beyond design-basis earthquake (requirement ESC-06). This requirement more specifically concerns the raising of the protection volume to protect against total loss of the heat sink or electrical power supplies in beyond-design-basis scenarios (increased rainfall, flooding induced by the failure of on-site equipment due to an earthquake, etc.). The deadlines for completion of the planned modifications range from 31st December 2014 and 31st December 2017.

In 2013 ASN published a new guide on protection against the external flood risk for nuclear facilities. It integrates the recommendations of RFS I.2.e[21] and the experience feedback from the flooding of the Blayais site in 1999. The hazards to take into consideration are defined on the basis of an in-depth assessment of knowledge in the different areas concerned, and in hydrology and meteorology in particular (11 different hazards considered). It is based on deterministic methods, incorporating increases and combinations integrated in the hazards, taking into account a "probabilistic" exceedance target of 10^{-4} per year. In 2014, ASN stated its position on the principles of application of this guide for the existing reactors.

17.4.1.1.3 Other natural risks

In the framework of the stress tests, the licensee also studied the margins in the event of extreme meteorological conditions such as wind, lightning, hail, and their combination, in the event of loss of the heat sink and electrical power supplies. ASN's analysis of the studies led it to set requirements and make additional demands concerning the evaluations of margins and reinforcing of the robustness of facilities beyond their current design basis.

In addition to this, in the context of the periodic safety review corresponding to the third ten-yearly outage of the 1300 MWe plant series, the baseline protection requirements of the NPPs against natural risks and risks for the heat sinks will be examined.

Lastly, ASN is going to consult the Advisory Committee of Experts on this subject, and the following points in particular:

[21] Basic safety rule RFS 1.2.e. of 12/04/1982 relative to consideration of the risk of flooding of external origin.

- experience feedback concerning external hazards;
- assessment of the procedures to take account of the risks associated with these hazards (methods, baseline requirements, hazard levels, requirements);
- comparison of the procedures and safety levels for the different hazards;
- impact of the BNI order;
- inclusion of international work, notably that of WENRA;
- consideration of climatic changes;
- consistency in the definition of requirements;
- general operating rules relative to hazards.

The baseline requirements associated with these hazards may be supplemented in the light of the conclusions of the review of the preceding themes.

17.4.1.1.4 Risks associated with other industrial activities

At the end of the stress tests, ASN asked EDF to take into account the risk created by the activities situated near the nuclear installations, in the extreme situations studied in the stress tests, liaising with the neighbouring licensees responsible for these activities .

17.4.1.2 Flamanville reactor No. 3 (EPR)

The Flamanville reactor No.3 was included in the scope of the stress tests in accordance with specifications identical to those for reactors in operation. This review led to issuing of the specific requirements[22]. ASN is currently examining EDF's responses.

17.4.2 Research reactors

Based on the conclusions of the technical review of the ITER BNI creation authorisation application file by the Advisory Committee of Experts, the conclusions of the board of inquiry, the opinion of the CLI and of the Prefect, a draft creation authorisation decree was submitted to the licensee in mid-2012 for consultation. After giving a hearing to a representative of the CLI and the licensee, ASN returned a favourable opinion on the draft decree, which was published on 10th November (decree 2012-1248 of 9th November 2012).

Alongside this, ASN has prepared a draft resolution setting the requirements for the design and construction of the facility. The civil engineering work, particularly the tokamak foundations, began in 2011.

ITER was included in the scope of the stress tests in accordance with specifications identical to those for reactors in operation. This review led to specific requirements being issued.

[22] http://www.french-nuclear-safety.fr/References/ASN-Resolutions/ASN-resolution-2012-DC-0283-of-26-June-2012.

18. Article 18: Design and construction

Each Contracting Party shall take the appropriate steps 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 mitigating 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 analysis;

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.

In the framework of the BNI commissioning application reviews, ASN - with the support of IRSN - is responsible for the detailed examination of the design of new installations. ASN also ensures regulation of their construction (see chapter 14).

18.1 The defence in depth concept

The safety principles and approaches have been implemented progressively in France and incorporate experience feedback from accidents.

The BNI order includes regulatory requirements concerning the demonstration of safety and notably the principle of defence in depth.

18.1.1 ASN requests

The main means of preventing accidents or limiting their consequences is "defence in depth". This consists in implementing material or organisational provisions (sometimes called lines of defence) structured in consecutive and independent levels, and which are capable of preventing the development of an accident. The defence in depth principle is an integral part of the safety case. In accordance with the regulations, the implementation of this principle is based in particular on:

- the choice of an appropriate site, giving particular consideration to the natural or industrial risks weighing on the installation;
- identifying the functions necessary to demonstrate nuclear safety;
- a cautious design approach, integrating design margins and wherever necessary introducing adequate redundancy, diversification and physical separation of the items that fulfil functions necessary to demonstrate nuclear safety, to obtain a high level of reliability and guarantee the functions mentioned in the preceding paragraph;
- the quality of the design, construction, operation, final shutdown, decommissioning, maintenance and surveillance of the installations;
- preparation for the management of any incident and accident situations.

In the extreme situations analysed in the stress tests, the approach presupposes successive loss of the lines of defence by applying a deterministic approach. The aim was to assess the robustness of the defence in depth approach, the appropriateness of the accident management measures, and to identify the possible means of improving safety.

18.1.2 Measures taken for nuclear power reactors

The safety of the nuclear power reactors in operation and under construction is based on the principle of defence in depth, which consists in implementing five successive and sufficiently independent levels of defence, the first four of which are the responsibility of the licensee:

1. the first level aims to prevent incidents;
2. the second level consists in detecting incidents and applying measures 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 installation in a safe condition;
3. the third level aims at controlling accidents that could not be avoided or, failing this, limit their aggravation by regaining control of the installation in order to return it to and maintain it in a safe condition;
4. the fourth level consists in managing accident situations that could not be controlled so as to mitigate the consequences, especially for persons and the environment;
5. The fifth level includes, in the case of a malfunction or ineffectiveness of the above-mentioned provisions, the measures to protect the public in the event of significant releases. This fifth level comes primarily under responsibility of the public authorities.

The concept of defence in depth - Measures taken for the EPR

The safety of the EPR reactor relies on the five above-mentioned levels with particular consideration being given at the design stage to severe accidents (by integrating more specifically an area for spreading and cooling the corium if necessary) and external hazards (including plane crashes, with a concrete shell for protecting the most sensitive parts of the installation).

A very high level of safety is targeted for the EPR reactor, firstly by facilitating reactor operation and maintenance, secondly by mitigating the immediate or deferred potential consequences. At the design stage, the approach for verifying design consistency with the principle of defence in depth was presented in the preliminary safety analysis report transmitted to ASN to support the reactor creation authorisation application, then substantiated in the commissioning application file transmitted in March 2015.

The implementation of the defence in depth concept during the qualification of the design and the technologies used is presented in § 18.2 and 18.3.

18.1.3 Measures taken for research reactors

The design of the CEA's Jules Horowitz Reactor (JHR) is based on the defence in depth concept which places particular emphasis on containment by defining barriers between the radioactive products and the external environment of the installation.

18.1.4 ASN analysis and oversight

The defence in depth concept is applied to all the nuclear installations by implementing systems that can detect or prevent certain failures of systems that guarantee the safety of the installations; these more particularly concern confinement barriers that prevent the dissemination of radioactive materials into the environment. The safety analysis must demonstrate the effectiveness of these systems in both normal operating situations and accident situations. These various systems are inspected at regular intervals.

The safety approach was reinforced in the stress tests by taking into consideration extreme natural phenomena and accidents that could affect several reactors on the same given site.

The safety approach applied by the licensees remains satisfactory on the whole, with certain areas for improvement identified on a case-by-case basis according to the installations concerned.

18.1.4.1 Nuclear power reactors

Flamanville 3 EPR reactor

The safety approach implemented at the design stage is based on the concept of defence in depth such as it is presented in the INSAG (International Nuclear Safety Advisory Group) documents. The main measures taken to implement it have been described in the preliminary safety analysis report which was submitted to support the creation authorisation application for this installation. The examination of the detailed design of this reactor, and in particular the review by ASN and its technical support agency of the concrete measures for implementing this concept, continued after delivery of this authorisation in 2007.

This reactor was also included in the scope of the stress tests.

EDF submitted the commissioning authorisation application for this installation in spring 2015; this application includes, among other things, the safety analysis report (update of the preliminary safety analysis report). ASN and its technical support agency are currently examining this application.

18.1.4.2 Research reactors

ASN's conclusions on the general design of the JHR are presented in § 18.3.3.

18.2 Qualification of the technologies used

18.2.1 ASN requests

The BNI order stipulates the requirements of the items and activities identified as being important for protection. The qualification of these items must be proportionate to the potential consequences, aiming in particular at guaranteeing the ability of these elements to fulfil their assigned functions in the situations where they are needed. Appropriate design, construction, tests, inspection and maintenance provisions must be implemented to enable this qualification to be maintained over time.

The BNI procedures decree specifies the files in which the licensee must set out its qualification procedure.

In addition, the manufacture of nuclear pressure equipment (ESPN) is subject to an individual conformity assessment whereby the conformity of these equipment items with all the regulatory requirements and their suitability to be used is assessed with respect to the predicted operating loads.

More specifically, ASN assesses the conformity with regulatory requirements of each of the ESPN items that are most important for safety, called "Level N1 ESPN". This assessment concerns the equipment intended for the new nuclear installations (EPR) and the replacement equipment for nuclear installations in operation (replacement steam generators). ASN can be assisted in this task by organisations that it has approved.

18.2.2 Measures taken for nuclear power reactors

Equipment qualification

As a general rule, the qualification of each equipment item is defined following rules and requirements that depend on its safety classification, that is to say its importance for safety and the types of loads or stresses it must withstand:

- a consequence of the seismic qualification is that the stresses resulting from the earthquakes must be taken into account in the design of the equipment;
- the purpose of qualification under accident environmental conditions (temperature, pressure, humidity, irradiation) is to prove through tests or analyses that the materials are capable of fulfilling their functions under the ambient conditions and stresses to which they are assumed to be subjected.

For the electrical safety equipment, three qualification categories representing "envelope" conditions have been defined:

- category K1: equipment items installed in the containment and having to fulfil their function in accident situations;
- category K2: equipment items installed in the containment and having to fulfil their function in normal situations;
- category K3: equipment installed outside the containment.

The environmental conditions include normal, incident and accident conditions and the seismic loads, according to the equipment and qualification category.

It is important to be able to check the sustainability of these qualifications over time during operation. This aspect is taken into consideration in the conformity assessments carried out during the periodic safety reviews.

Complete initial inspection and periodic requalifications of the main primary and secondary systems

The primary and secondary cooling systems of the PWRs are subject to a complete initial inspection and a periodic ten-yearly requalification. This includes an inspection of the system, non-destructive examinations, hydrostatic testing and a functional check of the over-pressure protection accessories.

Further applications are currently being developed and qualified in order to address new requirements, in particular concerning the Flamanville 3 EPR reactor, for which the processes to be implemented during the complete pre-service inspection shall be qualified.

Construction of the Flamanville 3 EPR reactor

- **Quality of on-site construction and assembly operations**

In application of the "BNI order" of 7th February 2012 setting the general rules relative to basic nuclear installations (chapter II), EDF monitors the performance of the activities important for the protection of interests within the meaning of the Environment Code: design, construction, on-site assembly and manufacture of elements important for protection (EIP).

ASN carries out unannounced and scheduled inspections on the work site.

Two significant safety events concerning the construction of the Flamanville 3 EPR reactor were notified by EDF in 2015. The first concerned the pre-stressing of the internal containment of the reactor building; the second concerned noncompliant indications on the ASG (auxiliary feedwater system) pumps during complementary radiographic inspections carried out on site.

- **Manufacturing quality for the EPR**

The EDF monitoring of manufacturing operations for the EPR reactor encompasses both the technical monitoring and the tracking of the manufacturing steps from the upstream review of the contractual conformity of the suppliers' technical documentation through to the inspections in factories and on the Flamanville 3 construction site.

EDF holds monthly meetings of its manufacturing monitoring teams in order to review industrial schemes, report on manufacturing progress, analyse the corresponding critical paths and examine the difficulties encountered.

These meetings are instrumental in ensuring manufacturing "quality and lead-time" coordination and monitoring, as well as the related progress reports.

ASN's analysis and oversight of the quality of manufacture of nuclear pressure equipment for the EPR are presented in § 18.2.4.1.

18.2.3 Measures taken for research reactors

The safety analysis methodology applied for all the research reactor licensees leads to a safety classification of the components that are required to ensure a safety function and which must be qualified. This classification determines the requirement level for manufacture, operation and monitoring alike.

Furthermore, the periodic safety reviews can lead to upgrading work in various areas, including the requalification of certain equipment items.

18.2.4 ASN analysis and oversight

18.2.4.1 Assessment of nuclear pressure equipment conformity (NPE)

Nuclear pressure equipments (NPE) are subject to the provisions of Chapter VII of title V of book V of the Environment Code, resulting from Act 2013-619 of 16th July 2013 comprising various provisions to adapt to European Union law in the area of sustainable development.

Decree 2015-799 of 1st July 2015 *relative to products and equipment involving risks*, which sets the procedures for application of this chapter VII, will come into force on 19th July 2016 for the majority of its provisions relative to NPE and will be supplemented by the provisions figuring in the order of 30th December 2015 *relative to nuclear pressure equipment.* Until that date, the regulatory provisions in effect are those defined by decree 99-1046 of 13th December 1999 *relative to pressure equipment and by the implementing texts* supplemented by the provisions figuring in the order of 12th December 2005. The principles of this regulation are those of the "new approach" in accordance with the European directive applicable to pressure equipment.

Nuclear pressure equipments are subject to both the BNI regulations and that for products and equipment involving risks.

NPE items are designed and produced by a manufacturer under its responsibility. The manufacturer is obliged to comply with the essential safety and radiation protection requirements figuring in the regulations and having the conformity of the item of equipment assessed by an independent and competent ASN-approved body. This conformity assessment concerns equally well the equipment intended for the new basic nuclear installations such as the Flamanville 3 EPR, the Jules Horowitz research reactor and the ITER nuclear fusion reactor, as spare equipment items such as replacement steam generators for installations in service.

The ASN-approved organisations assess the conformity of the level N2 and N3 nuclear pressure equipment with the regulatory requirements. The approved organisations are contacted directly by the manufacturers.

ASN assesses the conformity with the regulatory requirements of the pressure equipment items most important for safety, known as "level N1" equipment, such as the reactor vessel or the power reactor steam generators. ASN can be assisted in this task by an approved body. In such cases the approved body is mandated by ASN to perform some of the inspections on the level 1 equipment.

The oversight by ASN and the approved organisations is exercised at the different stages of the design and manufacture of the NPE. It is materialised by an examination of the technical documentation of each equipment item and inspections in the workshops of the manufacturers and their suppliers and subcontractors.

In 2015, ASN and the approved organisations carried out:

- 4,483 inspections to check the manufacture of nuclear pressure equipment intended for the Flamanville 3 EPR reactor, representing more than 10,133 man/days in the plants of the manufacturers and their suppliers and subcontractors;
- 1,063 inspections to check the manufacture of the spare steam generators for the NPP reactors in service, which represented more than 3,936 man/days in the plants of the manufacturers and their suppliers and subcontractors.

Most of these inspections were performed by the approved organisations under the supervision of ASN.

18.2.4.2 Flamanville 3 EPR reactor

18.2.4.2.1 Qualification of nuclear pressure equipment (NPE)

In application of the principles described earlier, ASN and the approved organisations assess the conformity of the NPE for the Flamanville 3 reactor on the site or on the manufacturer's premises. This regulation is materialised by an examination of the technical documentation of each equipment item and inspections in the shops of the manufacturers and their suppliers and subcontractors.

In addition, ASN and STÜK, the Finnish nuclear regulator, are in regular contact with each other to share experience in the manufacture of the ESPN items.

On 7th April 2015, ASN released information concerning an anomaly in the composition of the steel in the centre of the Flamanville 3 EPR 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.

Areva sent ASN a file presenting the approach it envisages to demonstrate the sufficiency of the mechanical properties of the material used in the manufacture of the vessel closure head and bottom head for the future Flamanville 3 EPR reactor. This approach is based in particular on the future results of a new mechanical and chemical tests programme.

After joint examination of this file with IRSN, ASN convened the Advisory Committee for nuclear pressure equipment (GP ESPN) on 30th September 2015. The GP ESPN outcome was given to ASN.

On this basis, ASN issued a position statement on 12th December 2015 concerning the approach proposed by Areva to demonstrate the mechanical properties of the Flamanville 3 EPR vessel closure head and bottom head.

Subject to its observations and demands being taken into account, ASN considers that the approach proposed by Areva is acceptable in principle and it has no objection to starting the planned test programme.

The results of this test programme will be crucial to ASN's decision on whether or not the Flamanville 3 EPR vessel closure head and bottom head are suitable for service. This test programme will run in 2016.

18.2.4.2.2 Qualification of other equipment items

As part of the detailed review of the Flamanville 3 reactor design (see § 18.3) and the examination of the commissioning authorisation application for this reactor, several subjects linked to the qualification of other equipment items are studied:

- qualification under accident conditions which aims to verify that the equipment used in the management of incidents and accidents remains usable under deteriorated environmental conditions;
- equipment reliability, which aims at verifying that the equipment is capable of fulfilling the functions necessary for the safety case with sufficient reliability.

18.2.4.3 Nuclear power reactors in operation

Examination of the installation modification notifications presented by EDF enables ASN to exercise an *a priori* check of the measures taken by EDF to guarantee the long-term durability of the qualification of modified equipment. This check is based on the substantiating documents required by ASN resolution 2014-DC-0420 of 13th February 2014 relative to physical modifications of basic nuclear installations. Changes in equipment qualification methods are examined within this framework.

The inspections conducted by ASN on EDF suppliers' premises, in the EDF engineering centres and the NPPs also aim at checking that the services and goods provided and built meet the specified requirements, particularly those relative to equipment qualification. Any deviations and their combinations are systematically assessed for their effects on the safety of the installation as part of the process that ASN applies to deliver the reactor start-up authorisation after refuelling.

Furthermore, the periodic safety reviews of the NPP reactors can result in modifications to the qualification requirements of several items of equipment due to an extension of the scope of the safety case or a re-evaluation of the constraints with which these items of equipment may be confronted. In order to guarantee that these modifications lead to tangible improvements in the level of safety, ASN has, prior to the 4th periodic safety review of the 900 MWe reactors, undertaken an in-depth assessment of the effectiveness of the organisation deployed by EDF to control the conformity of its installations and their baseline operating requirements with the safety case. The licensee's processes which govern the performance of the plant unit conformity reviews (ECOT), the complementary investigation programmes (PIC), the provisions for managing ageing and obsolescence and the particular tests to perform during the 10-yearly outages will thus be subject to a specific examination during the Advisory Committee of Experts' session devoted to operating experience feedback for the 2012 – 2014 period.

18.3 Design criteria

At the preliminary design study stage for a reactor, the manufacturer can submit a safety options file containing the main characteristics and general design choices in terms of safety (see § 7.2.1). This file can include technical baseline requirements (design or construction code, basic safety rules, ASN guide, etc.) that the licensee proposes using.

Once the nuclear facility has been commissioned after receiving ASN's authorisation, all the modifications made by the licensee that could affect safety, public health and sanitary conditions or protection of nature and the environment are either notified to ASN or subject to ASN authorisation or even, for substantial modifications, to Government authorisation after consulting ASN. The licensee must also perform periodic safety reviews taking into account any changes in techniques and regulations as well as experience feedback.

Lastly, in particular contexts the design criteria may be reviewed at specific safety reassessments.

18.3.1 ASN requests

The general technical regulations include texts of a general nature setting the technical rules in terms of nuclear safety, whether they are of a binding regulatory nature (see § 7.1.3.2) or not (see § 7.1.3.3).

ASN has developed RFS and guides (see Appendix 2) on various technical subjects concerning the BNIs.

The "technical directives for the design and construction of the next generation of pressurised water reactors" adopted by ASN in 2004, define the safety approach and the general safety requirements that ASN considers acceptable to apply for the design and construction of new reactors.

Over and beyond the technical criteria, ASN is also attentive to the conditions that are favourable or prejudicial to operators and worker groups making a positive contribution to the safety of nuclear facilities. In this context, ASN expects organisational and human factors to be integrated in a way that is appropriate for the safety issues concerning safety of the facilities and worker security in the design of a new facility or the modification of an existing one (see chapter 12).

Finally, in the particular context of the stress tests, ASN asked EDF to carry out and revise various design studies relative to the loss of the electrical power supplies and cooling systems of the reactors under construction and in operation.

18.3.2 Measures taken for nuclear power reactors

18.3.2.1 Design criteria (existing reactors and the EPR)

The safety case is based on a limited number of representative events and incident or accident scenarios to be considered at the reactor design stage, among those that could occur during its operation, as well as on the physical states of the reactor. The events initiating transients are grouped in several categories according to their estimated frequency of occurrence and their potential consequences for the environment.

These identified and classified events are used in the design of the primary and secondary cooling systems and the protection and safeguard systems used to control such situations, and consequently serve to prevent consequences that are unacceptable for the facility and its environment.

On the basis of the design of the facility and the control principles, the management of the main incident and accident operating conditions is analysed in the safety report.

Alongside the control of the simple initiating events, situations involving multiple failures that could lead to core meltdown are analysed on the basis of a probabilistic safety assessment (PSA) of the design. On account of defence in depth, additional lines of defence are put in place to prevent core meltdown situations or to mitigate their consequences.

Case of the EPR

- **Risk reduction and prevention of situations that can lead to core meltdown**

A risk-reduction process by preventing situations that can lead to core meltdown is implemented by analysing the combinations of predominant events that can lead to core meltdown situations through multiple failures. The list of multiple failure conditions proposed in this analysis may be revised during the detailed analyses carried out when updating the probabilistic safety assessments.

From the technical aspect, additional safeguard systems have been designed and installed to prevent core meltdown during these sequences.

- **Consideration of hypothetical accidents with core meltdown ("severe accidents") from the design stage**

Apart from the overall reduction in meltdown frequency, the EPR aims to bring a significant reduction in radioactive discharges that can result from all accident situations, including accidents with core meltdown which are taken into account in the EPR design and safety case. In this respect:

- accident situations with core meltdown that would lead to significant early discharges are "practically eliminated": when they cannot be considered as being physically impossible, measures are taken at the design stage to exclude their occurrence;
- the other accident situations with core meltdown are treated such that the corresponding radiological consequences, considering the measures adopted during design (such as corium catcher, spraying, EVU (ultimate heat evacuation) system, containment isolation, ventilation/filtration systems) necessitate only very limited protection measures in both space and time.

The "Severe accidents" process is based on a deterministic approach which identifies the physical phenomena resulting from core meltdown which in principle can affect the integrity of the 3rd containment barrier, the study of which leads to defining of the chosen design measures. Alongside this, the level-2 probabilistic safety assessment (PSA) which covers all the level-1 PSA sequences (apart from hazards) leading to core meltdown or clad failures is carried out; it enables the nature, scale and frequency of discharges outside the reactor containment to be evaluated, and it supplements the deterministic approach of the "severe accident" studies with respect to the situations identified above. It gives reasonable confidence in design conformity with the general safety objectives.

18.3.2.2 Experience feedback from the Fukushima Daiichi NPP accident (existing reactors and EPR)

Loss of electrical power supplies

Each reactor can isolate itself from the electricity transmission system via its step-down transformer. In addition, the reactors have on-site redundant conventional back-up sources capable of supplying the electrical panels vital for correct operation of the safety equipment (two backup diesel generator sets on the reactors of the fleet in operation and four main generator and two ultimate backup diesel-generator sets on the EPR reactor).

Each NPP also has an additional on-site emergency power source whose technology differs according to the plant series concerned.

Electric batteries with a power autonomy of one hour on the reactors in service and two hours on the EPR reactor ensure and guarantee continuity of the electrical supply to certain important equipment items when the generator sets are not operating.

In case of loss of the off-site electrical sources and the abovementioned on-site back-up sources, specific equipment is provided to supply certain items that are critical for managing this situation:

- on each reactor in service, one ultimate electrical power source provided by a turbine generator driven by steam from the steam generators;
- on the EPR reactor, two ultimate backup diesel-generator sets and, in the event of total loss of the electrical power supplies, two separate electrical distribution networks supplied by batteries dedicated to this situation ("24-hour" batteries).

To summarise the situation, EDF has proposed the following measures to counter the risk of loss of the electrical power supplies to the reactors in service:

- an ultimate backup diesel-generator set (DUS) that is robust to hazards will be installed on each reactor before the end of 2018;
- pending installation of the DUS, a small generator set capable of supplying the necessary instrumentation and control in the event of loss of the internal and external power sources and lighting of the control room has been installed on each reactor since the end of June 2013 (see § 17.2.1), in accordance with the ASN prescription;
- the possibility of ensuring an ultimate water make-up of certain tanks (primary system borated water tank (PTR tank), feedwater tank (ASG tank)) and of the spent fuel pool is taken into account by the mobile means and the installation of additional FARN tapping points;

For the EPR reactor, EDF has integrated in the design - in consideration of the hardened safety core scenarios - a provision for extending the autonomy of the ultimate backup diesel-generator sets by a mobile means of supply by gravity topping up of fuel from the main generator set tanks.

Other provisions rendering the EPR robust to other scenarios have also been adopted from the design stage:

- extension of the duration of electrical supply for essential functions by deploying supplementary fixed or mobile electrical power sources;
- means of restarting the instrumentation and control dedicated to severe accidents accidents in the event of failure to recover an electrical power source within 12 hours following the initiating event;
- addition of a mobile and independent water make-up device (motor-driven pump) in the reactor building.

Loss of cooling systems or heat sink

Each pumping station on the reactors of the fleet in operation has two redundant and geographically separate channels. The Flamanville 3 EPR pumping station is made up of four independent and geographically separate trains.

The reactors in service and EPR are designed to have an autonomy of at least 100 hours after a heat sink loss.

If the heat sink loss affects all of a site's reactors simultaneously, the targeted autonomy is 24 hours for coastal sites and 60 hours for riverside sites in the case of an unpredictable hazard, and 72 hours in the case of a predictable hazard, in which case the tanks can be filled to maximum level as a preventive measure.

The pumping station equipment is subject to safety requirements defined in the pumping station baseline safety standard.

No nuclear power reactor apart from the Flamanville 3 EPR currently under construction has an alternate heat sink. This being said, some NPPs have a larger water reserve through their design.

In response to the ASN requirement further to the stress tests, the licensee has carried out an overall review of the design of the heat sink of the reactors with respect to hazards having an impact on the flow and quality of water and the risk of clogging of the heat sink. The results of this design review were submitted to ASN within the set deadlines (end of June 2012). The licensee has identified the solutions it proposes to remedy the weaknesses detected by the robustness analyses. These changes are currently being integrated on the reactors.

Certain measures taken immediately using equipment present on the site enable loss of the heat sink to be compensated for temporarily until it is restored. These measures comprise:

- implementing of a operational control procedure allowing the use of the thermal inertia of the PTR tank as a back-up heat sink;
- maintaining of a make-up pump to ensure borated water make-up and depressurise the reactor by auxiliary spraying;
- resupply of the ASG tank to allow long-term evacuation of the residual power by the steam generators.

In a situation of total loss of heat sink and when the primary cooling system is closed, residual power is removed from the reactor core by the secondary system. In this case EDF identifies a cliff-edge effect related to the water depletion of the auxiliary feedwater tanks supplying the SGs. The time this would take is evaluated at "several days". EDF considers that in all cases the heat sink will have been restored before the core becomes uncovered. In situations where the primary cooling system cannot be pressurised, the residual power is removed by vaporisation of the reactor cavity water in the containment.

The EPR has its own reserve ensuring a water autonomy of at least 100 hours.

In all the configurations studied by EDF, for both the reactors and the spent fuel pools, the estimated time before the feared situation occurs (nuclear fuel uncovering) is greater than the required time estimated by EDF for restoration of the heat sink. EDF has nevertheless proposed an ultimate back-up make-up means specific to each reactor and robust to the hazards considered in the stress tests, which will draw water from the water table or large-capacity ponds using a stand-alone motor-driven pump or an electric pump backed by the ultimate back-up diesel generator. EDF has specified that this system will be installed in phase 2 (see § 6.3.1.3), jointly with deployment of the ultimate backup diesel generator on the reactors.

In response to the ASN requirement further to the stress tests, EDF carried out studies on the requirements assigned to the equipment necessary for controlling total loss of heat sink situations and the proposed changes to the baseline safety requirements and the resulting reinforcements of the installations in order to cope with these situations, in particular for long-duration scenarios.

The situation of total loss of the heat sink combined with total loss of the electrical power supplies has no additional impact compared with the total loss of electrical power alone. This is because loss of the electrical power supplies causes total loss of the heat sink.

Emergency management

On each site, EDF has undertaken the construction of a new local emergency management centre (CCL) that is robust to extreme hazard levels. The CCLs will enable the emergency response teams to ensure long-term management of a serious emergency such as that encountered with the Fukushima Daiichi NPP accident, particularly where several reactors are affected simultaneously.

18.3.3 Measures taken for research reactors

Although the Jules Horowitz Reactor (JHR) is of a very recent design that integrates operating experience feedback from the other experimental reactors, the stress tests process has resulted in the CEA identifying possibilities for improvements that could be implemented in spite of the advanced state of construction. ASN thus considered that some of the proposals made by CEA, which are likely to make the facility more robust, should be implemented. Moreover, making these improvements at the design/construction stage favours prevention, rather than mitigation, of the consequences of possible accident situations. In this context, through ASN resolution 2012-DC-0294 of 26th June 2012, ASN has published a number of additional requirements. In September 2012, CEA proposed its “hardened safety core” for the JHR and ASN prescribed putting in place associated measures through ASN resolution 2015-DC-0477 of 8th January 2015.

In order to facilitate oversight of the progress of construction of this reactor, and pursuant to the resolution setting the requirements for the design and construction of the JHR (ASN resolution 2011-DC-0226 of 27th May 2011), CEA transmits a quarterly progress report for the project. This document allows the identification of the activities or particular points which ASN considers need to be included in its spot checks during its inspections.

18.3.4 ASN analysis and oversight

18.3.4.1 Oversight of construction of the Flamanville 3 EPR reactor

The oversight of construction of the Flamanville 3 reactor comprises an examination of the detailed design, including the studies to define the data necessary for the production and inspection activities which encompass site preparation after delivery of the creation authorisation, manufacture, construction, qualification, assembly and testing of the structures, systems and components, whether on the construction site or on the manufacturers' premises.

This oversight also applies to the manufacturer of the ESPN items that will form part of the nuclear steam supply system (see § 18.2).

With regard to management of the quality of the design and manufacturing activities (excluding NPE) in the shops of suppliers of structures, systems and components for the Flamanville 3 EPR reactor, ASN has observed during its inspections that the organisation put in place in the various EDF departments, whether for engineering or for the teams in charge of monitoring its contractors' activities, was on the whole satisfactory and showed signs of improvement with respect to previous years.

18.3.4.1.1 Detailed design review

At the design stage, the approach for verifying reactor design consistency with respect to the different lines of defence in depth is presented in the preliminary safety report. These elements have been updated in the safety analysis report submitted with the commissioning authorisation application.

The ESPN represents an important subject for nuclear power reactors. The detailed design of the nuclear pressure equipment is examined as part of their conformity assessment.

Technical review of design studies

ASN examines the detailed design with the technical support of IRSN, on the basis of a documentary examination of the elements transmitted by EDF as part of the interchanges prior to submission of the commissioning authorisation application file, or after submitting the file, figuring in the commissioning authorisation application file or in its supporting documentation.

From 2013 to 2015, ASN and IRSN thus examined the detailed design of reactor backup systems and of systems supporting these backup systems. Furthermore, examination of the analysis methods and the rules defined for analysing the incident and accident transients continued over this period.

Four meetings of the GPR were dedicated to Flamanville 3 in 2014 and 2015. They addressed level-1 PSAs, safety classification principles, the appropriateness of operating team organisation for the reactor operational management means, and severe accidents and their radiological consequences.

Oversight of the quality of the design studies and manufacture

In addition to the technical review of the detailed design studies, from 2013 to 2015 ASN conducted inspections in the engineering departments responsible for the detailed design studies and for monitoring manufacturing operations.

During its inspections, ASN observed that the organisation put in place in the various EDF departments, whether for engineering or for the teams in charge of monitoring the activities performed by its contractors, was on the whole satisfactory and showed signs of improvement with respect to previous years.

Oversight of the Flamanville 3 EPR reactor construction activities *and start-up test activities*

Each year ASN performs inspections on the Flamanville 3 EPR reactor construction site, assisted by IRSN.

ASN face numerous challenges in overseeing the construction, start-up tests and preparation for operation of the Flamanville 3 reactor. These concern:

- checking the quality of the equipment manufacturing and installation construction work in a manner commensurate with the safety, radiation protection and environmental protection issues, in order to be able to rule on the ability of the installation to meet the defined requirements;
- capitalising on the experience acquired by each of the actors involved during the construction of this new reactor;
- ensuring that the start-up tests programme is satisfactory, correctly performed and that the required results are obtained;
- ensuring that the teams in charge of operating the installation after commissioning are well-prepared.

Year	Inspections performed	Main themes
2013	22	Civil engineering of the buildings and structures, mechanical and electrical assemblies of the systems and components, planned organisation for the start-up tests, non-destructive inspection of welds, worker radiation protection, environmental protection, impact of the construction activities on reactors 1 and 2 when installing the reactor building dome, and monitoring of outside contractors.
2014	21	Civil engineering of the buildings and structures (pre-stressing of the internal containment in particular), mechanical and electrical assemblies of the systems and components, installation of the instrumentation & control systems, non-destructive inspections of welds, worker radiation protection, environmental protection, first start-up tests, processing deviations, modification management and monitoring of outside contractors.
2015	20	Civil engineering of the buildings and structures (pre-stressing of the internal containment in particular), mechanical and electrical assemblies of the systems and components (large components of the primary system in particular), non-destructive inspections, worker radiation protection, organisation and management of safety within the construction site and within the future reactor operating team, environmental protection, performance of the start-up tests, reception and installation of non-nuclear pressure equipment.

Table 12: Inspections performed on the Flamanville 3 EPR reactor construction site

More specifically, ASN paid particular attention to the following subjects in 2015:

- maintaining a strategy to preserve the equipment and structures present on the construction site until the Flamanville 3 reactor is commissioned. Owing to the reactor commissioning postponements announced by EDF, ASN ensures that EDF continues to pay particular attention to defining and complying with requirements associated with the preservation of the equipment already installed and the structures already built. ASN regularly examines this point during its inspections, in particular ensuring that the risks associated with concomitant activities being carried out in the buildings simultaneously by several trades are taken into account;
- EDF processing of deviations which occurred during the pre-stressing operations. Pre-stressing determines compliance with the requirements relating to the inner containment's ability to withstand an accident situation, a point on which ASN is particularly vigilant. The pre-stressing operations gave rise to deviations concerning the tensioning of the cables and the infilling of the sheaths with grout. ASN was attentive to the implementation of the action plan defined by EDF to process these deviations and prevent them from recurring;
- continuation of the main primary system installation activities and the processing of several deviations. This system contains the reactor core and is thus of primary importance for safety. With regard to EDF activities, ASN has examined EDF's monitoring of the outside contractors involved in the assembly of the primary system, especially Areva NP, the system manufacturer. In this respect ASN is particularly attentive to compliance with work site cleanness requirements

and appropriate management by EDF of concomitant activities conducted near the equipment items;

- the preparation for and performance of the first start-up tests on the ventilation equipment and integration of experience feedback for the continuation of tests in the pumping station. The start-up tests must help demonstrate that the structures, systems and reactor components meet the requirements assigned to them;
- the preparation for operation of Flamanville 3 by the EDF entity which will be responsible for it following construction. This entity currently comprises more than 400 employees. With a view to reactor commissioning, EDF employs a process for gradual transfer of responsibility for the operation of the structures, systems and components from the entity in charge of construction and reactor start-up operations to the entity in charge of its future operation. The steps in this process enable the future operating personnel to improve their skills, familiarise themselves with the reactor equipment, draw up operating documentation and develop the appropriate tools. Through its oversight, ASN verifies whether the future operating teams take advantage of operating experience feedback and best practices employed in EDF's NPPs and whether they optimise their assimilation of the working of the equipment during reactor construction and systems start-up tests.

These verifications reveal that the organisation implemented by EDF has remained satisfactory on the whole. ASN nevertheless considers that EDF must be attentive to the rigour of processing deviations encountered during the start-up tests in order to rule on their representativeness and the acceptability of their results. EDF must moreover remain vigilant regarding the preservation of the equipment already installed.

18.3.4.1.2 Oversight of the manufacture of nuclear pressure equipment

This point is detailed in § 18.2.

18.3.4.2 Oversight of the construction for RJH and ITER reactors

To facilitate oversight of the construction of the Jules Horowitz Reactor (RJH) and ITER, and in application of the resolutions of 27th May 2011 and 12th November 2013 mentioned in § 18.3.3, CEA and ITER Organization (IO) transmit monthly lists of deviations detected on the work site and quarterly project progress reports. These documents allow the identification of the activities or particular points which ASN considers need to be included in its spot checks during its inspections.

Despite the international nature of the ITER project, it is subject to French legislation and regulations with regard to nuclear safety and radiation protection. The oversight and inspections of ITER are ensured by ASN in accordance with the same provisions as for the other BNIs on French territory. A framework programme concerning inspections and oversight has been drawn up by ASN and IO in accordance with the provisions of article 3 of the agreement of 7th November 2007 relative to the head office and the privileges and immunities of the ITER Organisation on French territory. The majority of the inspections conducted by ASN focus on the construction-design and the monitoring of outside contractors by the licensee.

19. Article 19: Operation

Each Contracting Party shall take the 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 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 Commissioning of a BNI

19.1.1 ASN requests

Commissioning corresponds to the first use of radioactive materials in the installation.

In application of the BNI procedures decree, the introduction of nuclear fuel into the perimeter of the installation and starting of the installation are subject to ASN authorisation. One year before the planned date of commissioning and 6 months before nuclear fuel is introduced into the BNI perimeter the licensee must send ASN a file comprising:

- the safety report (SAR);
- the general operating rules (RGE);
- a study of the installation's waste management;
- the on-site emergency plan (PUI), the decommissioning plan;
- the update of the impact study of the installation.

After checking that the installation complies with the objectives and rules specified in the Law and its implementing texts, ASN authorises the commissioning of the installation and communicates this decision to the Minister responsible for nuclear safety and to the Prefect.

Before the actual authorisation procedure is started or completed, partial commissioning may be authorised by an ASN resolution for a limited period of time in the following cases:

- the performance of specific operating tests requiring the introduction of radioactive materials into the installation;
- the introduction of nuclear fuel into the perimeter of the reactor before the first loading of fuel into this reactor (see § 19.1.4.1).

The resolution authorising commissioning sets the deadline for the licensee to submit to ASN a start-up completion file for the installation, comprising:

- a summary report of the installation start-up tests;
- a review of acquired operating experience;
- an update of the documents constituting the commissioning application.

The BNI procedures decree also applies to the commissioning of research reactors.

19.1.2 Measures taken for nuclear power reactors

19.1.2.1 Reactor commissioning at EDF

The commissioning tests comprise:

- preliminary tests: blank tests, pump-rotation tests, cleaning of circuits, etc;
- overall tests at the different stages of progress during commissioning.

The commissioning tests follow test procedure programmes which specify, for each elementary system or category of tests, the aim and the list of tests to be carried out for commissioning of the function, and the criteria to be satisfied.

Analysis of the results by the site personnel and the engineering centres may lead to retests. The tests are scheduled and coordinated by a group comprising the licensee and the manufacturers.

An on-site test committee meets at each important transition from one overall test phase to another. This committee comprises representatives from EDF and the manufacturers.

Preparation for operation of the Flamanville 3 EPR reactor

A unit of licensees based in Flamanville 3 is conducting the preparatory work for operation of the future reactors and is putting in place extensive training to develop personnel skills before start-up.

The site is preparing for operation in order to attain the top international standards, using the IAEA and WANO baselines as levers in collaboration with the other EPR licensees.

The site is putting in place the safety fundamentals and developing the safety culture of the personnel.

An independent safety organisation is in place. It oversees the quality of the activities carried out on the Unit and implements an annual programme of audits and verifications.

The site is continuing its contribution to the operating baseline requirements, and the RGE in particular, in collaboration with the designer, by checking their applicability with the help of Human Factors experts.

Preparation of the operating and maintenance documentation, which began in 2010, is also continuing with the drafting of optimised maintenance programmes and initialisation of the databases used for the multiyear programming and performance of the operating activities.

The process for transferring the elementary systems from the manufacturer to the future licensee is already in progress and is based on detailed verifications of conformity.

A first dummy fresh fuel reception exercise was carried out at the end of 2015 demonstrating the licensee's capability to receive the fuel.

The first exercises deploying part of the emergency response organisation integrating the lessons learned from the Fukushima Daiichi NPP accident were carried out in late 2015. Preparation for operation will continue in 2016 and 2017, focusing on:

- the finalisation of the operating documentation;
- participation in the start-up tests in close collaboration with the designer;
- gradual takeover of operation of the installation as the transfers proceed;
- preparation for the international start-up assessments (pre-start up WANO and pre-operational IAEA OSART peer reviews;
- sharing experience with the other EPR licensees and integration of international operating experience feedback from the sites in the start-up phase (WANO and IAEA).

19.1.3 Measures taken for research reactors

The commissioning authorisation is associated with the notification of prescriptions that the licensee endeavours to verify before effective start-up of the installation.

Commissioning tests are also carried out to verify that all the elements important for protection of the installation are functioning correctly and to declare that the elements concerned are available in compliance with their defined requirements.

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.

19.1.4 ASN analysis and oversight

19.1.4.1 Nuclear power reactors

On 19th March 2015, ASN received the commissioning authorisation application for Flamanville 3. Assisted by IRSN, its technical support organisation, ASN carried out a preliminary review of this application to check that it contains all the documents required by the regulations and the necessary information to allow a full technical examination. Following this preliminary examination, ASN confirmed that all the documents required by the regulations were indeed present but it considered that additional information was needed to enable ASN to rule on a possible commissioning authorisation for Flamanville 3. The additional information requested more specifically concerns the conformity of the as-built installation with the submitted file, the dimensioning of the systems and the accident studies.

ASN has nevertheless started the detailed technical examination of the file on the subjects for which few elements were missing, as indicated in § 18.3.4.1.

Furthermore, on 19th March 2015, ASN received the partial commissioning authorisation application for Flamanville 3 needed to admit fuel within the perimeter of the facility and carry out certain tests. ASN carried out a preliminary examination of this file, which concluded that a certain amount of additional information was required, more specifically to assess the risks and detrimental effects which could result from tests using radioactive tracer gases to verify the correct operation of certain effluent treatment systems.

Lastly, in 2013 ASN supplemented the technical prescriptions applicable to Flamanville 3 with prescriptions relative to the preparation and performance of the future start-up tests (see resolution 2013-DC-0347). These tests aim at verifying that the actual behaviour of the installation is indeed the same as that provided for in the safety analyses. The ASN technical prescriptions specify the procedures to follow to define the tests and prove their adequacy, draw up the documentation necessary for performance of the tests, and then perform the tests. The prescriptions also indicate the elements to transmit to ASN so that it can track the progress of the test programme and be informed of any deviations encountered.

ASN examines the start-up test programmes planned at Flamanville 3 on a random basis, assisted by IRSN. Since the first preliminary tests were performed in autumn 2014, ASN has conducted regular inspections to verify compliance with the prescriptions of resolution 2013-DC-0347.

19.1.4.2 Research reactors

In 2015, applying a procedure very similar to that for commissioning, ASN authorised divergence of the modified Cabri reactor following lengthy works by CEA to modify the sodium loop in the pressurised water loop.

In the context of the follow-ups to the creation authorisation for the ITER and RJH installations, additional demonstrations were requested or prescribed by ASN, which set the deadline for some of them as the date of commissioning (partial or complete) of these installations. Articles 4 and 20 of the decree of 2nd November 2007 concerning the commissioning authorisation procedure for a BNI provide for the licensee to transmit documents to ASN one year before the planned commissioning authorisation date.

19.2 The operating range of BNIs

Pursuant to the decree of 2nd November 2007, in view of the commissioning of a BNI, the licensee sends ASN a file containing the RGE which describe the operating conditions by transforming the initial hypotheses and the conclusions of the safety studies taken from the safety analysis report into operating rules. Implementation of this collection of rules is authorised by ASN before the installation is commissioned. Any modification in the abovementioned rules is notified to ASN and examined before being implemented if the said modification affects the level of safety of the installation.

19.2.1 ASN requests

19.2.1.1 ASN requirements for nuclear power reactors

The RGE for nuclear power reactors comprise several chapters, the main ones being:

- chapter III which describes the operating technical specifications (STE) that delimit the normal operating range of the reactor. The STEs also specify the actions to take if these limits are exceeded. They also identify the equipment required according to the operating range of the reactor and indicate the steps to take should this equipment malfunction or be out of service.

- chapter VI which contains the operating procedures for incident and accident situations. It specifies the action to be taken in these situations to maintain or restore the fundamental safety functions and return the reactor to a safe state.
- chapter IX which defines the inspection and periodic test programmes applied to verify the availability of the equipment and systems that are important for safety. If results are unsatisfactory, the action to take is specified in the STEs.
- chapter X which defines the programme of physical tests for the reactor core to ensure monitoring of the core during restarting and operation of the reactor.

EDF may be led to modify permanently the STEs in order to integrate its experience feedback, to enhance the safety of its installations, to improve its economic output or to take into account the impact of physical changes.

In exceptional circumstances, if EDF has to diverge from the normal operating procedures dictated by the STEs, this constitutes a deviation which must be notified to ASN.

ASN also ensures that the temporary modifications are justified and carries out each year an in-depth examination of them, on the basis of an assessment prepared by EDF. Hence, EDF is required to:

- re-examine periodically the soundness of the temporary changes in order to identify those that would justify a request for a permanent change to the STEs, and;
- identify any generic changes, notably those associated with the implementation of national physical changes and periodic tests.

In 2014, ASN authorised EDF to put in place an internal authorisation system enabling it to examine completely independently the temporary modifications to the STEs which have a minor impact on safety. The implementation of temporary modifications to the STEs which do not lie within the scope of the internal authorisation system remain subject to the prior agreement of ASN.

19.2.1.2 ASN requirements for research reactors

The perimeter covered by the RGEs for the research reactors is the same as for the nuclear power reactors. The provisions defined therein remain commensurate with the safety issues and take into account the particularity of operation of some of these reactors which operate in divergent condition for very few hours per year during the experiments (Cabri reactor).

The regulatory process for granting licensees the right to implement RGE modifications is the same as for the nuclear power reactors, as was described earlier. Furthermore, research reactor licensees also use the regulatory provision (article 27 of decree 1557-2007) which gives ASN the possibility of dispensing a licensee from the procedure for notifying modifications of its installations. This remains possible for operations of minor importance only, and on condition that the licensee institutes an internal verification system providing sufficient guarantees of quality, autonomy and transparency.

19.2.2 Measures taken for nuclear power reactors

For each operating range, the STEs define the required operating envelope, that is to say the limits for the physical parameters and the safety functions that must be available. A system or equipment item is available if, and only if, it can be demonstrated that it is capable of performing its assigned functions with the required performance levels (commissionning time, for example):

- in particular, the auxiliary equipment items required for its operation and its instrumentation and control are themselves available;
- the periodic test programmes in the general operating rules concerning these equipment items or systems are carried out in a normal manner (compliance with specified frequency, including tolerance, and procedure) and the results are satisfactory.

Unavailability can be:

- unscheduled: unexpected discovery of an operating anomaly on the equipment concerned;
- scheduled: its frequency and cause are known and predetermined (execution of a preventive maintenance programme or periodic tests);
- other: neither unscheduled nor scheduled. This is the case for example with unavailability due to the incorporation of a modification.

Any noncompliance with an STE rule (e.g. exceeding an range condition limit, unavailability of a required equipment item) constitutes an event. For each operating range, the STEs define the action to take following an event: fallback state, time taken to enter fallback state or repair time.

Fallback state is a reactor state in which the event either does not affect the safety of the reactor, or affects it to a lesser extent. Transition from the initial operating state to fallback state is made by applying normal operating procedures.

The actions for making the transition to the fallback state must always begin within the required "initiation" period, which provides the time to make a diagnosis, assess the situation, consider a repair and prepare for the transition to the fallback state. A repair time is authorized in order to attempt to make the required equipment available again.

Since September 2014, EDF has put in place, under article 27 of decree 2007-1557 of 2nd November 2007 and with the authorisation of ASN, an Internal Authorisation System for Temporary Modifications to the STEs (abbreviated in French to "SAI MT STE"), the implementation of which is governed by an organisation memo defining the eligibility criteria in particular.

Any waiver to the STEs which is not eligible for the Internal Authorisation System (SAI) must be agreed by ASN.

19.2.3 Measures taken for research reactors

19.2.3.1 CEA reactors

The operation of research reactors is based on the RGEs which supplement the safety analysis report for the operational aspects. The waste study and the on-site emergency plan for the centre supplement the RGEs.

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.

Requests for temporary modifications to the RGEs may be submitted to ASN on the basis of an in-depth safety analysis and a justification file.

A system of internal authorisations has been put in place for minor operations.

Experimental systems designed and operated in the facilities likewise comply with specified safety requirements. A complete safety analysis taking into account the reactor safety baseline requirements must demonstrate that the potential risks have been taken into consideration and that overall safety is ensured.

A technical design guide drawn up by DPSN (CEA's nuclear safety and protection division) defines the design and construction rules and the safety analysis of experimental systems. It serves among other things to determine the safety requirement levels and the technical provisions to adopt with respect to the safety issues. Operation of these systems is subject to the granting of a license.

19.2.3.2 The ILL high-flux reactor (HFR)

See § 17.3.

19.2.4 ASN's oversight and analysis

19.2.4.1 ASN's oversight and analysis of the nuclear power reactors

During its NPP inspections, ASN focuses on checking:

- compliance with the STEs and, if applicable, compensatory measures associated with temporary changes;
- the quality of normal operating documents, such as instructions and alarm sheets, and their consistency with the STEs;
- the training of operators in operational management of the reactor.

Although the procedure for periodic integration of operating experience feedback from the recurrent temporary modifications of the STEs implemented since 2010 by EDF aims at reinforcing the stability of the reactor' operating baseline requirements to facilitate their assimilation by the operators concerned, in 2015 ASN noted an increase in the larger-scale modifications to these baseline requirements concomitant with the integration of operating experience feedback. Under such conditions, achieving the objective of stability seems compromised, even though significant modifications to these baseline requirements are in the offing as the fourth periodic safety review of the 900 MWe reactors approaches. The preparation and integration of modifications to the STEs must therefore be subject to increased vigilance.

Management of operating activities is on the whole satisfactory.

Although a few one-off cases of deviations from the STEs are the consequences of problems with equipment, the most frequent deviations result from human failings or the operating organisation. A large proportion of these events lead to the unavailability of systems important for safety. ASN has taken note of the steps taken by EDF to correct these deviations.

The internal authorisation system implemented by EDF was inspected by ASN in 2015.

19.2.4.2 ASN's oversight and analysis of the research reactors

Inspections on the theme of operating rigour are also carried out on the research reactors. They focus essentially on reviewing the organisational setup and conducting random checks of compliance with the operating conditions and performance of the periodic tests. Human and organisational factors (HOF) are being taken into account in the revision of these procedures.

19.3 Operating, maintenance, inspection and test procedures

19.3.1 ASN requests

The BNI order defines the responsibilities of nuclear installation licensees and specifies the items important for protection (EIP). These EIP must undergo a qualification process that is representative of the requirements they must satisfy. Maintaining this qualification over time requires the implementing of appropriate construction, tests, inspection and maintenance provisions.

The nuclear power reactors and the research reactors are operated in accordance with the general operating rules (see § 19.2).

Other documents remain for nuclear power reactors, such as those describing the in-service inspection and maintenance operations to be carried out on the equipment.

Several maintenance methodologies have been developed by EDF and reviewed by ASN with the technical support of IRSN.

Main primary and secondary systems

The main primary and secondary systems are subject to non-destructive tests in service and full requalification every 10 years.

ASN ensures that the periodic technical checks on these elements defined by the licensee are pertinent and are continuously improved.

19.3.2 Measures taken for nuclear power reactors

19.3.2.1 Inspections and tests

The purpose of the periodic tests is to verify, throughout reactor operation with a sufficient level of confidence and insofar as the initial availability has been guaranteed:

- the availability of the safety-classified equipment and systems (see 19.2.2);
- compliance with the assumptions chosen for the operating conditions taken into account in the accident studies in the safety analysis report.

The periodic tests described in chapter IX of the general operating rules (RGE) concern the elementary systems that are classified as important for the safety (IPS) of the nuclear installation. The IPS systems form the subject of an exhaustiveness analysis note. This note aims to determine all the inspections necessary to guarantee the availability of the equipment items and their ability to fulfil their function. The periodic test rules and the associated summary tables are submitted to ASN.

Satisfactory performance of the periodic test programmes of the RGEs is one of the prerequisites for declaring that the equipment items and systems are available in accordance with the definition of availability given in the STEs. If this is not the case, the item concerned must be declared unavailable.

In 2006, EDF launched an action plan designed to enhance the quality of periodic testing programmes and to improve the integration of measurement inaccuracies, by calling upon the experience feedback from 20 years of operation. The last documentary changes relating to these improvements are integrated during the multi-annual revisions of the periodic testing programmes.

19.3.2.2 Maintenance

EDF's maintenance policy for the nuclear fleet in operation is structured to enhance the reliability of the equipment and systems, increase competitiveness and prepare the future, to guarantee throughout the installation's life cycle that the EIPs are capable of fulfilling their assigned functions with respect to stresses and ambient conditions that can prevail in the situations for which they are required, in accordance with the installation's Creation Authorisation File.

It has the following operational objectives:

- Draw up the programmes, the maintenance requirements and the chemical specifications to guarantee the required reliability of the systems, structures and components over the operating life of the reactors;
- Maintain and monitor the systems, structures and components, and guarantee the appropriateness and quality of the maintenance and monitoring activities, in compliance with the programmes;
- Maintain equipment qualification for accident conditions;
- Ensure the availability of spare parts, deal with equipment obsolescence and ensure the long-term durability of the industrial capabilities;
- Maintain control over equipment ageing and reliability in order to minimise, insofar as is reasonably possible, failures of components that are critical for compliance with protected interests and operation of the installation, and maintain failures of components and functions of significant importance at an acceptable value. An iterative continuous improvement process is in place; it aims at analysing any deteriorations or failures in order to optimise maintenance;
- Ensure that maintenance operations are carried out in accordance with a predetermined and lasting industrial strategy.

Organisation of maintenance

Certain preventive maintenance actions are carried out to ensure compliance with regulations and the requirements of protected interests, as well as to cater for the risks associated with operation of the nuclear fleet.

The preventive maintenance actions are:

- Derived from the regulatory domain. This domain covers in particular:
  - in-service monitoring of the main primary system and the main secondary systems;
  - in-service monitoring of the nuclear pressure equipment (NPE);
  - in-service monitoring of the other pressure equipment;
  - the in-service checks aiming to prevent and mitigate the nuisance factors and external risk resulting from operation of the BNIs;
  - the monitoring and maintenance of equipment meeting the requirements indicated under the Labour Code, the Public Health Code or the Environment Code;
- Imposed by the maintaining of the qualification for accident conditions;

- Resulting from the orientations set by the licensee. They are defined on the basis of different methodologies according to the nature of the equipment and structures (reliability-based maintenance optimisation methods, AP-913 (Advanced Process 913, an equipment reliability optimisation method), and maintenance doctrines).

Objectives of the maintenance programmes

The equipment and elementary systems classified as EIPs (elements important for protection) and selected to be subject to National basic maintenance programmes are identified on the basis of the implications for the Fleet (safety, radiation protection, environment, regulations, assets, availability, costs, security).

The preventive maintenance actions for the high-risk EIP equipment and systems are defined in the national basic maintenance programmes which specify the nature and substance of the tasks and the frequency of these actions. The programmes follow a continuous improvement process based on operating experience feedback from the systems, structures and components.

If an EIP equipment item or elementary system is not identified as "high risk", it is not necessarily subject to national requirements. Local issues can nevertheless lead individual NPPs, if they consider it necessary, to define local preventive maintenance programmes as a complement to any prescriptions decided by the DPN, based on their quality organisation and analysis of operating experience feedback.

Preventive maintenance helps ensure compliance with regulatory requirements and protected interests, and maintain the reliability and service life of the systems, structures and components.

Preventive maintenance programmes therefore consist of rules which aim at preventing failures of a system, structure or component, according to its importance for the protected interests and the licensee's challenges.

Scheduling the maintenance activities

The preventive maintenance activities are planned on a schedule in compliance with their conditions of performance (reactor in operation or during periodic outage, for example) and their frequency.

They are planned in compliance with the conditions laid down in the RGE.

Management of the maintenance activities

The maintenance activities identified as important for protection of the Protected Interests within the meaning of the BNI order are subject to the following requirements:

- work preparation including the constitution of a file that is written, checked and approved by authorised agents;
- conducting of the work using appropriate means;
- requalification after the work, which consists in verifying operation of the equipment or system to ensure that the required design performance levels are maintained or restored after the maintenance work, modifications or operating events;
- putting back into operation after the maintenance work when equipment availability is demonstrated further to requalification;
- detecting and processing deviations: any deviation from a defined requirement is subject to identification and a formalised analysis:

- Deviations are processed applying an approach that is commensurate with the risks. Processing a deviation consists in determining the technical, organisational and human causes, defining the curative and, if necessary, corrective and preventive actions, implementing these actions and assessing their effectiveness. For deviations of minor importance, maintaining as is or carrying out curative actions may be considered sufficient, without prejudice to the examination of the possible generic nature of the deviation.
- production of a work report to turn the experience feedback to good account

Experience feedback

An experience feedback process is organised at local and national level through organisational measures and bodies for processing the collected data (findings, events, operating data, etc.) on an appropriate time scale for the risks and operating requirements. It is highlighted as part of the monitoring of equipment performance to improve the maintenance baseline requirements and practices.

Control of ageing

As part of the defence in depth approach, a programme for analysing the ageing modes of certain EIPs is put in place as from the preparation for the 3rd 10-yearly outages, integrating in particular operating experience feedback and the current state of knowledge. The aim of this programme is to verify the adequacy of the operating and maintenance measures to control the ageing of EIPs.

Spare parts procurement

The process for procuring equipment and spare parts contributes to the long-term durability of EIP qualification. It aims at obtaining items identical to those to be replaced, except when obsolescence or operating experience feedback dictates otherwise. This process is based on a quality management system and contractual requirements which guarantee a logistic and technical response that is appropriate for the sites' equipment and spare parts requirements.

In this context, and to avoid calling into question the initial design by ensuring interchangeability from the functional, dimensional, reliability and resistances aspects, the procurement of spare parts forms the subject of:

- specifications and contractual technical conditions which meet the equipment design requirements, the regulatory requirements, the quality requirements and requirements concerning the EDF codification and in-house technical specifications;
- monitoring, traceability and documenting of product manufacture in compliance with the prescriptions setting the requirements relative to quality assurance, monitoring implementation, identification rules for the delivered equipment and spare parts, the documents to provide according to the contract and the rules for their transmission;
- storage conditions guaranteeing preservation of the quality of the spare parts until they are used.

19.3.3 Measures taken for research reactors

19.3.3.1 CEA reactors

A set of procedures and instructions managed by the relevant services ensure that all the operations are carried out in compliance with the applicable rules, rules with which outside contractors must also comply.

The licensee must ensure that the contractors comply with these rules.

Experimental systems designed and operated in the facilities likewise comply with very strict safety requirements.

A technical design guide drawn up by the CEA's DPSN defines the design and construction rules and the safety analysis of experimental systems. It serves among other things to determine the safety requirement levels and the technical provisions to adopt with respect to the safety implications.

In order to check the operation of items important for safety in each facility and ensure their availability, they undergo inspections and periodic tests. Their frequency is precisely defined and can be calendar-based or event-based.

Satisfactory performance of these tests at the required frequency enables the items concerned to be declared available. The aim of systematic maintenance is to prevent failures of these items of equipment and to preserve their capability to fulfil their function with the required performance. This preventive maintenance is carried out periodically in the same way as the inspections and periodic tests, in accordance with validated procedures and accompanied by a risk analysis if the intervention could affect safety.

19.3.3.2 The ILL high-flux reactor (RHF)

The measures taken for the Laue Langevin Institute (ILL) reactor are similar to those taken for the CEA reactors.

19.3.4 ASN analysis and oversight

19.3.4.1 Nuclear power reactors

19.3.4.1.1 Operation of the reactors

In 2015, a number of activities governed by prescriptive documents, such as the performance of periodic tests, were the cause of significant events. The root causes of these events are numerous and cumulative. Among them, ASN notes deficiencies in activity preparation, meaning that the persons concerned are not sufficiently aware of the risks involved or of the applicable documentation. ASN also notes the need to minimise the possible interpretations of these documents and take account of the differences in know-how and expertise among the personnel concerned. The preparation and integration of changes to the general operating rules need to be improved.

This situation is indicative of the insufficient involvement of the head office departments in monitoring the integration of the prescriptive documents by the NPPs. It is also indicative of external operating experience feedback (OEF) management that is not yet robust enough, both between the sites and with respect to EDF head office departments. It particularly highlights the need to reinforce the national OEF loop in order to improve the documentary production process.

With regard to the periodic tests, the efforts in the management of their planning, preparation and performance must be maintained. Furthermore, both the prior analysis of the operation and the interpretation of the results need to be taken to greater depth. ASN also considers that the process used by EDF for retrospective ruling on the validity of the tests needs to be reinforced in order to promote a questioning attitude.

19.3.4.1.2 Maintenance activities

ASN notes that the number of detected quality deficiencies associated with maintenance activities is generally stable. ASN nevertheless observes that the workers have to deal with constraints linked to work organisation, the preparation for certain activities, and worksite scheduling and coordination which lead to activity delays or postponements.

ASN notes that EDF has implemented a specific multi-year action plan designed to reinforce management of activities scheduled and carried out during maintenance outages of nuclear power reactors. Even if this action plan allows calmer management of the work preparation and performance phases by the licensee, ASN considers that EDF must continue its efforts over the long term, in particular with the prospect of the operating life extension of the reactors, the “major overhaul” programme and the lessons learned from the Fukushima Daiichi NPP accident, which lead to an increased volume of maintenance activities, as well as a high level of renewal of skills.

With regard to the implementation of the maintenance methods by the sites, ASN considers that EDF's situation can be improved and that recurrent shortcomings persist:

- although their number is falling, management deficiencies in activities concerning spare parts procurement and the repair of equipment persist;
- delays in the inspections or in incorporating new maintenance programmes into the documents lead to belated detection of deviations or equipment deterioration;
- the management of maintaining equipment qualification for accident operating conditions and of equipment requalification operations varies from one site to another.

Since 2010, EDF has been deploying a new maintenance methodology known as AP-913 (see § 19.3.2.2). The main benefit of this method is to aim for improved equipment reliability through in-service monitoring in order to improve preventive maintenance and through sharing of maintenance practices among the NPPs. However, ASN considers that proactive steps must be taken with the NPPs to allow correct implementation of this new method and ensure that it is effective. EDF must in particular more closely oversee the implementation of AP-913 in its various NPPs and allocate the necessary manpower to this task. EDF must also ensure that all participants follow the recommended methods for filling out the equipment monitoring indicators, for the preparation, performance and write-up of field visits and for the traceability of maintenance decisions.

19.3.4.1.3 Condition of equipment

The various maintenance programmes implemented by the licensee help maintain the equipment of the NPPs in generally satisfactory condition.

This being said, apart from the question of obsolescence, ASN considers that EDF must tighten its management of maintaining of equipment qualification for accident conditions. ASN notes that in 2011, EDF launched an action plan for management of the requirements regarding qualification of equipment and spare parts for accident conditions; ASN will closely monitor its effective implementation.

The first barrier

ASN considers that in 2015 the situation regarding the first barrier is getting better on the whole, even though certain points can be improved. It noted in particular that the organisation set up to prevent foreign material entering the primary system once again made progress this year.

In 2014, further to an ASN request, EDF adopted measures limiting the oxidisation of the Zircaloy-4 alloy cladding and keeping control rod movements to the strict minimum necessary once the calculated oxide thickness reaches 80 µm. In July 2015, 31 reactors were still using fuel assemblies with Zircaloy-4 cladding.

Pressure equipment and the second barrier

The situation of the nuclear pressure equipment in service in the EDF nuclear power reactors in operation is satisfactory on the whole.

The requirements of the regulations, more particularly with regard to maintenance work, processing defects, visits and periodic requalification of the main primary and secondary systems, are satisfied on the whole.

In 2011, the discovery of stress corrosion cracking on a bottom-mounted instrumentation (BMI) penetration on Gravelines reactor 1 led ASN to ask EDF to begin BMI penetration inspections on all the reactors. No similar indication has so far been detected on the other reactors. EDF has developed a process for repairing this defect which is to be implemented in 2016.

The third barrier and the confinement

It is considered that the condition of confinement, in particular the third barrier and its components, can be improved. The number of events relating to confinement has increased slightly, corresponding to the overall increase in the number of significant events in 2012.

The ageing of the 900 MWe reactor containments was examined in 2005 during the review associated with their third ten-yearly outage.

The results of the ten-year tests of the reactor containments have hitherto shown leak rates in compliance with the regulatory criteria. However, the results of the containment test on Bugey reactor 5, which met the criteria set by the general operating rules, were nevertheless not as satisfactory as those of the previous test 10 years ago. EDF has started to seek the cause of the increase in the containment leakage rate. An additional test of the containment carried out in 2015 revealed the need for repairs.

The results of the ten-year tests of the 1300 MWe and 1450 MWe reactor containments revealed an increase in the leak rates of the inner wall of some of these containments. This increase results notably from the combined effects of the deformation of the concrete and the loss of the prestressing in certain cables. Although these phenomena had been taken into consideration in the design, they were sometimes underestimated. EDF has implemented a repair programme using a resin liner in order to restore the leak-tightness of the most severely affected areas. The tests performed following the work all proved to be satisfactory.

An analysis of the issues linked to the 1300 MWe and 1450 MWe reactor containments was examined in preparation for the third ten-yearly outage inspections of the 1300 MWe reactors. ASN issued a ruling on this subject in 2014 and will be attentive to compliance with the undertakings that EDF made on this occasion.

19.3.4.2 Research reactors

Internal authorisation

The CEA has been authorised to implement an internal authorisation system (see § 7.3.2.2) since 2002. The framework of this system, which concerned some fifteen facilities, reactors, laboratories and "support" facilities, and the conditions of updating the baseline safety requirements have been covered by two ASN guides.

The experience feedback from almost 10 years of application of this system has enriched the internal authorisation criteria and increased process robustness. It has also confirmed the effectiveness of this system and did not reveal any significant or deliberate shortcomings of safety rules.

In March 2009, the CEA submitted a file which was supplemented in 2009, presenting the implementation particularities specific to this licensee. The ASN resolution approving this file was taken in March 2010.

For research-reactor operators, the internal authorisation system provides more flexibility in the management of the changes to be brought to their installations, which sometimes prove necessary for certain experiments, by ensuring better control over time of the delivery process of some authorisations. It enables ASN to focus its resources on the subjects and modification projects that represent the most significant risks for safety in accordance with a proportionate approach.

The safety of experimental devices

Some research reactors undergo regular core-configuration changes due to the experiments they host. Others accommodate specific experimental devices designed for the performance of certain types of experiments. One of ASN's challenges is to allow new experiments to be conducted on a regular basis, while ensuring that they are run under acceptable safety conditions.

The conditions pertaining to design, performance and irradiation authorisation of the experimental devices have been the subject of many exchanges between ASN and CEA for several years, resulting in the drafting of a CEA technical guide in 2006. This guide specifies the safety approach to use, the requirement levels and the technical provisions to adopt with respect to the safety implications, and precisely defines the content of the safety analysis file.

In 2014, ASN verified application of the approach of this technical guide to the case of an experimental system.

19.4 Management of incidents and accidents

19.4.1 ASN requests

The operating range of the nuclear facilities is set by the general operating rules which include the operational management procedures for incident and accident situations.

Stress Tests

The procedures necessary for the management of incidents and accidents were examined as part of the stress tests for situations going beyond the current baseline safety requirements. The warning and management procedures implemented on the sites to protect against flooding were also analysed.

19.4.2 Measures taken for nuclear power reactors

The operating parameters are monitored continuously and in the event of pre-set limits being exceeded, automatic systems trigger an alarm in the control room so that the operators can analyse the situation and take appropriate measures, in particular as required by operation technical specifications (STE). The analysis of alarms and physical variables may lead the operator to make a diagnosis that results in entry into an incident procedure.

For this purpose, all the nuclear sites in the EDF fleet today use the state-based approach (APE), method which covers all “thermal-hydraulic” incidents or accidents, whether single or multiple and whether or not combined with loss of systems, loss of electrical power or human failures. Its primary goal is to prevent the risk of core meltdown.

In the hypothetical case of core meltdown, the primary objective becomes to safeguard the containment. The reactor operation must for its part, take account of the new and complex phenomena that will occur as the accident develops, as well as the difficulty of diagnosing the reactor condition in a severely degraded situation. In this situation, the primary objective is to safeguard the confinement. The operating strategy in this case is contained in the Severe Accident Management Guidelines (SAMG).

The decision to apply the SAMG, which marks the abandonment of state-based approach procedures, is taken on criteria concerning the core outlet temperature and the dose rate in the containment. The Ultimate Backup Diesel Generator will be able in particular, to provide electrical back-up for the instrumentation allowing management of the severe accident situation.

In the stress tests report, EDF had reminded the existing measures in response to the identified risk in a severe accident situation.

- **Risk due to the production of hydrogen:**
  - Since the end of 2007, all the reactors in service are equipped with hydrogen passive autocatalytic recombiners (PAR). Associated operating provisions are applicable on the sites. EDF also studied the hydrogen risk in the other peripheral buildings of the reactor containment.
  - This study confirms that the time it takes to exceed the ignition threshold in the premises, including in the most penalising case is - for all the plant series of the nuclear fleet in operation - compatible with the implementation of measures to prevent the risk of combustion in the peripheral buildings.
  - The Flamanville EPR has PARs and devices for monitoring the hydrogen concentration in the various containment compartments.
- **Risk of slow pressurisation of the containment:**

  On the reactor fleet, the time before containment is lost due to exceeding of the containment mechanical characteristics varies from one to several days depending on the assumptions adopted for the studies. EDF considers that this leaves the operator the time to take steps to avoid containment destruction while optimising control of radioactive releases. This risk is countered by a containment venting-filtration system and the associated operating procedure that preserves its long-term integrity. This system opens at the earliest 24 hours after a minimum pressure equal to the containment design pressure has been reached. Thanks to the filtration of long-lived products which constitute the aerosols, such as caesium-137, the opening of this system mitigates the long-term radiological consequences. In response to an ASN prescription, EDF studied the possibilities of improving this venting-filtration system, including a review of the hydrogen risk and its potential consequences, and the resistance to earthquakes. The results were transmitted at the end of 2013.

  Further to this study, EDF decided to deploy an additional system to preserve containment integrity without opening the venting system in a "hardened safety core" situation. This system consists in cooling the water injected into the tank by the hardened safety core pump during the phases of recirculation on the containment sumps by means of an ultimate heat sink that is independent of the RRI (component cooling system) / SEC (essential service water system which cools the RRI) and the normal heat sink. This system is called EAS-u. It will be implemented in phase 3 of the post-Fukushima project. A filtration assessment concludes that the H_2 risk in the existing U5 filter is under control. The existing U5 filter will be reinforced to withstand the MHPE (maximum historically probable earthquake) and sodium tetraborate baskets for trapping the organic iodine in the containment are currently being installed on the reactors that do not have SIC (Silver-Indium-Cadmium alloy) clusters on the 1300 MWe/N4 plant series (see further on). These provisions together will mitigate the short and long-term consequences.

On the EPR reactor, the system for ultimate removal of heat from the reactor building (EVU system) enables the pressure in the containment to be controlled under all the accident situations, including accidents with core meltdown, considered in the EPR safety case.

- **Risk of reactor containment leak-tightness fault:**
  - On the reactors in service, confirmation of the isolation of the containment penetrations is required as part of the immediate actions on entry into a severe accident situation. The activity is monitored so that restoration measures can be implemented if necessary. Temporary Safety Instructions (ITS) have been implemented further to the stress tests to ensure closure of the motor-driven containment penetration valves that remain open. By 2018 at the latest, the DUS (ultimate back-up diesel generator set) will enable the train A containment penetration valves to be resupplied in the event of a station blackout (SBO) situation. The hardened safety core will allow the containment to be isolated.
  - On the EPR, the containment and the peripheral buildings are designed such that there is no direct leakage path from the reactor containment to the environment.
- **Risk of direct containment heating:**
  - To avoid direct containment heating (DCH), the severe accident (SA) operating procedure on the reactors in service requires depressurisation of the primary system by opening the pressuriser relief lines immediately on entry into the SA situation. A hardware modification (integration of a bistable control accessible from the relaying room using a new independent Mobile Safety Means) to enhance the reliability of relief valve opening, decided before the Fukushima Daiichi NPP accident, is or will be applied to all the reactors by the next 10-year outage of each reactor. In the interim, the reactors in which the modification had not yet been implemented have been equipped with a provisional mobile safety means enabling the pressuriser safety relief valves to be opened from the relay circuitry.
  - On the EPR, the primary system is depressurised by two redundant primary system discharge lines. The operator has one hour after entry into the SA situation to open these lines, which are supplied by the 24-hour batteries.
- **Re-criticality risk:**
  - EDF has carried out reactivity studies on the fleet to analyse the risk of return to criticality for different corium configurations - compact or fragmented - in the reactor vessel or the reactor pit following the injection of water. These studies conclude that the criticality risk is zero when the corium is not fragmented in the water and excluded when the borated water is injected at the minimum boron concentration of the tank.

As the SAMG prohibits the injection of non-borated water as long as the corium is in the reactor vessel, the re-criticality risk is excluded for such configurations. After reactor vessel rupture, the injection of clarified water could be envisaged after analysis and if recommended by the emergency response team. The re-criticality risk is ruled out in the short term but borated water make-ups must be provided in the long term

- On the Flamanville EPR, measures are taken to guarantee a dry reactor pit and a dry corium spreading area.

Added to the above-mentioned risks is the risk of basemat melt-through further to rupture of the reactor vessel containing the corium. On the operating reactors, reflooding the corium in the vessel or injecting water into the reactor pit via the perforated vessel to keep the corium flooded limits the risk of basemat melt-through, or failing this, delays its occurrence. The SAMG defines the water injection conditions, particularly with respect to the risks of early loss of containment.

Maintaining the corium in the vessel avoids the ex-vessel corium-concrete interaction phase and thus contributes to the goal of maintaining containment integrity. Stabilisation of the situation in the vessel necessitates restoring a means of injecting borated water into the primary cooling system within a sufficiently short period of time to avoid vessel rupture. For its operating reactors, EDF envisages different possibilities for retaining the corium in the vessel in a severe accident situation, using existing systems that are not specifically designed for managing accidents with core meltdown, and depending on their availability. Following the stress tests, EDF plans to have the reactor coolant system injection means (hardened safety core pump) backed-up by an Ultimate Backup Diesel Generator.

In addition to this, under the prescriptions relative to the hardened safety core, EDF will install on each reactor a system for preventing basemat melt-through in the event of reactor meltdown and reactor vessel melt-through. This system is based on dry spreading of the corium followed by passive flooding of the corium with the water from the sumps.

For the operating reactors, there is also an ex-vessel steam explosion risk for which an international research programme is in progress to characterise the conditions of occurrence and the intensity of such phenomena. The available studies show the containment to be well able to withstand the loads resulting from a steam explosion. Its integrity would therefore probably not be compromised in this situation.

For the Flamanville EPR, the core catcher is intended to collect, cool and stabilise the corium. Prevention of basemat melt-through is thus based on a reactor pit and a core catcher that are both dry when the corium arrives, on the collection and spreading of the corium and on its passive cooling after spreading. In the longer term, the CHRS system in the reactor building enables the residual power to be removed from the corium.

For the reactor fleet, in addition to these measures to prevent basemat melt-through, examination of measures to counter the dissemination of radioactive products by the "water route", i.e. potential contamination of the groundwater in the event of a severe accident with basemat melt-through, has been achieved. In late 2012 EDF submitted a study on the setting up of such "water route" countermeasures which concludes that the measures that could be envisaged display substantial uncertainties regarding their feasibility and effectiveness and would bring only minimal gains in safety. EDF considers that the modifications envisaged to further reduce the risk of core meltdown and those studied to prevent the risk of basemat melt-through taken as a whole will consolidate the residual nature of this risk. This led EDF to favour prevention of the risk of basemat melt-through, which enables the corium to be maintained in the containment and presents a tangible and measurable gain in safety.

For the particular case of the Fessenheim reactors which have the thinnest basemat of the fleet, ASN instructed EDF in July 2011 to reinforce the basemat of Fessenheim reactor No.1 before 30th June 2013 in order to greatly increase its resistance to corium in the event of a severe accident (minimum basement melt-through time exceeding three days in all cases). The reinforcement work was completed in spring 2013 and ASN prescribed the same reinforcement for the Fessenheim reactor No.2, which EDF has also carried out.

In response to the ASN requirement concerning the installation of redundant means for detecting vessel melt-through in the reactor pit and redundant means for detecting hydrogen in the containment, EDF is making modifications. Completion of deployment is planned for the end of 2016 for the 900 MWe and P4 plant series reactors and the end of 2017 for the P'4 and N4 series.

Feasibility of immediate actions in the Severe Accident Management Guide (SAMG)

Assuming an event leading to simultaneous loss of all electrical power supplies and the primary cooling system means for all the reactors of a site, the feasibility of all the immediate actions provided for in the SAMG must be guaranteed for each reactor, in particular depressurisation of the primary system, with the operating and emergency response teams present on the site.

In this respect, EDF studied the adequacy of the human and material resources for the activities involved in the deployment of the hardened safety core equipment items (including the immediate measures specified in the SAMG) and the additional equipment proposed further to the stress tests.

ASN has started analysing the file EDF submitted on the sizing of on-site staffing levels to cope with extreme situations in order to have an opinion from the Advisory Committee of Experts on the subject by 2017 or 2018 (see § 6.3.1.3).

Habitability of the control room

EDF's preliminary studies on the habitability of the control room in the event of a severe accident with the control room ventilation-filtration system becoming unserviceable lead to envisaging not having operators permanently present in the control rooms in the period following opening of the venting-filtration system and maintaining the supervision and monitoring of the facilities by complementary measures. In addition, EDF has planned reinforcing the electrical backup of the control room ventilation-filtration by the ultimate backup diesel generator set (DUS) (phase 2 modification). Pending installation of the DUS, a modification is in progress to allow the resupply of one train of the ventilation system (DVC/DCC) of the control room by another ultimate backup diesel generator set, the "DUS". Thanks to these backup measures, the control room remains habitable under all circumstances.

On the Flamanville EPR, control room ventilation is backed up by the station blackout (SBO) diesel generators. The control room remains habitable.

To reduce iodine discharges, EDF has decided to put in place in phase 2 a passive system comprising sodium tetraborate baskets to trap the organic iodines on the reactors of the 1300 MWe/N4 series which are not equipped with SIC clusters.

Spent fuel storage pools:

At the end of June 2012, in compliance with ASN's requirement, EDF presented the modifications to be made to its facilities to reinforce prevention of the risk of accidental emptying of the fuel building pool:

- EDF has redesigned the siphon vacuum breaker on the cooling system delivery pipe to prevent complete and rapid siphon emptying of the pool in the event of rupture of a connected pipe. This modification was carried out on all the reactors before the end of March 2014.
- EDF is going to automate isolation of the cooling system intake line, which will prevent gravity draining of the pool via the intake line. This modification is currently being deployed and should be completed before the end of 2016, in accordance with ASN requirements.

The Bugey and Fessenheim plants could entail a particular risk of spent fuel pool damage should a fuel transport container fall. In response to the ASN requirement, at the end of 2012 EDF submitted a study of the consequences of an accident involving the falling of a spent fuel transport package, integrating the extreme situations studied under the stress tests for these two sites. At Fessenheim, the integrity of the basemat is not called into question by the falling of a package. The analyses at the Bugey NPP have resulted in proposing the installation of a hydraulic damper in the loading pit similar to that of Fessenheim, and an energy absorbing system beneath the handling opening.

In response to the ASN requirement, at the end of December 2012 EDF submitted the feasibility studies for handling the case of a breach in the transfer tube. Two types of solution can be used to prevent exposure of the fuel assembly during handling. The detailed studies that will serve in particular to optimise the choice of the solution adopted according to the configuration of the premises concerned and the radiation protection constraints are in progress.

Furthermore, in order to prevent rapid loss of the water inventory in the storage compartment in hypothetical situations of leakage of the transfer tube or the transfer compartment drainage line or the compartments of the reactor building pool, closing of the door between the transfer compartment and the storage compartment will be required. In accordance with the requirement, EDF implemented before June 30th 2013 the material and organisational provisions to guarantee the manoeuvrability of the door, including in the case of total loss of the electrical power supplies.

In the case of the EPR:

- the design of the reactor and fuel buildings, which stand on a common basemat, thereby limiting differential movements;
- the design of the connection expansion joints of the transfer tube leading to the fuel pools, which are entirely metallic and do not have flexible elastomer sleeves;
- the checks carried out in the procurement and transfer tube manufacturing phases;
- the operating provisions that will be applied in operation to avoid any risk of stress corrosion of the transfer tube casing;
- the in-service inspection programme which will be applied and which integrates an analysis of the available operating experience feedback;

are currently being examined as part of the Flamanville 3 commissioning examination.

Further to the studies conducted in 2012 to protect the fuel assemblies during handling in the reactor building, EDF favours the maintaining of a sufficient water margin above the assembly left in position after an earthquake.

At the end of 2012, in response to the ASN requirement, EDF submitted a study concerning the following 3 themes:

- change of fuel behaviour over time in pool emptying and heat sink loss situations;
- evaluation of the radiological atmosphere in a boiling fuel pool situation;
- evaluation of the hydrogen concentrations resulting from radiolysis that could be reached in situations involving loss of fuel building ventilation.

The studies conclude that no complementary measures need to be implemented in the fuel building for any of these themes.

Instrumentation in the spent fuel pool necessary for accident management

For the reactors in operation and the EPR, EDF studied the steps to take to reinforce the robustness of the instrumentation in the spent fuel pool to ensure management of the situation and the management of water make-up in particular. By the end of 2013, EDF had ensured the resupply of electrical power of a two-threshold level gauge by the ultimate backup diesel generator set (DUS) installed on all the reactors in service. On the EPR, in the preparation of the Advisory Committee of Experts on nuclear reactors (GPR) work on the safety of fuel storage and handling, EDF as ascertained that, further to the latest design changes, the PTR tank level measurements in the spent fuel pool were sufficiently protected by virtue of their installation.

Furthermore, the emergency response team has charts for determining the time taken for the spent fuel pools in the reactor building to boil, depending on their stored residual power, so that the site can be assisted in managing water make-up for the pools according to the boiling time.

Accessibility and habitability of the control room in case of fuel assembly degradation

If the fuel assemblies are undamaged, control room habitability remains ensured. However, an accident leading to deterioration of the fuel assemblies could lead to significant releases in the fuel building, against which it is hard or even impossible to implement effective means of mitigating the consequences.

EDF has examined the feasibility for the NPPs in operation and the EPR, of relocating the make-up system controls to areas protected from the propagation of steam. The finding of this study is that given the measures taken elsewhere to improve the robustness of the facility, by mobile or fixed equipment, there is no need to continue studying the relocating of the controls.

19.4.3 Measures taken for research reactors

19.4.3.1 CEA reactors

Outside normal operating situations, the analysis of the alarms and operating parameters measured on the installation and transmitted to the control room, can lead the operators to enter into incident or accident operating procedures.

These procedures describe the operational control applicable in such situations, the objectives being to maintain the reactor in a safe condition and to mitigate the consequences of the incident or accident.

The operational management rules applicable in incident and accident situations are described in the general operating rules.

The management of accident situations will be reinforced to take into account the extreme situations resulting from the experience feedback from the Fukushima Daiichi NPP accident (see § 16.3.2).

19.4.3.2 The ILL high-flux reactor (RHF)

The RGE No.11 and the reactor note "Infra PUI" (On-site emergency plan infrastructure) describe the operational control applicable outside normal operating situations and the conditions of transition to the accident mode organisation.

This organisation is described in the on-site emergency plan (PUI). The criteria for triggering the PUI are indicated in it, as are the particular operating rules that must be applied according to the situation.

The stress tests enabled the safeguard, prevention and mitigation systems to be supplemented. These systems are controlled automatically, but it is possible to revert to manual control at any time. After rod drop, cooling by natural convection is sufficient, therefore it is not necessary to guarantee a heat sink. The safeguard systems essentially allow a minimum water inventory to be maintained around the fuel element and the depressurisation of the reactor containment to avoid any overpressure that could lead to a discharge. Lastly, the emergency management room can withstand simultaneous extreme external hazards (see § 14.2.3.2).

19.4.4 ASN analysis and oversight

19.4.4.1 ASN's oversight and analysis of the nuclear power reactors

The various works carried out in the framework of the stress tests took into account scenarios that had not been considered in the past. Consequently, integration of the conclusions of the stress tests and the associated requirements will lead to significant modifications in the documents relating to severe accident management.

These measures are specified on the ASN website[23] and detailed in the national action plan[24] resulting from the stress tests. They include provisions relative to severe accident management, particularly concerning:

- implementation of a hardened safety core of robust material and organisational measures (see § 6.3.1.3);
- integration in the accident operational management procedures and the severe accident management documents, including the SAMG, of the new provisions for handling the extreme situations studied in the stress tests and affecting several reactors on the same site, for all operating states, as well as the fuel storage buildings;
- development of the accident situation operational control of the reactors to adapt it to the different reactors states (EDF commitment of 15th September 2011). The elements were submitted on 31st December 2012 and require ASN approval before being implemented. ASN has already agreed to the implementation of a change in accident management in situations of total loss of electrical power supplies with a break at the reactor coolant pump seals, in order to guarantee a sufficient steam supply to drive the turbine-driven pump of the steam generator (SG) emergency feedwater system and the emergency turbine generator set by preventing the risk of excessive depressurization of the SGs;

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[23] http://www.french-nuclear-safety.fr/Information/News-releases/ASN-Report-on-the-Complementary-Safety-Assessments-CSA.

[24] http://www.french-nuclear-safety.fr/Information/News-releases/European-stress-tests-ASN-publishes-its-national-action-plan.

- the defining of new emergency procedures that will integrate the new provisions identified through the stress tests. The implementation of this organisation is accompanied by specific personnel training.

2012 was marked by the implementation on 15th November 2012 of the new baseline safety requirements concerning the on-site emergency plans (PUI) for the EDF sites. ASN considers that these new baseline safety requirements improve EDF's preparedness for the management of emergency situations.

ASN has issued other requirements relative to severe accident management:

- Installation of redundant means in the reactor pit to detect vessel melt-through and redundant means in the containment to detect the presence of hydrogen (requirement ECS-19. The deadlines for implementing these means are set at 31st December 2016 or 31st December 2017, depending on the sites);
- Installation of reinforced instrumentation in the pool for measuring the state of the spent fuel pool (temperature and water level) and the radiological atmosphere in the fuel building hall (requirement ECS-20. The modifications have been carried out by EDF);
- Implementation of additional measures to prevent or mitigate the consequences of a fuel transport package falling in the fuel building on the Bugey and Fessenheim sites (requirement ECS-21);
- Reinforcement of the measures to prevent accidental rapid draining of the fuel storage pools (requirement ECS-22);
- Study of the possible measures, in the event of total loss of electrical power supplies and accidental emptying, to ensure the safe positioning of a fuel assembly during handling in the fuel building, before the ambient conditions no longer allow access to the premises (requirement ECS-23. This study is currently being analysed and the deadline for implementing the modifications is set at 30th June 2013);
- Study of the evolution over time of the fuel and the water present in the spent fuel pool, in situations of emptying and loss of cooling, and presentation of the planned modifications (requirement ECS-24. The study and the planned modifications have been submitted and are currently being analysed);
- Study of conceivable changes to equipment or operating conditions to prevent uncovering of the fuel assemblies during handling, for example as the result of a break in the transfer tube between the pools of the reactor building and the fuel building or in the compartment drainage pipes (requirement ECS-25. The study has been submitted and is currently being analysed);
- Study of the feasibility of installing a geotechnical containment;
- EPR reactor: reinforcement of the provisions for controlling the pressure in the containment (requirement ECS-28. The elements have been submitted and are currently being analysed);
- Detailed study of the possibilities for improving the venting-filtration device, taking account of the robustness to hazards, the limitation of the risks of hydrogen combustion, the efficiency of filtration in the case of simultaneous use on two reactors, the improvement of filtration of fission products, particularly iodines and the radiological consequences of opening of the device, notably on site accessibility, and the radiological atmosphere of the emergency rooms and the control room (requirement ECS-29);

- Modifications planned on its site to ensure that, in the event of release of dangerous substances or opening of the venting-filtration system, operation and monitoring of all the facilities on the site are guaranteed until a long-term safe state is reached; and the corresponding deployment schedule (requirement ECS-31. The modifications study has been submitted and is currently being analysed);
- Reinforcing of the material and organisational measures to take account of accident situations affecting all or part of the site's facilities simultaneously (requirement ECS-32). A new on-site emergency plan (PUI) baseline has been deployed on all EDF sites since 15 November 2012. It takes into account accident situations affecting several facilities on a given site simultaneously.

19.4.4.2 ASN's oversight and analysis of the research reactors

For the research reactors, pursuant to the ASN resolutions of 5th May 2011, the licensees have carried out stress tests on each of their facilities for which there are major potential risks, in order to integrate the lessons learned from the Fukushima accident. The stress tests performed in Europe on the nuclear power reactors were extended in France to cover all basic nuclear installations, including research reactors. The prime aim of the stress tests was to determine the safety margins that exist on these facilities with regard to extreme hazards such as earthquakes and flooding.

Following the analysis of these stress tests, ASN asked CEA and the ILL to define a "hardened safety core" of robust material and organisational measures to:

- 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 carry out its emergency management duties.

The concept of the "hardened safety core" aims to create structures and equipment capable of withstanding extreme events and of performing essential functions for the safety of the facilities and management of the emergency on the site. This entails protecting the equipment needed to manage the safety functions against hazards that exceed those considered in the design of the facilities.

In 2015, ASN establishing additional prescriptions stipulating the requirements applicable to the hardened safety cores proposed by the licensees, and to the management of emergency situations. These resolutions clarify the design rules to be adopted for the structures and equipment constituting the "hardened safety core". They must comply with the most demanding standards, so that their functions can be guaranteed until the facility is returned to a safe state.

In addition to the requirements concerning the "hardened safety core", ASN asked the licensees to take the necessary steps concerning the management of emergency situations, such as to ensure:

- independent operation of the "hardened safety core" equipment for the first 48 hours in an extreme situation, with provision being made for supplies to be brought in from outside the site (water, electricity, fuel, etc.) after this period;
- automatic and robust transmission of key data concerning the status of the facility (water levels, temperature, etc.) to the emergency management centres;
- the availability of reinforcements (personnel, equipment, etc.) on each site to ensure long-term management of an extreme situation.

All the provisions shall be integrated in the safety case documents (safety analysis report [SAR], general operating rules [RGE], on-site emergency plan [PUI]) when they are effectively implemented on the facilities.

19.5 The technical support

19.5.1 ASN requests

The regulations, and the BNI order in particular, require that the licensees establish and implement a policy for public health and safety and protection of nature and the environment. This policy defines objectives, indicates the licensee's strategy to achieve them and the resources it undertakes to assign to it.

the licensee must indicate how it organises its technical capabilities, that is to say whether they are held internally, in subsidiaries or through third parties with whom formal agreements must be made; the most fundamental capabilities must be held by the licensee or one of its subsidiaries;

The licensee must also implement an integrated management system.

Consequently, ASN expects the licensees to have appropriate expertise and technical skills to ensure operation of the facilities, maintenance of the equipment and systems and management of incidents and accidents.

19.5.2 Measures taken for nuclear power reactors

The nuclear engineering development project initiated by EDF in 2006 has led to the setting up of new modes of functioning and organisation in the NPPs and the engineering units. This project met the unanimously stated needs to simplify the processes for making modifications to the installations and the associated documentation, and to close the gap between the designer and the licensee.

Reinforcing the links between the nuclear engineering teams and the NPPs is a strong intention of DPN in order to improve the operation of the production fleet.

These studies for a closer cooperation resulted in the creation of an EDF guide to operational engineering, defining new responsibilities for the NPPs and the engineering units with the designation of a pilot site for each plant series, which was put into application on 1st January 2007.

A revision of the engineering guide was issued in 2012 to draw lessons from experience feedback and to integrate into the guide the impacts associated with the TSN act and the BNI procedures decree, particularly in terms of the conditions of functioning with ASN.

19.5.3 Measures taken for research reactors

At each CEA centre, technical support units bring together the various skills required for the different activities involved in operating the facilities. 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, but their expertise is called upon wherever necessary.

19.5.4 ASN analysis and oversight

ASN carries out inspections in the head office departments of the main nuclear licensees, the workshops or design offices of the subcontractors, the construction sites, and the plants or workshops manufacturing components that are important for safety.

ASN has found that the organisational measures implemented by EDF for the quality management of the activities of the nuclear power reactor fleet in service are satisfactory. Moreover, ASN underlines the quality of the work carried out by the EDF engineering teams for the stress tests. However, the equipment modification process often results in delays in sending the modification files to the NPPs, making work preparation difficult, particularly for the reactor outages. Furthermore, the quality of the some modification files is not up to the required standard and can lead to deviations. ASN considers that steps must be taken to correct these failings, especially given the substantial amount of work planned in the complementary safety measures required further to the stress tests and the ongoing or forthcoming periodic safety reviews.

Technical support for the CEA facilities is coordinated by the risk control centre, which is assisted in particular by the DPSN and the skills centres. The skills centres have been put in place and developed since 1996. They provide the facilities with the assistance of specialists in diverse technical areas such as seismic risks, paraseismic engineering, fire, criticality, chemical risks, pressure equipment, dynamic mechanics, thermomechanics, instrumentation and control, containment-ventilation, measurements, impact studies (environment and drawbacks) and human and organisational factors (HOF). The skills centres are called upon by the DPSN or the installation or project managers via internal contracts. The organisation and functioning of the CEA skills centres are subjects provided for by ASN instruction "Management of safety and radiation protection at the CEA" which formed the subject of a meeting of the GPE in 2010. The implementation of CEA's commitments and the GPE's recommendations are monitored and inspected by ASN. An examination of this subject by the GPE is planned in 2020.

The supporting examination at the GPE meeting of 2010 revealed the centres' lack of responsiveness to the analysis requests made during the year and the lack of room for manoeuvre in the work load plan.

Furthermore, since 2011 some skills centres have been assigned to the expert appraisals associated with the post-Fukushima actions. ASN considered that the files submitted in 2011 and 2012 for the stress tests were satisfactory and underlined the substantial effort made by CEA and the other licensees to carry out these analyses within a tight time frame.

Examination of these stress test files nevertheless led ASN to make additional prescriptions and requests in 2012 and 2015, particularly concerning the hardened safety core of the CEA installations and centres. ASN has noted that the quality of the files submitted for these complements to the stress tests is lower than for the initial stress tests.

19.6 Significant events

Operating experience feedback is one source of improvement in the areas of safety, radiation protection and the environment. The regulations, and the BNI order in particular, stipulate this principle and require the implementation by the licensee of an integrated management system that includes the provisions enabling it to identify and process the deviations and significant events (see § 7.3.3.3).

19.6.1 ASN requests

ASN requires that licensees notify it of any significant events that occur in the NPPs. Criteria have been set for notifying the public authorities in a document named "Guide to the conditions of notification and codification of the criteria relative to significant events involving safety, radiation protection and the environment applicable to BNIs and the transport of radioactive materials". Each significant event is classified by ASN on the INES scale.

Licensees must notify all events that are significant for nuclear safety to ASN within 48 hours, with a proposed classification on the INES scale (ASN has sole responsibility for the final classification decision). ASN analyses this initial notification to verify the implementation of immediate corrective measures, to decide whether to perform an on-site inspection to analyse the event in depth and, if necessary, to prepare the communication of information to the public.

The use of the INES enables ASN to select, among all the events and incidents that occur, those that have sufficient significance to be subject to communication on its part:

- events rated level 0 only form the subject of an incident notice if they are of particular interest;
- events rated level 1 always form the subject of an incident notice published on www.asn.fr (in French);
- events rated level 2 and higher also form the subject of a press release and are notified to the IAEA;
- international transport events concerning foreign countries are also notified to the IAEA from events rated level 1 upwards, and from level 0 upwards if they result in the loss of a radioactive source.

The notification is supplemented within two months by a report indicating the conclusions the licensee has drawn from the analysis of the events and the measures it is taking to improve safety or radiation protection. ASN checks that the licensee has suitably analysed the event, taken the appropriate measures to correct the situation and prevent it occurring again, and has circulated the lessons learned from it.

ASN performs specific inspections to investigate the circumstances, causes and consequences of certain incidents.

19.6.2 Measures taken for nuclear power reactors

Between 2013 and 2015, the average number of significant event notifications per reactor per year fell from 11.5 in 2013 to 10.0 in 2015. The number of significant events classified on the INES scale remained relatively stable over these 3 years: 1.19 per reactor per year in 2013, 1.14 per reactor in 2014 and 1.16 per reactor in 2015.

19.6.3 Measures taken for research reactors

19.6.3.1 CEA reactors

Three significant events rated level 1 on the INES scale were notified during the 2013-2015 period. They are presented in § 6.2. It can be noted on the basis of the events rated level 0 that:

- 40% of the events result from manual or automatic actuation of the reactor trip function, whether untimely or not;

- 25% result from failure to comply with the safety baseline requirements;
- 15% result from deviations on one of the containment barriers.

19.6.3.2 The ILL high-flux reactor (HFR)

L'ILL a déclaré 3 évènements significatifs de niveau 1 sur l'échelle INES pour l'ensemble des 3 années :

- Presence of a gamma ray beam outside the reactor;
- Irradiation of the skin of the palm of an operator's hand (250 mSv maximum on the skin, as the passive dosimeter, which was developed as a matter of urgency, indicated 60 μSv for the period from 1st to 24th June 2015);
- Slight positive pressurisation of the reactor building.

19.6.4 ASN analysis and oversight

ASN examines all notified significant events both locally and nationally. For certain significant events considered to be more noteworthy due to their nature or their frequency of occurrence, ASN has IRSN carry out a more detailed analysis. If this analysis reveals information that warrants international dissemination, it may subsequently be published in the IAEA and NEA's International Reporting System (IRS) database.

In order to guarantee rapid dissemination of information, ASN endeavours to inform its counterparts as quickly as possible when a notable event occurs in France by using the existing multinational structures and networks.

During its nuclear installations inspections, ASN examines the organisation and measures taken by the sites to deal with significant events. ASN analyses the way the licensees (EDF, CEA, ILL) deal with significant events on an annual basis, and takes this into consideration in its assessment of the overall performance of the nuclear installations.

For nuclear power reactors, in application of the rules relative to the notification of significant events(see § 7.3.3.3), EDF in 2015 notified 586 significant events relating to safety, 109 relating to radiation protection and 79 relating to protection of the environment.

The following graph shows how the number of significant events notified by EDF and classified on the INES scale has evolved since 2007. In 2015, 697 events were classified on the INES scale.

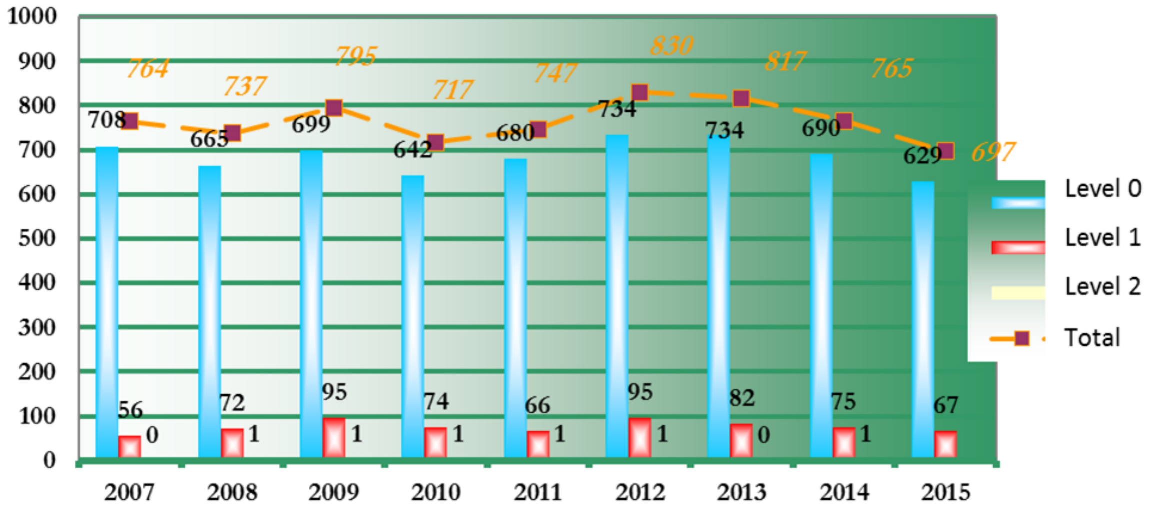


Figure 10 : Evolution of the number of significant events classified on the INES scale in the EDF NPPs between 2007 and 2015

The following graph shows the evolution the number of significant events notified since 2007 by domain: events significant for safety (ESS), events significant for radiation protection (ESR) and events significant for the environment (ESE).

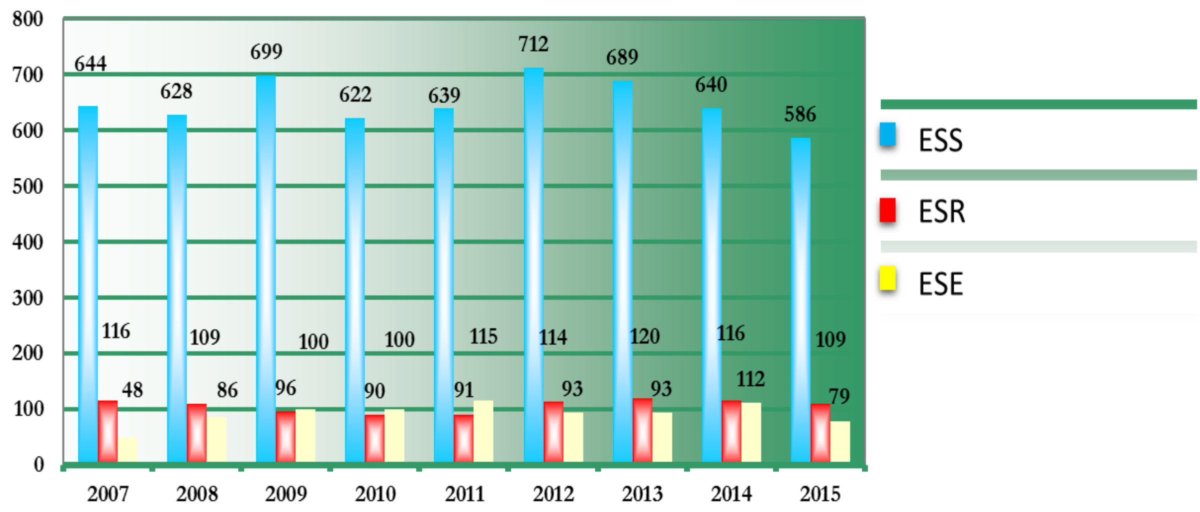


Figure 11: Evolution of the number of significant events by domain in the EDF NPPs between 2007 and 2015

The number of significant safety events (ESS) notified has fallen by about 8% compared with 2014, confirming the downward trend which began in 2012. Several activities governed by prescriptive documents, such as the performance of periodic tests, are still the cause of significant events.

The number of significant radiation protection events (ESR) remained stable over the same period. This rise is mainly due to industrial radiology operations and the non-performance of technical inspections (zoning and mobile radiation protection devices). Furthermore, as the entity responsible for radiation protection on the NPPs, EDF must ensure the protection and preservation of the radiation protection culture of both its own staff and the personnel of outside contractors.

The number of ESE's is down on last year but remains high compared with previous years: environmental protection must remain one of the core concerns of EDF.

The following graph shows the average number of significant events rated at INES level 0 and 1 per plant series for the year 2015. For the 900 MWe and 1300 MWe plant series, the average number of significant events is higher than for the N4 series; this difference is chiefly due to the average volume of maintenance work in 2015, which was greater on these reactors than on the N4 reactors due to the start of the third 10-yearly outages on these two plant series. The increase in the number of maintenance interventions during the outage periods generally contributes to the rise in the number of deviations.

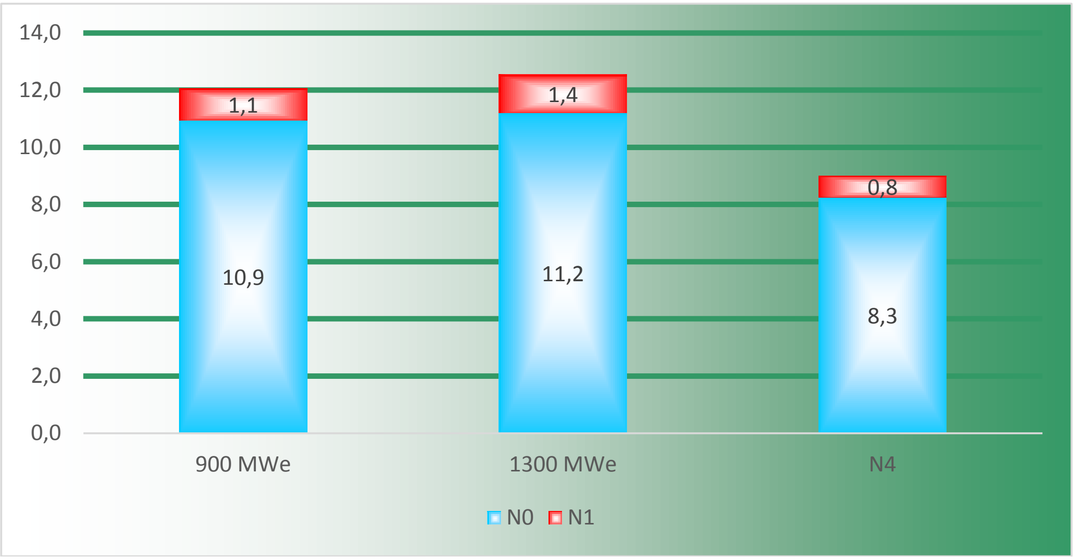


Figure 12: Mean number of significant events rated on the INES scale in EDF NPPs per type of reactor and per year for 2015

No events of INES level 2 or higher have occurred on research reactors since the 5th Review Meeting of the CNS.

In application of the rules relative to notification of significant events in the areas of safety, radiation protection and the environment, the research reactor licensees (CEA and ILL) notified between 20 and 35 significant events classified on the INES scale (relating to nuclear and radiological safety) per year between 2007 and 2015. The number of significant events rated level 1 did not exceed 5 per year.

The following graph shows how the number of significant events notified and classified on the INES scale has evolved since 2007.

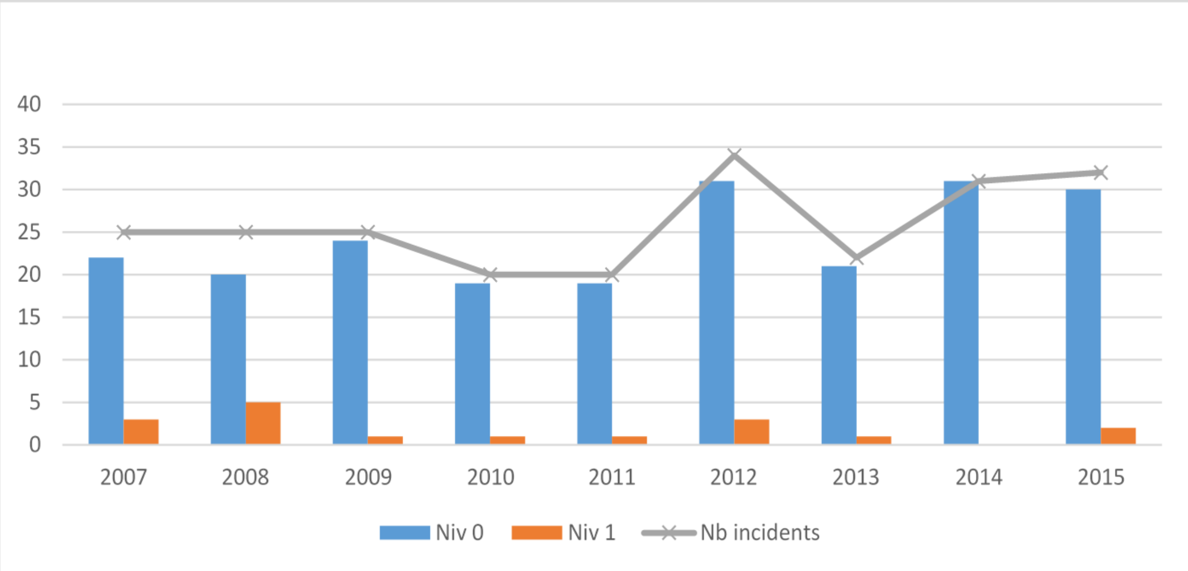


Figure 13: Evolution of the number of significant events for research reactors

Furthermore, nuclear safety is very much the predominant area for notified events concerning research reactors, with proportions always exceeding 75%.

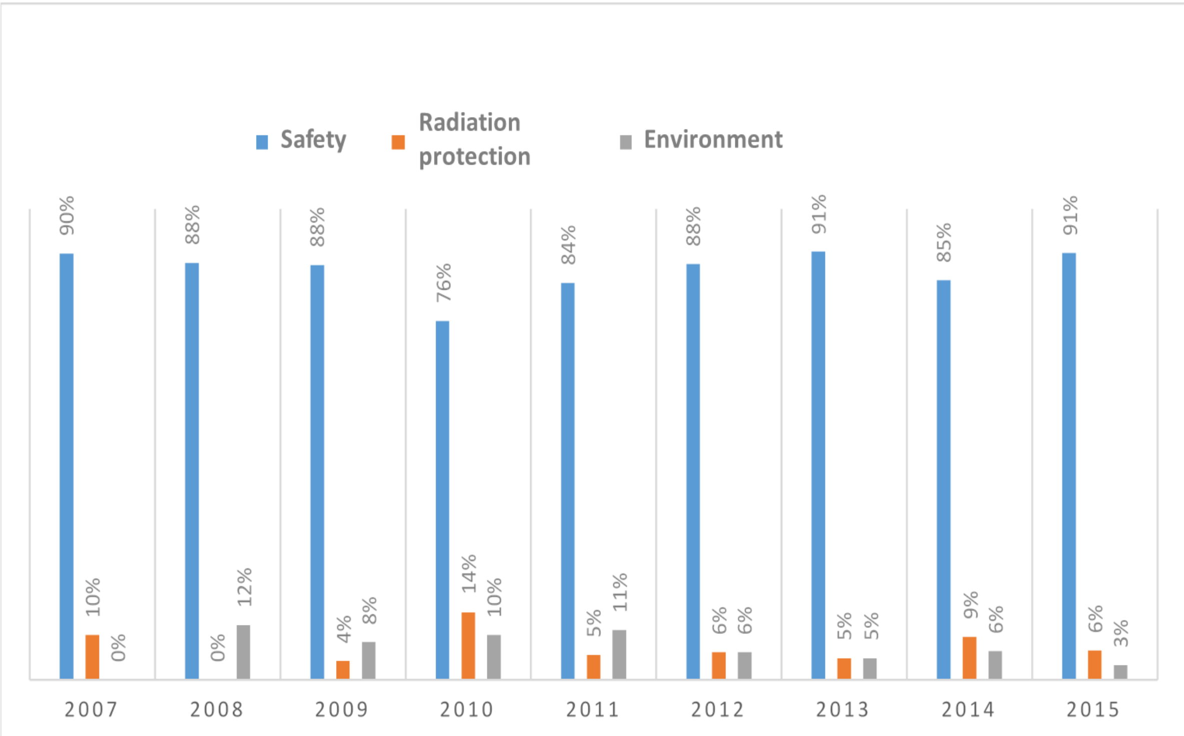


Figure 14: Distribution of significant events by area for research reactors

19.7 Integration of experience feedback

As mentioned in §19.6, ASN places great importance on the handling of experience feedback.

The BNI order stipulates this principle and requires the licensee to implement an integrated management system that includes provisions enabling it to identify and process the deviations (difference between an observed situation and a required situation) and significant events, and to gather the experience feedback from the operation of its facility or other facilities, whether similar or not and in France or abroad, or resulting from research and development.

ASN also endeavours to disseminate experience feedback from French nuclear facilities during bilateral or multilateral discussions with its counterparts and 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 the NEA's *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. ASN is also a member of the Nuclear Energy Agency's *Multinational Design Evaluation Programme* (MDEP) which evaluates the design of new reactors.

19.7.1 ASN requests

The ASN assessment, the significant event reports and the periodic assessments submitted by the licensees from the basis of the experience feedback organisation. ASN asks licensed reactors operators to turn the experience feedback from significant events and reactor operation to good account. They must also draw the lessons from significant events that occur abroad, particularly from the reports in the IRS database of the IAEA and the NEA.

The significant events notified to ASN are systematically assessed with the aim of deciding, among other things, on the appropriateness of the corrective and preventive actions implemented by EDF. The events that have the greatest implications for safety are analysed in depth and if necessary lead to requests for additional measures. With regard to events occurring on installations in other countries, whether similar to the French nuclear power reactors or not, ASN has asked EDF to systematically analyse their causes and examine any weaknesses in its installations in the light of this analysis. The event which occurred at Philippsburg 2 (Bade-Wurtemberg) in 2013, involving the deterioration of a guide pin on the upper internals of the core, its consequences on the deformation of a fuel assembly and the risks induced by such a deformation, particularly when opening the reactor vessel and unloading the upper internal equipment, led ASN to question EDF on the adequacy of the checks on the condition of the internal structures before reloading fuel.

Operating experience feedback

The periodic safety reviews aim to improve the safety of the nuclear installations, particularly in the light of the OEF from operation of the facility or from other nuclear facilities in France and abroad, and the lessons learned from other facilities or items of equipment at risk. Integration of the licensee's experience feedback can result in modifications to equipment (and the management procedures) which are subject to review by ASN.

ASN periodically calls on the GPR concerning the lessons learned from experience feedback for fuel and foreign reactors.

Following the Fukushima Daiichi NPP accident, ASN considered that it was necessary to perform stress tests on the French civil nuclear facilities, with respect to the type of events which led to this accident. Several modifications are made to the installations to take account of this.

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 1,600 reactor-years.

In 2010 a project to reorganise operating experience feedback was initiated at EDF/DPN. Following a diagnostic phase then a trial phase, new principles are now being implemented for the local and national experience feedback loops.

The OEF process comprises the following phases:

1. the phase of detection, collection and selection

Detection is performed on the basis of all the information available: findings in the field, operating experience feedback (periodic assessments), professional feedback (professional practices, activity networks), events feedback (observed deviations, anomalies, malfunctions, events and incidents including international and outside the nuclear field but taken into consideration at national level).

The purpose of the selection process is to prioritise the subjects to be addressed according to the implications and to initiate the method of addressing them. Selection is a collegial process where each stakeholder contributes its experience, favouring the taking into account of all the components of the information and the implications. It is also a managerial process through the validation of priorities.

Selection is carried out at each level of the organisations. It helps ensure the early detection of recurrent problems or subjects with national implications because they are potentially generic or of a precursory nature.

2. the analysis phase, including the defining of corrective, preventive and conservative actions when necessary

The aim of the analysis is to define the subject to address, to specify the risks, the implications and the areas concerned, to identify the existing experience feedback and actions already engaged, and the objectives. It leads to the proposing of corrective, preventive, alternative or conservative solutions.

Supplementing the "unit" analysis performed after the event, the periodic analysis of trends uses the codification that is carried out for each finding or event. This approach allows the identification of a drift in a given event category and the defining of appropriate action to reverse the trend.

Analyses using the same methods, carried out at Fleet level (complementary analyses) on events of national importance or on the grouping of events of the same type, allow the identification of generic causes and the defining of more widely-sweeping corrective actions at Fleet level.

3. the phase of implementation of the defined corrective or preventive actions, integrating the oversight of implementation and verification of their effectiveness

The actions and solutions defined by the experience feedback process can be of three different types, and contribute to:

- the reliability of the equipment (modifications for example);

- the reliability of the organisations (e.g. changes in rules and methods, or operational documentation, or change in a work process);
- the reliability of humans and acts carried out (e.g. provision of information, adapting training courses).

The phase of implementing actions also includes verifications of conformity and monitoring of effectiveness with respect to the desired objectives.

4. the phase of sharing experience feedback with the work teams

The aim of this phase is to disseminate and share the lessons learned from the analyses of information on experience feedback made available to the work teams at each level of the organisations.

Capitalising on the OEF information and decisions through shared and readily accessible databases and developing products based on experience feedback with the end-user in mind and made available at the right time participate in this sharing and utilisation of experience feedback.

These provisions are supplemented by the collective sharing of experience and holding activity workshops.

The experience feedback process is organised at local and national level through systems and bodies allowing:

- the entry of findings that are accessible to everyone;
- the characterisation of the findings, their weighing up and prioritising according to the implications, their codification which will allow trends to be analysed, and the assigning of selected findings to the stakeholders responsible for analysing them;
- in-depth analysis of the selected findings to propose corrective or preventive actions and the validation of the actions;
- the analysis of trends performed on the findings taken as a whole to identify the drifts to be remedied, and propose corrective actions.

The experience feedback project detailed these principles and the associated organisation (Corrective Actions Plan). At the end of 2015, all the NPPs have put in place new organisational arrangements. At national level the new system has been implemented since 2011. These coordination and supervision systems are now integrated in the operational life of the local and national entities, with greater managerial involvement than in the previous systems. The efficiency of these systems is subject to annual assessment reviews.

19.7.3 Measures taken for research reactors

At the CEA, deviations and their processing are recorded in sheets for each facility. The support services can also open deviation sheets.

A CEA circular specifies that the duties of the head of a facility include analysing the anomalies and events affecting his/her facility.

Taking OEF into account in the centres consists notably in organising and promoting exchanges between the facilities and the centres. On this account an experience feedback leader is designated in the 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 DPSN to make sure that the various units consult one another, and to ensure the integration of experience feedback and the exchange of best practices. The DPSN also draws up an assessment of the significant events and defines the lines of progress. This role also leads it to identify situations that require the expertise of the competence centres.

Experience feedback is also integrated in the documents (circulars and recommendations, directives, technical data sheets) that the DPSN is responsible for producing.

The aids used are:

- the OEF sheets initiated by DPSN;
- the Central Experience File which contains all the notified events that have occurred since 1990;
- the significant event analysis and processing guide;
- the significant events situation assessment, established from the significant event reports (CRES);
- the IAEA international database.

19.7.4 ASN analysis and oversight

During its nuclear installations inspections, ASN examines the organisation and measures taken by the sites to integrate experience feedback.

On 13th February and 10th March 2014, the GPR met to examine the notable findings for the 2009 – 2011 period relating to the significant events concerning radiation protection, the environment and the safety of EDF reactors. In this context, the reliability of the electrical power sources, the vulnerability of the heat sinks to external hazards, the deviations affecting the equipment important for safety and the anomalies affecting the studies that underpin the nuclear safety case received particular attention.

Following this examination, ASN considers:

- the integration of lessons learned from events affecting foreign nuclear installations or French nuclear installations other than nuclear power reactors has improved;
- the development of the experience feedback analysis method presented includes a more far-reaching search for the root organisational causes of the events and provides for the implementation of appropriate measures to correct them;
- Although EDF's integrated management system provides for a check on implementation of the corrective actions, it does not give enough importance to assessing the effectiveness of these actions in order to decide on their relevance before considering that the event having caused them has been resolved.

On the whole, the organisation implemented by the licensee for handling experience feedback in the NPPs is satisfactory.

For the research reactors, as a complement to the inspections and on the scale of the installations, ASN examines the organisation and the actions taken to integrate experience feedback and the analysis of the main events in the context of the periodic safety reviews. For CEAS, these examinations are supplemented by a 10-yearly review by the ASN Advisory Group of Experts on the subject of safety and radiation protection management (see § 10.3). The last meeting of the Advisory Committee of Experts on this subject was held in November 2010.

Integration of the experience feedback from the Fukushima Daiichi NPP accident

ASN continued the inspections on the implementation of installation modifications in response to the ASN technical prescriptions.

Conclusions drawn from the peer review of the European stress tests

The stress test reports from the different European countries were subject to a peer review process which took place from January to April 21012 and comprised two successive phases: firstly a cross-cutting thematic review of all the national reports followed by a detailed review of each national report:

On 26th April 2012, the institutional group of European safety regulators ENSREG and the European Commission adopted a report on the results of the stress tests carried out on Europe’s NPPs. ENSREG and the Commission praised the quality of the work done and the efforts made by all the European stakeholders to carry out this unprecedented process in the best possible conditions. They also underlined the progress that it will be possible to achieve in the field of nuclear safety, thanks to the stress tests report.

The ENSREG report gives a positive appreciation of the results of the stress tests carried out in France and notes the comprehensive nature of the assessments conducted under ASN's supervision. This report praises the wide range of improvements decided upon, which go beyond the existing safety margins of the French facilities, and the establishing of a hardened safety core in particular. This report also makes a number of recommendations that ASN has integrated in its national action plan.

19.8 Management of radioactive waste and spent fuel

Directive 2011/70/Euratom of 19th July 2011 establishes a European framework for the safe and responsible 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, when this waste is the result of civil activities. Like the directive of 25th 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 safety regulators and the licensees. Several of the requirements of this directive, whose transposition was scheduled to be completed before August 2013, are in force in France, for example through the provisions of the Environment Code concerning waste and the Waste Act.

National radioactive materials and waste management plan (PNGMDR)

Legislation specific to radioactive waste was established for the first time in 1991. It was modified and supplemented in 2006 by the act of 28th June 2006 for the programme relative to the sustainable management of radioactive materials and waste.

This act more particularly institutes a National Radioactive Materials and Waste Management Plan (PNGMDR) and sets a programme of research and work concerning radioactive waste for which there is no definitive means of management, along with a schedule for implementing it.

The PNGMDR presents an overall view of the management of radioactive materials and waste, with the double aim of checking that appropriate management routes exist for each category of radioactive substance in both the short and long term, and to improve mutual consistency between routes. Furthermore, the decree that establishes the requirements defines a clear road map for improving the management of radioactive materials and waste.

Radioactive waste management

The removal of waste is checked on a case-by-case basis when the activities producing the waste are subject to a licensing system (case of the BNIs). In addition to what is written in § 15.1.2.2.5, the management of radioactive waste from the BNIs is based on a regulatory framework, notably the BNI order of 7th February 2012 and, since 1st July 2015, ASN resolution 2015-DC-0508 of 21st April 2015 relative to the waste management study and the situation assessment of the waste produced in the basic nuclear installations. The regulations provide for:

- a waste management study: approved by ASN, it presents a description of the operations behind the production of waste, the characteristics of the waste produced or to be produced and an estimation of the waste production streams. It thus establishes an assessment of the waste management situation on each site;
- A waste zoning plan: integrated in the waste management study, it presents and substantiates the methodological principles relative to:
  - the delimiting of potential nuclear waste production zones and conventional waste zones, enabling a reference waste zoning map to be drawn up;
  - the procedures implemented for the temporary or definitive waste zoning delicensing or reclassification measures;
  - the traceability and conservation of the historical record of the zones or structures and soils which could have been contaminated or activated.
- An annual quantitative and qualitative waste management assessment.

The waste studies system should help improve the overall management of waste, particularly in terms of transparency, and help develop optimised management routes.

Spent fuel management

France has opted for a strategy of reprocessing the spent fuel resulting from the nuclear power process, a choice that is confirmed by the Act of 28th June 2006. EDF is responsible for the processing and what becomes of the spent fuel and associated waste it produces.

The management strategy for the spent fuel produced in research reactors is developed according to the characteristics of the fuel and depending on the case may involve reprocessing or direct disposal. The quantities of spent fuel planned for direct disposal are nevertheless very much smaller than the quantities of reprocessed fuel.

In the 2016 revision of its decommissioning, waste and materials management strategy, CEA must demonstrate that the substances contained in its spent or irradiated fuels have a planned or envisaged subsequent use that is sufficiently well established.

19.8.1 ASN requests

19.8.1.1 Radioactive waste management

The waste produced in EDF's reactors comprises the activated waste and the waste resulting from the operation and maintenance of the NPPs. To this can be added the legacy waste and waste resulting from ongoing decommissioning operations. EDF and CEA are also the owners of high-level and intermediate-level long-lived waste resulting from spent fuel, in the AREVA La Hague plant.

For all the radioactive waste, ASN examines the baseline requirements of the licensee's waste management study, in accordance with the regulations.

This baseline requirement comprises the following themes:

- an assessment of the existing situation, summarising the different wastes produced and their quantities;
- the waste management procedures and the organisation of waste transport;
- the "waste zoning";
- the state of the existing disposal solutions.

Each site sends ASN annually a detailed report of its waste production with the chosen disposal routes, an analysis of the trends compared with previous years, an assessment focusing on the observed deviations and the functioning of the site's waste management organisation and the notable events that have occurred. The future prospects are also considered.

On 21st April 2015 ASN issued a number of technical prescriptions relative to waste management which are valid for all nuclear licensees.

19.8.1.2 Spent fuel management

EDF uses two types of nuclear fuel in the pressurised water reactors;

- uranium oxide (UO_2) based fuels enriched with Uranium-235 to a maximum of 4.5%;
- fuels consisting of a mixture of depleted uranium oxide and plutonium oxide (MOX).

Fuel management is specific to each reactor series.

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 AREVA NC fuel reprocessing plant at La Hague.

EDF, in collaboration with the fuel cycle industry players, keeps up-to-date a file concerning the compatibility between the changes in the characteristics of new and spent fuel and the changes in the fuel cycle facilities. The review of the most recent version of this file by ASN was completed in 2010. EDF is now updating this file for mid-2016, still in collaboration with the fuel cycle manufacturers, in order to integrate the changes in the fuel cycle facilities, notably the storage capacities of the reactor pools and of the reprocessing plants, and the management of the fuels and the products it uses in the reactors.

Lastly, the design and the resistance of the spent fuel pools situated in the NPPs and the fuel cycle facilities were examined in the framework of the stress tests performed further to the Fukushima Daiichi NPP accident.

CEA has a large variety of spent fuels.

19.8.2 Measures taken for nuclear power reactors

The management of spent fuel and radioactive waste forms the subject of the joint convention on the Safety of spent fuel management and on the safety of radioactive waste management..

The spent fuel undergoes a reprocessing-recycling process at the AREVA La Hague plant that allows:

- the recycling of materials that can be reused;

- the conditioning of ultimate high-level long lived-waste in vitrified form in standard containers. This waste is stored on the La Hague site for cooling for a period of several decades. The waste is then intended to be disposed of in the deep geological repository that ANDRA is currently developing in the Meuse *département*.

Below is a reminder of the modes of management of the waste resulting directly from reactor operation.

Waste management on a production site comprises the following main phases: "waste zoning", waste collection, sorting, characterisation, reprocessing/conditioning, storage, shipment.

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). Right from the collection phase, the physical management of radioactive waste must at all levels be separate from that of conventional waste and prevent any mixing of incompatible materials.

The radioactive waste resulting from the operation of PWRs is essentially very low, low or intermediate level short-lived waste. It can be classified in two categories:

- the process waste that comes from the purification and treatment of the liquid or gaseous effluents to reduce their activity before being discharged;
- the technological waste that comes from maintenance operations. This waste can be solid or liquid.

The most radioactive waste, of intermediate level, is conditioned in concrete containers and disposed of directly at ANDRA's Aube waste repository (CSA). A part of the process waste and the technological waste is coated or immobilised in a hydraulic binder on fixed facilities: NPP nuclear auxiliaries building or effluent treatment building. For the final conditioning of the ion exchange resins, EDF uses the MERCURE process (coating in an epoxide matrix), implemented using two identical mobile machines.

For the treatment of sludge, EDF uses fixed treatment facilities on the 900 MWe series (apart from Fessenheim) and is developing a mobile facility (for the other plant series and Fessenheim) for encapsulating the sludge in concrete packages, which is planned to enter service at the end of 2017 at the earliest. Pending availability of the mobile treatment machine, the sludge produced is stored on the sites.

EDF has several treatment possibilities for borated concentrates: encapsulation in concrete shell on the fixed facilities of the 900 MWe plant series (apart from Fessenheim), incineration on CENTRACO and a mobile machine for producing concrete shells (UMC, approval currently under examination).

The solid low-level waste is:

- either compacted on site in 200-litre metal drums and sent directly to ANDRA's 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 SOCODEI 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;

  This low-level waste processing and conditioning centre is equipped with a melting unit for metal waste, in addition to its incineration unit which also processes liquid waste. This melting unit produces 200-litre ingots which are disposed of at the CSA or CIRES repository (see below) when their specific activity so permits.

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.

Note: The management of operational radioactive waste was disrupted by the stopping of melting following the accident on the CENTRACO melting unit on 12th September 2011, making it necessary to favour direct transfer to the CSA repository. Normal operation at CENTRACO has resumed since May 2015.

19.8.3 Measures taken for research reactors

19.8.3.1 CEA reactors

Waste management

The majority of the waste produced by the operation of the CEA's experimental reactors is routed to the disposal facilities managed by ANDRA. The sodium wastes that will result from the post-operational clean-out and decommissioning of the Rapsodie and Phénix reactors will be treated in a facility that will be set up on the Phénix site.

Spent fuel management

All the spent fuel from the CEA experimental reactors undergoes or will undergo reprocessing. On this account the spent fuel from the Osiris and Orphée reactors is regularly transferred to the AREVA La Hague plant.

19.8.3.2 The ILL high-flux reactor (RHF)

The majority of the waste produced by the operation of the experimental reactor at the Laue Langevin Institute (ILL) is routed to the disposal facilities managed by ANDRA. The spent fuel is transferred to the AREVA La Hague plant.

19.8.4 ASN analysis and oversight

19.8.4.1 Radioactive waste management

During its NPP inspections, ASN examines the organisation and measures taken by the sites in terms of waste and spent fuel management. The inspectors review the site’s organisation of radioactive waste management, from sorting through to packaging and various points such as the processing of deviations. They also check the operation of the waste storage and treatment areas.

EDF has developed and implemented standard baseline operating requirements for the buildings in which radioactive waste is managed. It enables the management rules to be specified for each phase of the nuclear waste management process. These baseline requirements are then adapted for each NPP.

As part of the periodic safety review, ASN asks EDF to update the safety report for the NPPs concerned so that it contains the safety analysis approach adopted for the buildings concerned, along with the main elements of the safety case. Alongside this, ASN has asked EDF to integrate in the general operating rules (RGE), the provisions for guaranteeing compliance during normal operation with the hypotheses considered in the safety case.

Despite the positive trend already observed in previous years and progress in terms of environmental organisation on most of the sites, ASN considers that there is still room for improvement in EDF's radioactive waste management organisation. In effect, EDF does not give sufficient attention to and sufficiently anticipate the processing of facility conformity deviations, the implementation of maintenance programmes and the updating of operational documents. Furthermore, the sorting of waste and the establishing and enforcing of waste zoning remain points that ASN considers require particular attention.

Extension of the operating life of the nuclear power reactors

EDF's intention to extend the operating life time of the nuclear power reactors will lead to an increase in maintenance work. ASN considers that these maintenance operations must be sufficiently anticipated in order to take into account the volumes of waste produced and the available treatment routes.

Opinion of the Advisory Committees of Experts for Waste (GPD) and Plants (GPU)

ASN has asked EDF to present its strategy for the management of radioactive waste resulting from the operation and maintenance of its nuclear power reactors for the next ten years.

At the request of ASN, on 1st July 2015 EDF submitted its strategy for the management of radioactive waste resulting from the operation and decommissioning of the NPPs to the GPD and GPU Advisory Committees of Experts.

The Advisory Committees examined more specifically the appropriateness of EDF's organisation with regard to safety for waste management from production to disposal or storage and the optimisation of these management routes, along with the control of the radiological characterisation of the waste.

To conclude, the Advisory Committees consider that EDF has made significant progress in its waste management strategy. Improvements are nevertheless still required, particularly as regards the characterisation of certain long-lived radionuclides present in the waste, the setting up of appropriate waste management means, and the optimisation of these means in order to cope with the availability problems of certain outlets.

19.8.4.2 Spent fuel management

The safety of fuel storage in the spent fuel pool has been the subject of in-depth examinations during past or ongoing periodic safety reviews, as well as in the context of the stress tests. These successive examinations have led to the defining and implementation of modifications to prevent the risk of emptying of the spent fuel pool, to improve the robustness of the water make-up means and to improve the management of accident situations (see § 19.4.2). Despite these modifications, ASN underlines that the initial design and the current state of the spent fuel pools fall significantly short of the safety principles that would be applied in a new facility. Moreover, the implementation of effective means of mitigating the consequences of prolonged exposure of spent fuel assemblies is not currently conceivable on the spent fuel pools of the EDF nuclear reactor fleet in operation. In view of these facts, ASN has asked EDF to examine options for the on-site storage of spent fuel other than the current spent fuel pools, using the safety objectives defined for the generation III reactors as a reference.

The stress tests included an in-depth examination of the consequences of a major natural hazard on the systems that can evacuate the residual power of the fuel stored in pools, on the integrity of the pools in the fuel building and the reactor building and the systems connected to them, the risks of storage rack deformation and the risks of falling loads. The conclusions of the analyses have led ASN to issue requirements, in particular to reinforce the electrical power resources, the water supply resources, the instrumentation and the measures to prevent accidental emptying of the pools.

G – INTERNATIONAL COOPERATION

20. International cooperation measures

20.1 ASN's international activities

The nuclear installations regulated by ASN represent one of the largest and most diverse fleets in the world. ASN therefore aims to ensure that its nuclear regulation and radiation protection activities constitute an international reference.

ASN conducts its international action to ensure that nuclear safety and radiation protection principles are taken into account and promoted and to share its work and experience. Its main objectives are:

- to develop exchanges of information with its foreign counterparts on regulatory systems and practices, communicate and explain the French approach and practices and provide information on the steps taken to solve the problems encountered;
- to inform foreign States of events that have occurred in France and provide the countries concerned with all useful information about French nuclear facilities located close to their borders;
- to contribute to improving the rules and practices at European and international levels and to take an active part in work to harmonise nuclear safety and radiation protection principles and standards and in work to prepare European community law;
- to implement the undertakings of the French State concerning nuclear safety and radiation protection, in particular within the framework of international conventions to which IAEA is warden;
- to participate in the international committees that produce the scientific syntheses and the recommendations stemming from them.

ASN pursues its objectives in multilateral frameworks (both European and non-European), by promoting the harmonisation of practices in the regulation of nuclear safety and radiation protection. These actions are carried out within the multilateral organisations, both formal (IAEA, OECD/NEA, MDEP, ICRP, UNSCEAR, etc.) and informal (WENRA, HERCA, etc.), but also bilaterally, by setting up exchanges with its foreign counterparts on all subjects of common interest.

The European Commission has set up a number of bodies in which ASN participates (such as the European Nuclear Safety Regulators Group – ENSREG).

In addition, article L. 592-28 of the Environment Code now formalises the activities in which ASN participates in representing France on the bodies of competent international and European Union organisations in its areas of competence.

Furthermore, article L. 592-28-1 stipulates that: "*ASN cooperates with the competent authorities of the other countries in its areas of competence. At the request of these countries, it can provide consultancy services and carry out technical support missions under agreements which can provide for the reimbursement of expenses incurred.*

ASN can examine the conformity of the safety options of nuclear installation models intended for export with the requirements applicable to the same type of installation in France. Such cases are referred to ASN under the conditions stipulated in the first paragraph of article L. 592-29 and it renders public the conclusions of the examination."

20.2 IRSN's international activities concerning reactor safety

Within the scope of the duties assigned to it by the public authorities, IRSN (Institute for Radiation Protection and Nuclear Safety) develops international relations with regard to research and expertise in the areas of nuclear reactors and fuel cycle installations safety, radioactive material transport safety, human and environmental protection, safety and regulation of sensitive nuclear materials and organisation and training for emergency management.

IRSN's international activities have three main objectives:

- increase the scientific and technical knowledge required for better risk assessment and improved risk control;
- contribute to the establishing of international consensus both on technical questions and on the drafting of guides, recommendations and standards;
- take part in the implementation of projects aimed at reinforcing radiation protection, nuclear safety and security abroad.

These activities are conducted within the framework of bilateral and multilateral collaborations, work performed under the auspices of such international organisations as the IAEA, the OECD/NEA, the UNSCEAR, the ICRP and the European Commission, but also as part of services or cooperation projects developed by the IAEA, the European Commission or the European Bank for Reconstruction and Development. Some of these activities are carried out to support ASN in international collaborations.

20.3 EDF's international activities concerning reactor safety

EDF's international activities concern 3 key areas:

- Experience sharing between licensees:
  - ➢ bilateral exchanges of experience, mainly via twinning agreements; the development of nuclear projects internationally enables EDF to turn increased mutual experience feedback to good account and to develop synergies within the Group, particularly with regard to safety;
  - ➢ the international institutions (WANO, FROG, WOG, EPRI, WNA, INPO, etc.) promote dialogue and exchanges between nuclear licensees. EDF makes extensive use of these institutions with the aim of improving the safety and operating reliability of nuclear power plants on a global scale;
  - ➢ consultancy and service activities in the form of contracts;
- International safety standards:
  - ➢ In the field of safety, whether considering the regulatory aspects (international agreements, European directives), normative aspects (IAEA, ISO, IEC standards) or for establishing recommendations (WENRA Safety Reference Levels), EDF is involved in the discussions with the text issuing bodies, particularly via ENISS (European Nuclear Installations Safety Standards), in consultation with the other European licensees;
  - ➢ The preparation of the reactors of the future and technological watch. EDF's activity is exercised essentially through its participation in the European Utility Requirements (EUR) organisation, the Cooperation on Reactor Design Evaluation and Licensing (CORDEL) group and the World Nuclear Association (WNA).

- In the areas of nuclear R&D:
  - In the OECD (CSNI - Committee on the Safety of Nuclear Installations) or the EPRI (Electric Power Research Institute), EDF contributes to the sharing of information and experience and the promotion of international cooperation for international research programmes in R&D facilities.

20.4 CEA's international activities concerning reactor safety

The CEA participates in international collaborations in nuclear areas, particularly that relating to the safety of nuclear power reactors.

Research into safety focuses chiefly on the following main objectives:

- the Organisational and Human Factors aspects in operation (see § 12.3.1);
- the use of passive systems for returning to a safe state from an accident situation;
- the reduction in the probability of core meltdown;
- mitigation of the off-site consequences of a severe accident situation, notably by reinforcing containment.

The CEA contributes to the IAEA’s work on research reactors and has established regular exchanges with foreign counterparts, based on operational experience and lessons learned from incidents. In the area of fast-neutron reactors, it maintains close contact with Russia, India and Japan.

With regard to the 4th generation reactors, in the collaborative framework of the Forum, the CEA contributes to studies on fuel and the safety of the gas-cooled fast-neutron experimental reactor project (ALLEGRO).

With regard to radiation protection, the CEA participates in various research activities as well as the activities of UNSCEAR.

20.5 French participation in the Nuclear Safety and Security Group (NSSG) of the G7

ASN provides its technical support to the French authorities within the Nuclear Safety and Security Group of the G7 countries (G7/NSSG). Since the accident at the Fukushima Daiichi NPP, this group has essentially worked on coordinating the actions of the seven member States and of the European Commission to support the preparation then implementation of the IAEA's Action Plan on Nuclear Safety and on reflections on the improvement of the international safety framework (strengthening effective implementation of relevant international conventions).

APPENDIX 1 – LIST AND LOCATION OF NUCLEAR REACTORS IN FRANCE

1.1. Location of the nuclear reactors

The 58 nuclear power reactors and the 11 research reactors in operation in the administrative sense as at 31st July 2013 are distributed over the French territory as shown in the map below. In addition to this, one nuclear power reactor and one research reactor are currently under construction.

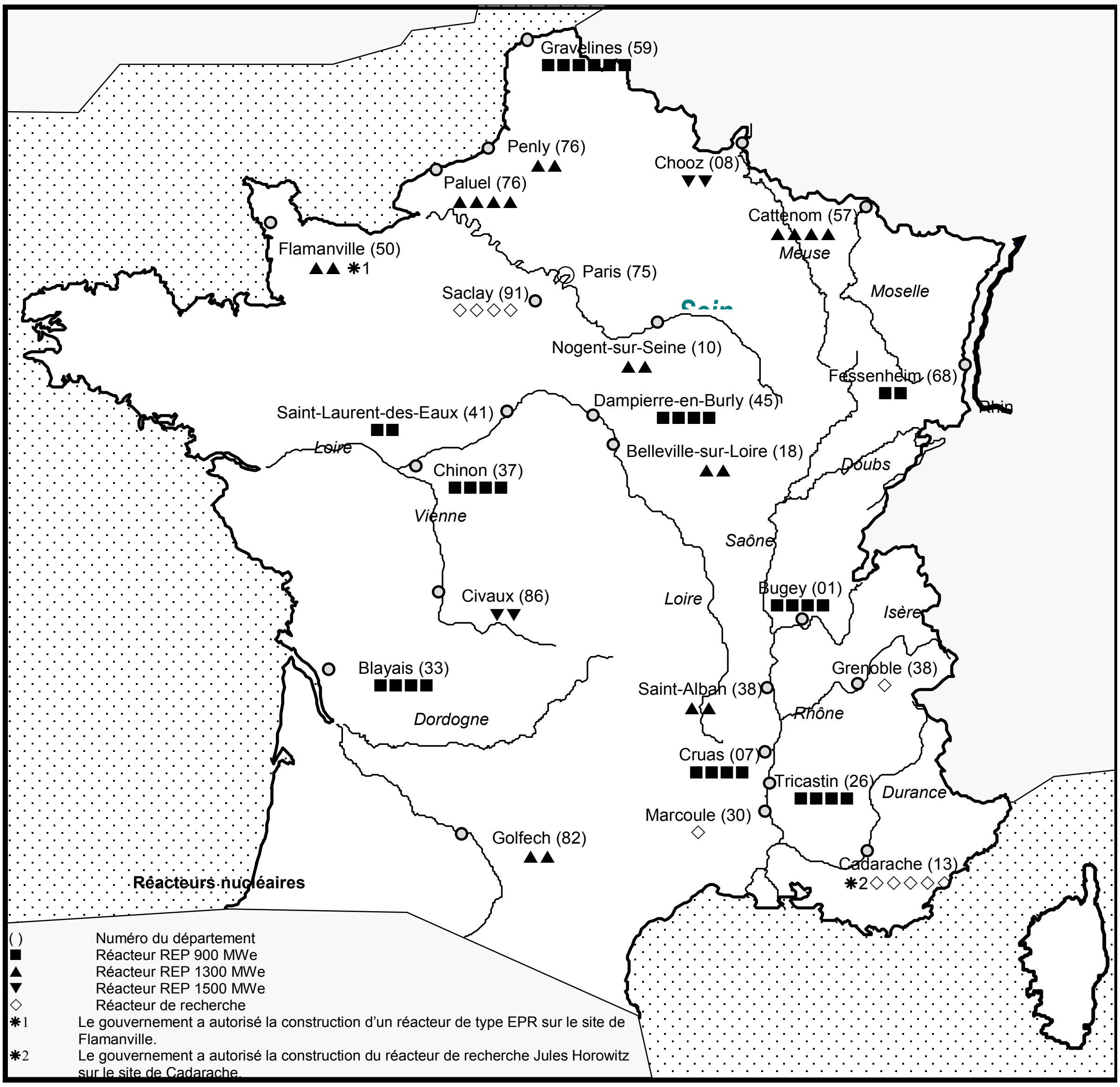


Figure 15: Map of France situating the nuclear reactors in operation and under construction

The total installed electrical power is of the order of 64,000 MWe.

The 58 pressurised water nuclear power reactors situated on 19 sites are operated by EDF.

The prototype fast-neutron nuclear power reactor PHENIX (shut down) and 9 other research reactors are operated by the CEA. The high-flux research reactor (RHF) is operated by the Laue-Langevin Institute (ILL).

APPENDIX 1 – List and location of nuclear reactors in France

1.2. List of nuclear power reactors

Table 13: Nuclear power reactors in operation and under construction

BNI no.	NAME AND LOCATION OF THE INSTALLATION	OPERATOR	Type of installation	Author-ised on:	OBSERVATIONS
75	FESSENHEIM NUCLEAR POWER PLANT (reactors 1 and 2) 68740 Fessenheim	EDF	2 PWR reactors CP0 900 MWe	03.02.72 (O.J. of 10.02.72)	Boundary change: decree of 10.12.85 (O.J. of 18.12.85)
78	LE BUGEY NUCLEAR POWER PLANT (reactors 2 and 3) 01980 Loyettes	EDF	2 PWR reactors CP0 900 MWe	20.11.72 (O.J. of 26.11.72)	Boundary change: decree of 10.12.85 (O.J. of 18.12.85)
84	DAMPIERRE NUCLEAR POWER PLANT (reactors 1 and 2) 45570 Ouzouer-sur-Loire	EDF	2 PWR reactors CP1 900 MWe	14.06.76 (O.J. of 19.06.76)	
85	DAMPIERRE NUCLEAR POWER PLANT (reactors 3 and 4) 45570 Ouzouer-sur-Loire	EDF	2 PWR reactors CP1 900 MWe	14.06.76 (O.J. of 19.06.76)	
86	LE BLAYAIS NUCLEAR POWER PLANT (reactors 1 and 2) 33820 Saint-Ciers-sur-Gironde	EDF	2 PWR reactors CP1 900 MWe	14.06.76 (O.J. of 19.06.76)	Boundary change: decree of 10.02.14 (O.J. of 12. 02.14)
87	TRICASTIN NUCLEAR POWER PLANT (reactors 1 and 2) 26130 Saint-Paul-Trois-Châteaux	EDF	2 PWR reactors CP1 900 MWe	02.07.76 (O.J. of 04.07.76)	Boundary change: decree of 10.12.85 (O.J. of 18.12.85) ; decree of 15.12.15 (O.J. of 17.12.15)
88	TRICASTIN NUCLEAR POWER PLANT (reactors 3 and 4) 26130 Saint-Paul-Trois-Châteaux	EDF	2 PWR reactors CP1 900 MWe	02.07.76 (O.J. of 04.07.76)	Boundary change: decree of 10.12.85 (O.J. of 18.12.85) and decree of 29.11.04 (O.J. of 02.12.04); decree of 15.12.15 (O.J. of 17.12.15)
89	LE BUGEY NUCLEAR POWER PLANT (reactors 4 and 5) 01980 Loyettes	EDF	2 PWR reactors CP1 900 MWe	27.07.76 (O.J. of 17.08.76)	Boundary change: decree of 10.12.85 (O.J. of 18.12.85)
96	GRAVELINES NUCLEAR POWER PLANT (reactors 1 and 2) 59820 Gravelines	EDF	2 PWR reactors CP1 900 MWe	24.10.77 (O.J. of 26.10.77)	Boundary change: decree of 29.11.04 (O.J. of 02.12.04); decree of 20.11.15 (O.J. of 22.11.15)
97	GRAVELINES NUCLEAR POWER PLANT (reactors 3 and 4) 59820 Gravelines	EDF	2 PWR reactors CP1 900 MWe	24.10.77 (O.J. of 26.10.77)	Boundary change: decree of 29.11.04 (O.J. of 02.12.04); decree of 20.11.15 (O.J. of 22.11.15)
100	ST-LAURENT-DES-AUX NUCLEAR POWER PLANT (reactors B1 and B2) 41220 La Ferté-Saint-Cyr	EDF	2 PWR reactors CP1 900 MWe	08.03.78 (O.J. of 21.03.78)	

APPENDIX 1 – List and location of nuclear reactors in France

BNI no.	NAME AND LOCATION OF THE INSTALLATION	OPERATOR	Type of installation	Author-ised on:	OBSERVATIONS
103	PALUEL NUCLEAR POWER PLANT (reactor 1) 76450 Cany-Barville	EDF	1 PWR reactor P4 1300 MWe	10.11.78 (O.J. of 14.11.78)	
104	PALUEL NUCLEAR POWER PLANT (reactor 2) 76450 Cany-Barville	EDF	1 PWR reactor P4 1300 MWe	10.11.78 (O.J. of 14.11.78)	
107	CHINON NUCLEAR POWER PLANT (reactors B1 and B2) 37420 Avoine	EDF	2 PWR reactors CP2 900 MWe	04.12.79 (O.J. of 08.12.79)	Modification: decree of 21.07.98 (O.J. of 26.07.98); Boundary change: decree of 05.01.15 (O.J. of 07.01.15)
108	FLAMANVILLE NUCLEAR POWER PLANT (reactor 1) 50830 Flamanville	EDF	1 PWR reactor P4 1300 MWe	21.12.79 (O.J. of 26.12.79)	
109	FLAMANVILLE NUCLEAR POWER PLANT (reactor 2) 50830 Flamanville	EDF	1 PWR reactor P4 1300 MWe	21.12.79 (O.J. of 26.12.79)	
110	LE BLAYAIS NUCLEAR POWER PLANT (reactors 3 and 4) 33820 Saint-Ciers-sur-Gironde	EDF	2 PWR reactors CP1 900 MWe	05.02.80 (O.J. of 14.02.80)	Modification: decree 2013-440 of 28.05.13 (O.J. of 31.05.13)
111	CRUAS NUCLEAR POWER PLANT (reactors 1 and 2) 07350 Cruas	EDF	2 PWR reactors CP2 900 MWe	08.12.80 (O.J. of 31.12.80)	Boundary change: decree of 10.12.85 (O.J. of 18.12.85) and decree of 29.11.04 (O.J. of 02.12.04)
112	CRUAS NUCLEAR POWER PLANT (reactors 3 and 4) 07350 Cruas	EDF	2 PWR reactors CP2 900 MWe	08.12.80 (O.J. of 31.12.80)	Boundary change: decree of 29.11.04 (O.J. of 02.12.04)
114	PALUEL NUCLEAR POWER PLANT (reactor 3) 76450 Cany-Barville	EDF	1 PWR reactor P4 1300 MWe	03.04.81 (O.J. of 05.04.81)	
115	PALUEL NUCLEAR POWER PLANT (reactor 4) 76450 Cany-Barville	EDF	1 PWR reactor P4 1300 MWe	03.04.81 (O.J. of 05.04.81)	
119	SAINT-ALBAN NUCLEAR POWER PLANT (reactor 1) 38550 Le Péage-de-Roussillon	EDF	1 PWR reactor P4 1300 MWe	12.11.81 (O.J. of 15.11.81)	
120	SAINT-ALBAN NUCLEAR POWER PLANT (reactor 2) 38550 Le Péage-de-Roussillon	EDF	1 PWR reactor P4 1300 MWe	12.11.81 (O.J. of 15.11.81)	

APPENDIX 1 – List and location of nuclear reactors in France

BNI no.	NAME AND LOCATION OF THE INSTALLATION	OPERATOR	Type of installation	Author-ised on:	OBSERVATIONS
122	GRAVELINES NUCLEAR POWER PLANT (reactors 5 and 6) 59820 Gravelines	EDF	2 PWR reactors CP1 900 MWe	18.12.81 (O.J. of 20.12.81)	Boundary change: decree of 10.12.85 (O.J. of 18.12.85) Modification Decree of 02.11.07 (O.J. of 03.11.07)
124	CATTENOM NUCLEAR POWER PLANT (reactor 1) 57570 Cattenom	EDF	1 PWR reactor P'4 1300 MWe	24.06.82 (O.J. of 26.06.82)	
125	CATTENOM NUCLEAR POWER PLANT (reactor 2) 57570 Cattenom	EDF	1 PWR reactor P'4 1300 MWe	24.06.82 (O.J. of 26.06.82)	
126	CATTENOM NUCLEAR POWER PLANT (reactor 3) 57570 Cattenom	EDF	1 PWR reactor P'4 1300 MWe	24.06.82 (O.J. of 26.06.82)	
127	BELLEVILLE-SUR-LOIRE NUCLEAR POWER PLANT (reactor 1) 18240 Léré	EDF	1 PWR reactor P'4 1300 MWe	15.09.82 (O.J. of 16.09.82)	
128	BELLEVILLE-SUR-LOIRE NUCLEAR POWER PLANT (reactor 2) 18240 Léré	EDF	1 PWR reactor P'4 1300 MWe	15.09.82 (O.J. of 16.09.82)	Boundary change: decree of 29.11.04 (O.J. of 02.12.04)
129	NOGENT-SUR-SEINE NUCLEAR POWER PLANT (reactor 1) 10400 Nogent-sur-Seine	EDF	1 PWR reactor P'4 1300 MWe	28.09.82 (O.J. of 30.09.82)	Boundary change: decree of 10.12.85 (O.J. of 18.12.85)
130	NOGENT-SUR-SEINE NUCLEAR POWER PLANT (reactor 2) 10400 Nogent-sur-Seine	EDF	1 PWR reactor P'4 1300 MWe	28.09.82 (O.J. of 30.09.82)	Boundary change: decree of 10.12.85 (O.J. of 18.12.85)
132	CHINON NUCLEAR POWER PLANT (reactors B3 and B4) 37420 Avoine	EDF	2 PWR reactors CP2 900 MWe	07.10.82 (O.J. of 10.10.82)	Modification: decree of 21.07.98 (O.J. of 26.07.98)
135	GOLFECH NUCLEAR POWER PLANT (reactor 1) 82400 Golfech	EDF	1 PWR reactor P'4 1300 MWe	03.03.83 (O.J. of 06.03.83)	Boundary change: decree of 29.11.04 (O.J. of 02.12.04)
136	PENLY NUCLEAR POWER PLANT (reactor 1) 76370 Neuville-lès-Dieppe	EDF	1 PWR reactor P'4 1300 MWe	23.02.83 (O.J. of 26.02.83)	
137	CATTENOM NUCLEAR POWER PLANT (reactor 4): 57570 Cattenom	EDF	1 PWR reactor P'4 1300 MWe	29.02.84 (O.J. of 03.03.84)	

APPENDIX 1 – List and location of nuclear reactors in France

BNI no.	NAME AND LOCATION OF THE INSTALLATION	OPERATOR	Type of installation	Author-ised on:	OBSERVATIONS
139	CHOOZ B NUCLEAR POWER PLANT (reactor 1) 08600 Givet	EDF	1 PWR reactor N4 1500 MWe	09.10.84 (O.J. of 13.10.84)	Commissioning postponement: decrees of 18.10.1993 (O.J. of 23.10.93) and 11.06.99(O.J. of 18.06.99)
140	PENLY NUCLEAR POWER PLANT (reactor 2) 76370 Neuville-lès-Dieppe	EDF	1 PWR reactor P'4 1300 MWe	09.10.84 (O.J. of 13.10.84)	
142	GOLFECH NUCLEAR POWER PLANT (reactor 2) 82400 Golfech	EDF	1 PWR reactor P'4 1300 MWe	31.07.85 (O.J. of 07.08.85)	
144	CHOOZ B NUCLEAR POWER PLANT (reactor 2) 08600 Givet	EDF	1 PWR reactor N4 1500 MWe	18.02.86 (O.J. of 25.02.86)	Commissioning postponement: decrees of 18.10.93 (O.J. of 23.10.93) and of 11.06.99 (O.J. of 18.06.99)
158	CIVAUX NUCLEAR POWER PLANT (reactor 1) BP 1 86320 Civaux	EDF	1 PWR reactor N4 1450 MWe	06.12.93 (O.J. of 12.12.93)	Commissioning postponement: decree of 11.06.99 (O.J. of 18.06.99)
159	CIVAUX NUCLEAR POWER PLANT (reactor 2) BP 1 86320 Civaux	EDF	1 PWR reactor N4 1450 MWe	06.12.93 (O.J. of 12.12.93)	Commissioning postponement: decree of 11.06.99 (O.J. of 18.06.99)
167	FLAMANVILLE NUCLEAR POWER PLANT (reactor 3) 50830 Flamanville	EDF	1 EPR PWR reactor 1600 MWe	10.04.07 (O.J. of 11.04.07)	Decree 2007-534 pf 10.04.07 (O.J. 11.04.07)

1.3. List of research nuclear reactors

Table 14: Research reactors in operation, in the administrative sense, and under construction

BNI no.	NAME AND LOCATION OF THE INSTALLATION	OPERATOR	Type of installation	Declared on:	Authorised on:	OBSERVATIONS
24	CABRI (Cadarache) 13115 Saint-Paul-lez-Durance	CEA	Reactor 25 MWth	27.05.64		Modification: decree of 20.03.06 (O.J. of 21.03.06) Divergence of the modified reactor authorized by resolution of 20.10.15
39	MASURCA (Cadarache) 13115 Saint-Paul-lez-Durance	CEA	Reactor 0.005 MWth		14.12.66 (O.J. of 15.12.66)	
40	OSIRIS (Saclay) 91191 Gif-sur-Yvette Cedex	CEA	Reactor 70 MWth		08.06.65 (O.J. of 12.06.65)	Shut down on 16.12.15

APPENDIX 1 – List and location of nuclear reactors in France

BNI no.	NAME AND LOCATION OF THE INSTALLATION	OPERATOR	Type of installation	Declared on:	Authorised on:	OBSERVATIONS
	ISIS (Saclay) 91191 Gif-sur-Yvette Cedex	CEA	Reactor 0.70 MWth		08.06.65 (O.J. of 12.06.65)	
42	EOLE (Cadarache) 13115 Saint-Paul-lez-Durance	CEA	Reactor 0.0001 MWth		23.06.65 (O.J. of 28 and 29.06.65)	Shut down in 2017
67	HIGH FLUX REACTOR (RHF) 38041 Grenoble Cedex	Institut Max von Laue Paul Langevin	Reactor 57 MWth		19.06.69 (O.J. of 22.06.69) and 05.12.94 (O.J. of 06.12.94)	Boundary change: decree of 12.12.88 (O.J. of 16.12.88)
71	PHÉNIX Fast reactor (Marcoule) 30205 Bagnols-sur-Cèze	CEA	Reactor 563 MWth (350 MWth since 1993)		31.12.69 (O.J. of 09.01.70)	Shut down
92	PHÉBUS (Cadarache) 13115 Saint-Paul-lez-Durance	CEA	Reactor 40 MWth		05.07.77 (O.J. of 19.07.77)	Shut down
95	MINERVE (Cadarache) 13115 Saint-Paul-lez-Durance	CEA	Reactor 0.0001 MWth		21.09.77 (O.J. of 27.09.77)	Shut down in 2017
101	ORPHÉE (Saclay) 91191 Gif-sur-Yvette Cedex	CEA	Reactor 14 MWth		08.03.78 (O.J. of 21.03.78)	Shut down in 2020
172	JULES HOROWITZ REACTOR – JHR (Cadarache) 13115 Saint-Paul-lez Durance Cedex	CEA	Reactor 100 MWth		12.10.09 (O.J. of 14.10.09)	Decree 2009-1219 (O.J. of 14.10.09)

APPENDIX 2 – MAIN LEGISLATIVE AND REGULATORY TEXTS

2.1. Codes, acts and regulations

- Environment Code.
  - Book I – Part II – Chapter V (Articles L. 125-10 to L.125-40)
  - Book V – Part IV – Chapter II (Articles L. 542-1 to L.542-14)
  - Book V – Part IX (Articles L. 591-1 to L.59-7-46)
- Public Health Code: 1st Section – Book II – Part III – Chapter III (Articles L 1333-1 and following and articles corresponding to the regulatory section of this Code) relative to the general protection of individuals against the hazards of ionising radiation.
- Labour Code: Articles 4451-1 and following and R.4451-1 and following relative to the protection of workers against the hazards of ionising radiation.
- Defence Code: Articles D. 1333-68 and 69 relative to the Interministerial Committee for Nuclear or Radiological Emergencies.
- Act 2006-686 of 13th June 2006 relative to Transparency and Security in the Nuclear Field (Articles 19 and 21).
- Planning Act 2006-739 of 28th June 2006 relative to the Sustainable Management of Radioactive Materials and Waste (Articles 3 and 4).
- Decree 2007-830 of 11th May 2007 relative to the Nomenclature of Basic Nuclear Installations.
- Decree 2007-831 of 11th May 2007 setting the Appointment and Certification Procedures for Nuclear Safety Inspectors;
- Decree 2007-1557 of 2nd November 2007 relative to Basic Nuclear Installations and the Control, with Regard to Nuclear Safety, of the Transport of Radioactive Substances (decree concerning the procedures).
- Decree 2007-1572 of 6th November 2007 relative to Technical Inquiries into Accidents or Incidents Concerning a Nuclear Activity;
- Decree 2008-251 of 12th March 2008 relative to Local Information Committees for Basic Nuclear Installations.
- Decree 2010-277 of 16th March 2010 relative to the High Committee for Transparency and Information on Nuclear Security.
- Order of 7 February 2012 setting the general rules concerning basic nuclear installations.
- Interministerial Order of 10th November 1999 relative to the monitoring of operation of the main primary system and the main secondary systems of pressurized water nuclear reactors.
- Ministerial order of 12th December 2005 amended relative to nuclear pressure equipment.

APPENDIX 2 – Main legislative and regulatory texts

2.2. ASN regulatory resolutions

Table 15: List of ASN regulatory resolutions as at end of June 2015

Theme	Reference	Consultations
Texts relative to the procedures		
Periodic safety review		From 25/04 to 26/05/2013 (1st consultation on 18/03/10 by post and via the Internet from 18/04/10 to 15/7/2010; WENRA on 26/03/10 (by e-mail)
Treatment of equipment modifications	ASN resolution 2014-DC-0420 of 13th February 2014. Approval: order of 11/04/2014 (Official Journal of French Republic of 14/05/2014)	On 18/03/10 by post and via the Internet from 18/04/10 to 15/7/2010; WENRA on 26/03/10 (by e-mail)
Safety report (content),	ASN resolution 2015-DC-0532 of 17th November 2015 Approval: order of 11/01/2016 (Official Journal of French Republic of 15/01/2016)	On 21/04/11 by post and via the Internet from 30/04/11 to 31/07/2011)
Internal authorisations	ASN resolution 2008-DC-0106 of 11th July 2008 Approval: order of 26/09/2008 (Official Journal of French Republic of 11/10/2006)	-
Decommissioning plan (content)		-
Public consultation procedures	ASN resolution 2013-DC-0352 of 18th June 2013. Approval: order of 15/07/2013 (Official Journal of French Republic of 26/07/2013)	Public consultation: from 12/03/2013 to 13/04/2013 CSPRT (Higher Council for the Prevention of Technological Risks): 28/05/2013
Diverse provisions concerning the procedures		-
Audition of licensees and CLIs	ASN resolution 2010-DC-0179 of 13th April 2013	-

APPENDIX 2 – Main legislative and regulatory texts

Technical texts		
Control of accident risks and harmful effects (excluding waste)		
RGE and BNI operation resolution		On 22/06/10 by post and via the Internet from 06/07/10 to 30/09/2010 WENRA on 06/07/10 by e-mail
Shutdown and restarting of PWRs	ASN resolution 2014-DC-0444 of 15th July 2014. Approval: order of 21/11/2014 (Official Journal of French Republic of 02/12/2014)	On 30/03/10 by post and via the Internet from 18/04/10 to 15/7/2010; WENRA on 09/04/10 (by e-mail)
Design and operation of waste repositories		-
Control of fire risks	ASN resolution 2014-DC-0417 of 28th January 2014. Approval: order of 20/03/2014 (Official Journal of French Republic of 02/04/2014)	From 26/12/12 to 28/02/13
Control of criticality risk in BNIs	ASN resolution 2014-DC-0462 of 7th October 2014. Approval: order of 20/11/2014 (Official Journal of French Republic of 02/12/2014)	-
Control of detrimental effects and impact on the environment	ASN resolution 2013-DC-0360 of 16th July 2013. Approval: order of 09/08/2013 (Official Journal of French Republic of 21/08/2013)	From 15/03/13 to 16/04/13 CSPRT: 03/07/2013 (1st consultation on 12/07/10 by post and via the Internet from 19/07/10 to 15/10/10)
Waste management and disposal		
Content of the BNI waste studies	ASN resolution 2015-DC-0508 of 21th April 2015. Approval: order of 01/07/2015 (Official Journal of French Republic of 04/07/2015)	On 28/05/10 by post and on via the Internet from 26/05/10 to 31/08/10; WENRA on 16/10/10 by e-mail
Conditions of approval of waste conditioning		On 26/07/10 by post and via the Internet from 20/09/10 to 05/12/10)
Design and operation of on-site waste storage facilities		-
Management of emergency situations		
Management of emergency situations		On 21/05/10 by post and via the Internet from 26/05/10 to 31/08/10) WENRA on 10/06/10 by e-mail

APPENDIX 2 – Main legislative and regulatory texts

Informing of the authorities and the public		
Notification of incidents		
Nuclear Pressure Equipment (NPE)		
Spare parts for the main primary system (MPS) and main secondary system (MSS)	ASN resolution 2012-DC-0236 of 3rd May 2012 Approval: order of 22/06/2012 (Official Journal of French Republic of 04/07/2012)	On 01/10/10 by post and via the Internet from 11/10/10 to 31/12/2010) CCAP 04/10/2011
Regulations applicable to NPE		-

After a first series of consultations in 2010 and 2011, the draft resolutions were revised in the light of the observations made and of the order of 7th February 2012 *setting the general rules relative to basic nuclear installations.* The new versions of draft resolutions have been subject to consultation before they are adopted.

2.3. Basic safety rules and guides

As indicated in § 7.1.3.3, as part of the on-going restructuring of the general technical regulations, the basic safety rules (RFS) are being modified and transformed into guides.

There are at present about forty basic safety rules and other technical rules published by ASN which can be consulted on its website.

2.3.1 Rules relative to PWRs

RFS 2002-1 Basic safety rule 2002-1 on the development and the utilisation of probabilistic safety assessments for PWRs (26th December 2002).

RFS-I.2.a. Integration of risks related to aircraft crashes (5th August 1980).

RFS-I.2.b. Integration of risks of projectile release following fragmentation of the turbogenerators (5th August 1980).

RFS-I.2.d. Integration of risks related to the industrial environment and communication routes (7th May 1982).

RFS-I.3.a. Use of the single failure criterion in safety analyses (5th August 1980).

RFS-I.3.b. Seismic instrumentation (8th June 1984)

RFS-I.3.c. Geological and geotechnical site studies; determination of soil characteristics and study of soil behaviour (1st August 1985).

RFS-II.2.2.a. Design of containment spray systems (5th August 1980); revision 1 (31st December 1985).

RFS-II.3.8. Construction and operation of the main secondary system (8th June 1990).

RFS-II.4.1.a Software for safety-classified electrical equipment (15th May 2000).

RFS-IV.I.a. Classification of mechanical equipment, electrical systems, structures and civil engineering works (21st December 1984).

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 (21st December 1984).

RFS-IV.2.b. Requirements to be considered in the design, qualification, implementation and operation of electrical equipment included in safety-classified electrical systems (31st July 1985).

RFS-V.I.a. Determination of the activity released outside the fuel to be considered in accident safety studies (18th January 1982).

RFS-V.I.b. Means of meteorological measurements (10th June 1982).

RFS-V.2.b. General rules applicable to civil engineering works (ref.: RCC-G code), (30th July 1981).

RFS-V.2.c. General rules applicable to the production of mechanical equipment (ref.: RCC-M code), (8th April 1981); revision 1 (12th June 1986).

RFS-V.2.d. General rules applicable to the production of electrical equipment (ref.: RCC-E code), (28th December 1982); revision 1 (23rd September 1986).

RFS-V.2.e. General rules applicable to the production of fuel assemblies (ref.: RCC-C code), (28th December 1982); revision 1 (25th October 1985); revision 2 (14th December 1990).

RFS-V.2.g. Seismic calculations for civil engineering works (31st December 1985).

RFS-V.2.h. General rules applicable to the construction of civil engineering works (ref.: RCC-G code), (4th June 1986).

RFS-V.2.j. General rules relative to fire protection (ref.: RCC-I code), (20th November 1988).

Memorandum SIN 3130/84 of 13 June 1984 on the conclusions of the review of the document entitled "Design and Construction Rules for PWR NPPs. Handbook of rules on processes - 900 MWe reactors" (ref.: RCC-P code).

2.3.2 Rules relative to the other BNIs

RFS-I.1.a. Integration of risks related to aircraft crashes (7th October 1992).

RFS-I.1.b. Integration of risks related to the industrial environment and communication routes (7th October 1992).

RFS-I.2.a. Safety objectives and design bases for surface facilities intended for long-term disposal of solid radioactive waste with short or intermediate half-life and low or intermediate specific activity (8th November 1982 – revision of 19th June 1984).

RFS-I.2.b. Basic design of ionisers (18th May 1992).

RFS-I.3.c. Criticality risk (18th October 1984).

RFS-I.4.a. Fire protection (28th February 1985).

RFS-II.2. Design and operation of ventilation systems in BNIs other than nuclear reactors (20th December 1991).

RFS-III.2.a. General provisions applicable to the production, monitoring, processing, packaging and interim storage of various types of waste resulting from reprocessing of fuel irradiated in PWRs (24th September 1982).

RFS-III.2.b. Special provisions applicable to the production, monitoring, processing, packaging and storage of high-level waste packaged in the form of glass and resulting from reprocessing of fuel irradiated in PWRs (12th December 1982).

RFS-III.2.c. Special provisions applicable to the production, monitoring, processing, packaging and interim storage of low or intermediate level waste encapsulated in bitumen and resulting from reprocessing of fuel irradiated in PWRs (5th April 1984).

RFS-III.2.d. Special provisions applicable to the production, monitoring, processing, packaging and interim storage of waste encapsulated in cement and resulting from reprocessing of fuel irradiated in PWRs (1st February 1985).

RFS-III.2.e. Prerequisites for the approval of packages of encapsulated solid waste intended for surface disposal (31st October 1986 – revision of 29th May 1995).

2.3.3 Other basic safety rules

RFS 2001-01 Determination of seismic movements to be taken into account for the safety of installations (revision of RFS-I.2.c and RFS-I.1.c – 16th May 2001).

RULE SIN C-12308/86 (RR1)

Cleaning systems equipping nuclear research reactor ventilation systems (4th August 1986).

RULE SIN A-4212/83

Relative to meteorological measurement means (12th August 1983).

RULE SIN C-12670/9-1 (RR2)

Protection against fire risk in nuclear research reactors (1st July 1991).

2.3.4 Guides

ASN Guides (in force in June 2016) related with the subject matter of this report

ASN Guide 2/01 (26th May 2006) dedicated to consideration of seismic risk in conception of BNIs civil engineering works, except for long-term storage of radioactive waste.

General safety orientation guide for siting of long-life low-level activity waste storage facility (May 2008).

N°1 Safety guide on the final disposal of radioactive waste in a deep geological formation (8th February 2008).

N°2 Transport of radioactive materials in airports (15th February 2006).

N°3 Recommendations for the preparation of annual reports on public information concerning BNIs (20th October 2010).

N°6 Final shutdown, decommissioning and delicensing of French BNIs (18th June 2010).

N°7 Shipment approval requests and certification applications for package design or the road transport of radioactive materials for civilian uses (28th February 2013).

N°8 Conformity assessment of nuclear pressure equipment (4th September 2012).

N°9 Determining the BNI scope (31st October 2013).

N°10 Involvement of local information committees (CLIs) in the framework of the third ten-yearly outages of 900-MWe reactors (1st June 2010).

N°12 Notification procedures and the codification of criteria relating to significant events involving safety, radiation protection or the environment applicable to BNIs and to the transport of radioactive materials (21st October 2005).

N°13 BNIs protection against external flooding (8th January 2013).

N°14 Acceptable complete clean-out methodlogies in BNIs in France (21st June 2010).

N°15 Control of activities in the BNI neighbourhood (24th March 2016).

N°17 Contents of management plans for incidents and accidents involving the transport of radioactive substances (22th December 2014).

N° 19 Implementation of the 12th December 2005 order related to nuclear pressure equipment (21st February 2013).

N° 21 Treatment of compliance deviations with a requirement defined for an element important for protection (EIP) (6st January 2015).

Draft ASN Guides (in April 2016)

Table 16: List of draft ASN Guides

Title	Consultation
Safety requirement for PWR design	
Setting and modification of BNI waste zoning plan	
Management of contaminated soil by BNI activities	
Stakeholders contribution to drafting of a resolution or an ASN guide	
Interests protection policy (PPI) and integrated management system (SMI)	From 24/01/2014 to 21/02/2014. From 03/08/10 by mail or via internet from 10/08/10 to 15/11/10. WENRA the 10/08/2010 by mail
PWR fuel	
Shut down for refuelling PWR	
Criticality risk management	
Approval methods for waste packaging	
Design and operation of internal waste storage	
Emergency preparedness	
Incident notification	

APPENDIX 3 – ORGANISATION OF NUCLEAR REACTOR OPERATORS

3.1. EDF's organisation for nuclear power reactors

EDF is France's main electricity producer, and the country's only operator of nuclear power reactors. Nuclear safety and radiation protection are applicable to all BNIs operated by the company as well as to nuclear materials shipped from them. Nuclear safety and radiation protection concern all personnel working or present in a BNI for any reason. In this respect, EDF has defined and implemented a nuclear safety and radiation protection policy (see above - § 10.2), with the setting up of an independent evaluation on each nuclear site, at Nuclear Production Department (DPN) level and at Chairman and CEO level.

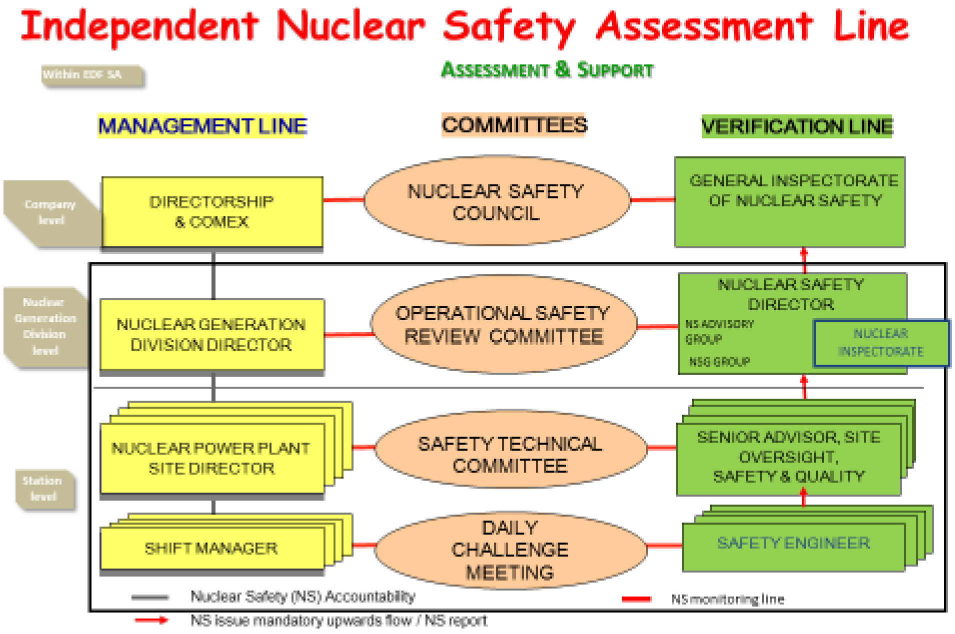


Figure 16: Organisation of nuclear safety and oversight at EDF

3.1.1 The Chairman and Chief Executive Officer

Under the powers delegated to him by the Board of Directors, the Chairman & CEO has all the powers required for EDF S.A. to exercise its role as a nuclear licensee. In particular, he determines strategies regarding nuclear safety. He sets the general organisational principles and the resources that allow EDF S.A. to exercise its responsibilities as nuclear licensee, with the support of the Senior Executive Director for nuclear and thermal generation and of the Senior Executive Director for engineering and new nuclear projects.

He chairs the Nuclear Safety Board and 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.

The Inspector General for Nuclear Safety and Radiation Protection ensures that nuclear safety and radiation protection concerns have been properly taken into account for the company's nuclear installations, and reports to the Chairman & CEO in this respect.

APPENDIX 3 – Organisation of nuclear reactor operators

The new organisation for nuclear power production put in place in 2015, is based on two departments:

- DPNT, the Nuclear and Thermal Fleet Department;
- DIPNN, the Engineering and New Nuclear Projects Department.

They lead 4 major projects:

- for the DPNT: operation of the reactors over the long term with the implementation of the renovation and associated works programme (major overhaul), dismantling and the management of waste;
- for the DIPNN: the Flamanville 3 EPR and the new reactor models.

With regard to operation of the nuclear reactors, the DPNT includes in particular:

- the nuclear production division, with all the sites in operation, the UNIE (operation engineering unit) and the UTO (central technical department);
- the nuclear fuel division;
- a dismantling and waste projects department;
- a division for fleet engineering, dismantling and the environment, which groups all the CIPN teams and some of the CIDEN teams (environment, new construction and civil engineering, risk control and operation);
- the major overhaul programme.

With regard to engineering and new nuclear projects, the DIPNN includes more specifically:

- a technical and industrial department;
- a Flamanville 3 project department;
- a new model EPR project department;
- a development department.

The following engineering units are attached to the DIPNN: the CNEPE (National Electricity Generating Equipment Centre), the CNEN (National Centre for Nuclear Equipment), the SEPTEN (Design Department for Thermal and Nuclear Projects) and the CEIDRE (Construction and Operation Expert Appraisal and Inspection Centre).

With these units of expertise, which are also necessary for the fleet in service, the DIPNN is at the centre of the challenges facing the fleet in service and the new nuclear age.

3.1.2 The Group Executive Director in charge of nuclear and thermal production and the Group Executive Director in charge of engineering and new nuclear projects

The Group Executive Director in charge of nuclear and thermal production and the Group Executive Director in charge of engineering and new nuclear products, take all the necessary measures for EDF S.A. to exercise its role as nuclear licensee, particularly in all the phases of the process under their responsibility: operation of the reactors, construction and commissioning of the Flamanville 3 EPR.

They propose and implement the organisation and operating principles to ensure compliance with the nuclear safety and radiation protection rules, and due exercising of the responsibility of nuclear licensee, particularly with regard to the main investment decisions and preservation of assets (technical and intellectual), in accordance with the corresponding internal procedures. They are assisted by the directors and technical unit directors under their authority in the various areas concerned.

They are the point of contact with the competent nuclear safety and radiation protection authorities for nuclear reactors, each in their own area.

The Group Executive Director in charge of engineering and new nuclear products is responsible for developing the design baseline requirements and integrating them in the design of the reactors. The development of the design baseline requirements during operation of the nuclear fleet reactors is the responsibility of the Group Executive Director in charge of nuclear and thermal production, in consultation and with the support of the relevant directors of the engineering and new nuclear projects division.

They set the specific measures to be implemented in their field, as well as the policy and directions in terms of nuclear safety and radiation protection. They set the objectives and distribute the resources among the units. The Group Executive Director in charge of nuclear and thermal production ensures that unit managers have at all times the authority, skills and resources required to achieve the set objectives, either within their respective units, or as collective resources available to them within or outside their department.

3.1.3 Directors of the Nuclear Power Operations Division and the Nuclear Engineering Division

Under the authority of the Group Executive Director in charge of nuclear and thermal production, the Director of the Nuclear Operations Division is the representative of EDF S.A. as nuclear licensee for all nuclear reactors in operation.

The Director of the Nuclear Power Operations Division takes all of the measures required for EDF S.A. to exercise its role as nuclear licensee, particularly in all the phases of the process concerning operation of the nuclear fleet which is the responsibility of the company. He proposes and implements the principles of organisation and operation that ensure compliance with nuclear safety and radiation protection rules, and the effective exercise of the responsibilities of EDF S.A. as nuclear licensee.

He is the chief point of contact for the competent regulatory authorities in the area of nuclear safety and radiation protection in respect of the generic aspects of the reactors for which he is the nuclear licensee.

More specifically, the Director of the Nuclear Operations Division is responsible for approving and integrating changes to the baseline operating requirements of the reactors and is assisted in this task by the other departments concerned.

In the performance of their duties, the Directors of the Engineering and New Nuclear Projects Department organise the support for the design and engineering units of their unit in the activities of the Nuclear Operations Division.

3.1.4 NPP Manager

As the representative of EDF S.A. the nuclear licensee in respect of the facilities for which responsibility is delegated to him by the Director of his Division, and under the latter's authority, the Unit Manager takes all measures necessary to exercise this responsibility. In particular, in all phases of the process for which the company is responsible, he proposes and implements the principles of organisation and operation that ensure compliance with nuclear safety and radiation protection rules and allow the effective exercise of the responsibilities of EDF S.A. as the nuclear licensee.

APPENDIX 3 – Organisation of nuclear reactor operators

The NPP manager enacts internal measures to facilitate compliance with nuclear safety and radiation protection requirements. He has compliance with these requirements verified through appropriate internal checking. He reports the information relating to nuclear safety and radiation protection to the Director of the division. He is the chief point of contact for the national and local competent regulatory authorities in the area of nuclear safety and radiation protection for the issues specific to the installations under his responsibility.

3.2. Organisation of the CEA

The CEA is a public research organisation established in 1945. In 2001, it set up an operational organisation based on the establishment of 4 operational "sectors" corresponding to its main areas of activity as illustrated on the organisation chart below in figure 16: nuclear energy sector, technological research sector, fundamental research sector and defence sector. Four other functional sectors, including the "risk control sector", have been completed the organisation. Each operational sector is provided with resources (general management, objectives departments, internal functional resources) that it uses to develop, plan and control all its activities.

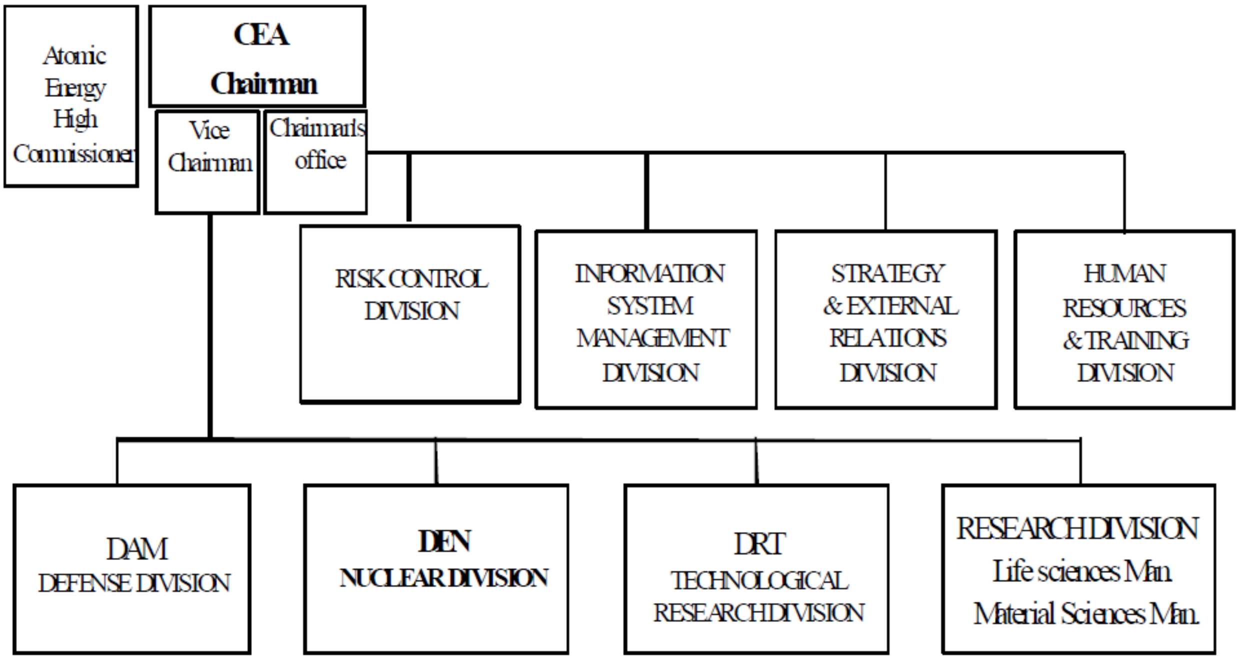


Figure 17: General Organisation of the CEA until end 2015

The nuclear reactors covered by this report are managed by the Nuclear Energy Division (formerly the Nuclear Energy Centre) which defines the programmes and ensures their through-life support.

This organisation changed in January 2016 with term "pôle" (centre) being replaced by "directions" (Divisions). This new general organisation of the CEA is illustrated in figure 17.

- With regard to safety, which includes nuclear safety, there are three levels of delegation of responsibilities:
- the General Administrator, head of the CEA and, as such, the nuclear licensee of the reactors;
- Directors of the centres, local representatives of the General Administrator and of the nuclear licensee in particular;

- the Installation Managers, responsible for ensuring compliance with the regulations and internal rules applicable to their installation 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 Nuclear Energy signs an annual safety objectives agreement (COS) with the General Administrator, which formalises the objectives Execution of this safety objectives agreement is monitored by the Protection and Nuclear Safety Department on behalf of the General Administrator

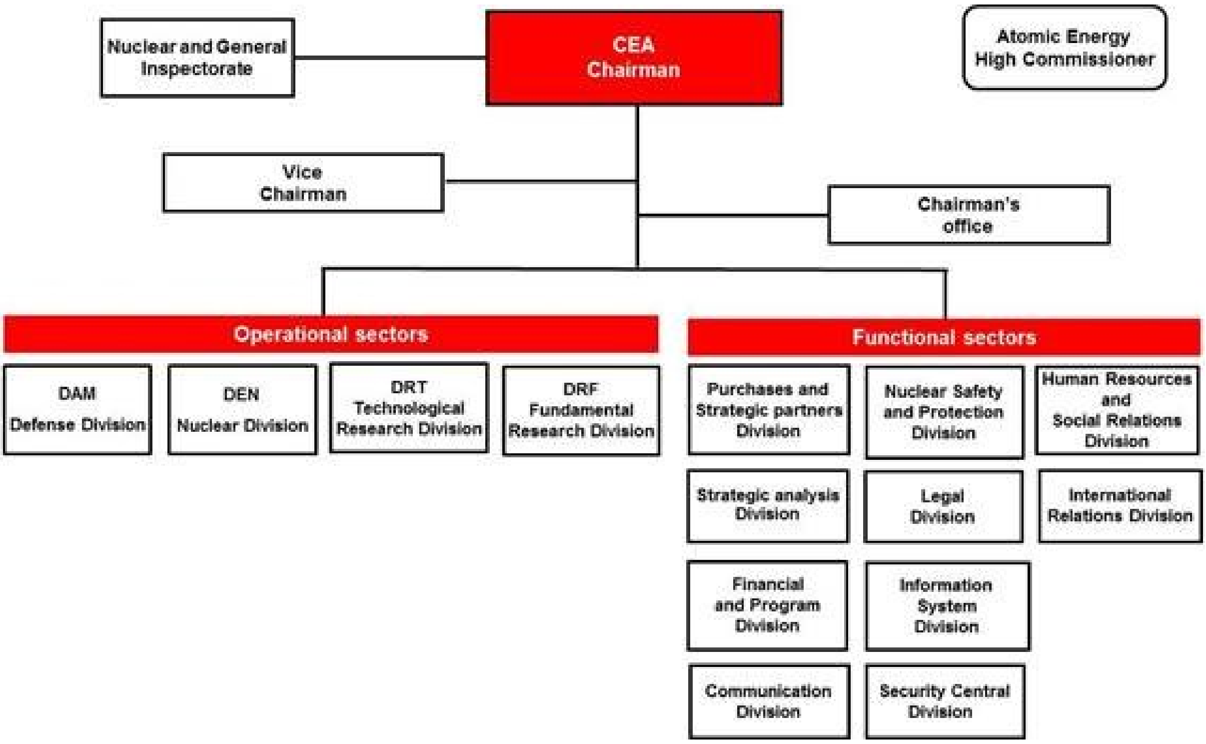


Figure 18: Organisation of the CEA since January 2016

3.3. Organisation of the ILL

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 in association with its 11 scientific members countries (Spain, Italy, Switzerland, Austria, the Czech Republic, Hungary, Slovakia, Polonia, Belgium, Sweden and Denmark).

It is currently organised into four divisions managed by the Director:

- the science division groups together includes all the scientific activities;
- the projects and techniques division manages infrastructures necessary for carrying out experiments. It also includes activities for the development of experimental techniques and techniques for the construction or modification of experimental devices;
- the administration division is responsible for normal administrative activities and some general services;
- the reactor division is responsible for operating the reactor, its facilities and auxiliary equipment.

APPENDIX 3 – Organisation of nuclear reactor operators

The Radiation Protection and Environmental Monitoring Service, which also includes conventional security, reports directly to the Director of the ILL.The quality assurance and the risk management are also directly attached to the the ILL Director.

With regard to the management of the BNI and the other facilities specified in the safety report, the Director delegates his responsibilities as licensee to the Head of the Reactor Division. The Head of the Reactor Division is Deputy Director with regard to the safety and management of the BNI and the other facilities specified in the safety report. In this capacity he is responsible for the final decision concerning the safety of the operating conditions of the reactor, the instruments and the experimental devices.

APPENDIX 4 – ENVIRONMENTAL MONITORING

4.1. Monitoring of NPP discharges (based on the most recent authorisations issued by ASN)

4.1.1 Regulatory monitoring of NPP liquid discharges

Table 17: Regulatory monitoring of NPP liquid discharges

ORIGIN AND TYPE	REGULATORY SAMPLINGS AND CHECKS TO BE CARRIED OUT BY THE LICENSEE
T Tanks Process effluents, Service effluents, Steam generator blowdowns	Sampling from each tank after mixing: • pre-discharge analyses: ➢ pH, α_G, β_G, γ_G, ^3H, γ spectrometry ; ➢ chemicals according to site configuration • post-discharge analyses: ^{14}C Continuous measurement of γ activity on the discharge pipe upstream from its outlet into the cooling water At end of month, taking of a pooled monthly average sample • analyses : ^{63}Ni, DCO and metals
EX Tanks (Turbine hall effluents)	Sampling from each tank after mixing: • pre-discharge analyses: ➢ β_G, ^3H ➢ chemicals according to site configuration At end of month, taking of a pooled monthly average sample • analyses: pH, α_G, β_G, γ_G, ^3H, γ spectrometry
Wastewater, stormwater	Spot water sampling – analyses: β_G, potassium, ^3H Sampling of the deposits in the drainage systems at least once a year • analyses: γ spectrometry

Activity α_G, β_G, γ_G = activity α, β, γ globale

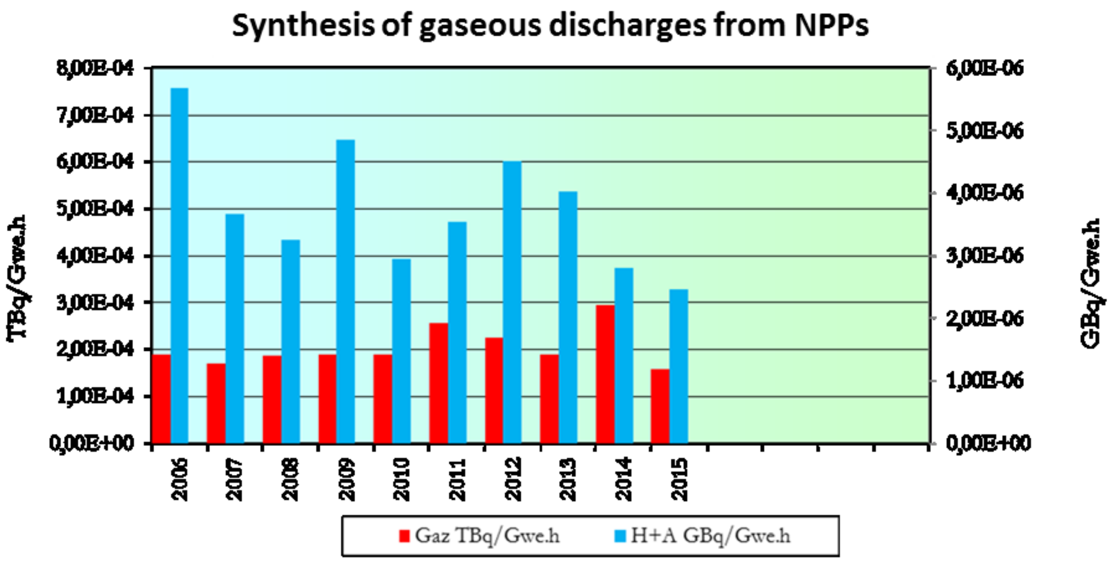
4.1.2 Regulatory monitoring of NPP gaseous discharges

Table 18: Regulatory monitoring of NPP gaseous discharges

ORIGIN AND TYPE	REGULATORY SAMPLINGS AND CHECKS TO BE CARRIED OUT BY THE LICENSEE
Continuous measurement with recording of β_G activity in each stack	
CONTINUOUS DISCHARGES (ventilation)	Instantaneous weekly gas samples – analyses: γ spectrometry (rare gases) Continuous sampling of tritium and weekly analyses Continuous sampling of gaseous halogens – weekly analyses: γ_G, γ spectrometry Continuous sampling of aerosols – weekly analyses: α_G, β_G, γ spectrometry Continuous sampling of ^{14}C – quarterly analyses (currently being set up)

PLANNED DISCHARGES (draining of tanks, air from reactor buildings, etc.)	Pre-discharge analyses: • gas – analyses: γ spectrometry (rare gases), ^{3}H • gaseous halogens – analyses: γ_G, γ spectrometry • aerosols – analyses: α_G, β_G, γ spectrometry

4.1.3 Synthesis of discharges from NPPs (2006 – 2015)



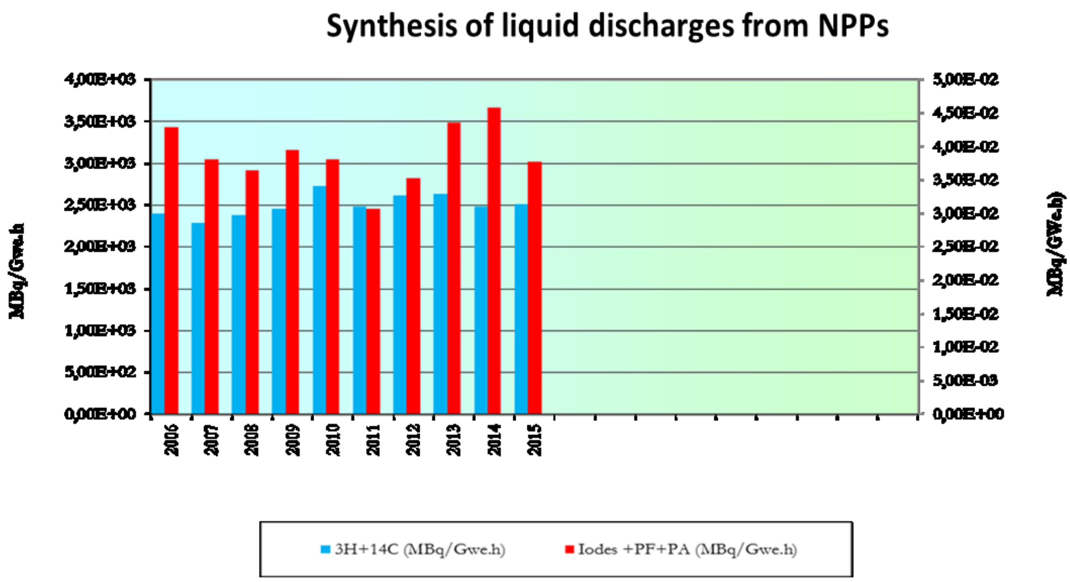


Figure 19: Synthesis of discharges from NPPs (2006 – 2015)

PF: Fission products   PA: others activation products

4.2. Nature of environmental monitoring around the NPPs

Table 19: Nature of environmental monitoring around NPPs

Monitored medium of type of check	NPP
Air at ground level	• 4 continuous fixed-filter atmospheric dust-sampling stations with total daily β measurements (β_G); γ spectrometry if β_G > 2 mBq/m^3. • For each station, γ spectrometry on the monthly aggregation of the daily filters • 1 continuous sampling station downwind of the prevailing winds with weekly tritium (^3H) measurement
Ambient γ radiation	• 4 detectors at 1 km with continuous measurements and recordings • 10 detectors with continuous measurements on the site boundary (monthly reading) • 4 detectors at 5 km with continuous measurements
Rainfall	• 1 station downwind of prevailing wind (continuous sampling) with measurements of β_G and ^3H on bimonthly pool
Outlet of liquid discharges	• Upstream river sampling at mid-discharge for each discharge (for riverside NPPs) or sampling after dilution in the cooling water and semi-monthly samples at sea (for coastal NPPs): measurements of β_G, (K) and ^3H • Continuous ^3H sampling (daily average pool) • Annual samplings in sediments, aquatic fauna and flora with measurements of ^3H, ^{14}C,γ spectrometry
Groundwaters	• 5 sampling points (monthly check) with measurements of β_G, K and ^3H
Soil	• 1 annual sampling of topsoil with γ spectrometry
Plants	• 2 grass-sampling points (monthly check) and γ spectrometry; measurement of ^3H, ^{14}C and total carbon (quarterly) • Annual campaign on major agricultural produce with measurements of ^3H, ^{14}C and total carbon, and γ spectrometry
Milk	• 2 sampling points (monthly check) with γ spectrometry and, every year, measurements of ^{14}C and ^3H.

4.3. Monitoring exposure of the population and the environment (examples)

The French national network of environmental radioactivity measurements (RNM)

Article R. 1333-11 of the French Public Health Code provides for the creation of a national network of environmental radioactivity measurements (RNM) with a dual aim:

- ensuring information transparency by making the environmental monitoring results available to the public along with information on the radiological impact of nuclear activities in France;
- guaranteeing the quality of the environmental radioactivity measurements by instituting a system of laboratory approvals delivered by ASN resolution.

On 2nd February 2010 the RNM launched a website presenting the results of environmental radioactivity monitoring and information on the impact of the nuclear industry on health in France. In order to guarantee measurement quality, only the measurements made by an ASN approved laboratory or by IRSN can be communicated to the RNM.

The website provides information on radioactivity, on the RNM, and access to a database that groups all the radioactivity measurements made on the French national territory (i.e. nearly 1,700,000 measurements).

The RNM is accessible on www.mesure-radioactivite.fr. This website is undergoing a major redesign which began in 2014 with the aim of making the information more understandable for the general public, and will be operational during 2016.

Figure 20: Location of the environmental monitoring stations in 2015 (source: IRSN)

TELERAY is a set of beacons for measuring the ambient gamma radioactivity which are permanently linked to a centralised supervision system via a data transmission network. This set of sensors spread over the French territory, including the French overseas departments, regions and collectivities (DROM-COM), enables IRSN to monitor permanently the radiological situation on behalf of the citizens and the public authorities. It also fulfils an alert function in the event of discharges over French territory or more distance locations: thus, if an abnormal level of radioactivity is detected, an alarm is sent immediately to the person on call (24h/24h).

APPENDIX 4 – Environmental monitoring

The renovation of the Téléray network, which began in 2009, culminated in 2015 with the installation of nearly 420 new-generation beacons (see Figure 20) near nuclear installations which are potential sources of discharges as well as in built-up areas.

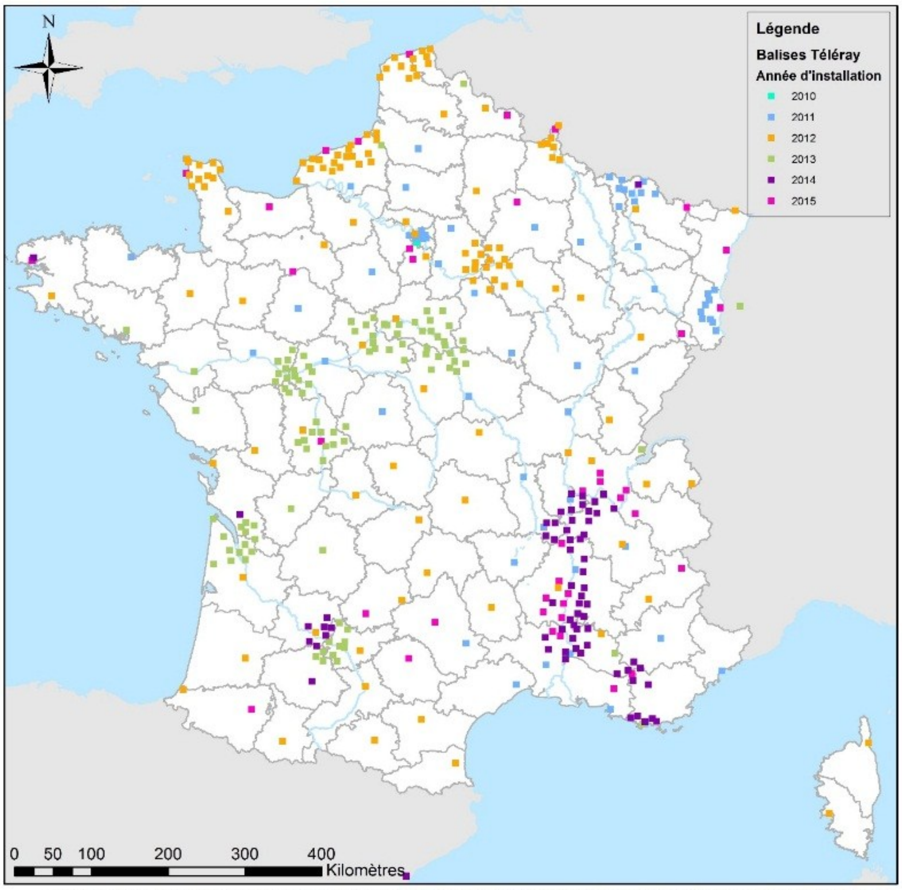


Figure 21: Location of Teleray stations network in 2015 (Source: IRSN)

APPENDIX 5 – OSART MISSIONS

France is a regular host to OSART missions

The in-depth analysis of the operational safety of NPPs is carried out through OSART (Operational Safety Review Team) missions. Each mission, which lasts 3 weeks on average, concerns a nuclear power plant and is supplemented by a follow-up mission which takes place 18 months after the review mission.

France has hosted OSART missions and the associated follow-up missions since 1985. In 2016, the entire French NPP fleet had been reviewed at least once. Thus, with regard to these missions, France will have applied the recommendation of the IAEA's action on nuclear safety decided after the Fukushima accident: *"Member States to be strongly encouraged to voluntary host IAEA peer reviews, including follow-up reviews, on a regular basis"*.

France moreover regularly sends experts to participate in the teams conducting audits abroad.

The following table lists the OSART missions carried out or planned in France.

Table 20: List of OSART missions carried out in France

	NPP	Mission dates	Follow-up mission dates
	Bugey	13th – 30th November 2017	2019
	Golfech	10th – 27th October 2016	2018
	Dampierre	31st August – 17th September 2015	2017
	Corporate EDF	24th November – 9th December 2014	7th – 11st November 2016
	Flamanville (Reactors 1 and 2)	6th – 23 th October 2014	28th November – 2nd December 2016
25	Chooz	17th June – 4th July 2013	1st – 5th June 2015
24	Gravelines	12th - 29th November 2012	19th – 23th May 2014
23	Cattenom	14th November – 1st December 2011	3rd – 7th June 2013
22	Saint-Alban	20th September – 6th October 2010	19th - 23rd March 2012
21	Fessenheim	23rd March – 8th April 2009	7th -11th February 2011
20	Cruas	24th November - 11th December 2008	13th - 17th December 2010
19	Chinon	27th November – 14th December 2007	7th - 11th December 2009

APPENDIX 5 – OSART Missions

18	Saint Laurent	25th November – 14th December 2006	6th - 10th October 2008
17	Blayais	2nd - 18th May2005	6th - 10th November 2006
16	Penly	29th November - 15th December 2004	2nd - 5th May 2006
15	Civaux	12th - 28th May 2003	6th - 10th December 2004
14	Nogent	20th January – 6th February 2003	15th - 19th November 2004
13	Tricastin	14th - 31st January 2002	17th - 25th November 2003
12	Belleville	9th - 26th October 2000	13th - 17th May 2002
11	Bugey	8th - 25th March 1999	5th - 9th June 2000
10	Golfech	26th October - 12th November 1998	6th - 10th March 2000
9	Paluel	12th - 30th January 1998	21st - 25th June 1999
8	Dampierre	11th - 29th November 1996	15th - 19th June 1998
7	Flamanville	30th January - 16th February 1995	3rd - 7th June 1996
6	Cattenom	14th - 31st March 1994	12th - 16th June 1995
5	Gravelines	15th March - 2nd April 1993	7th - 10th November 1994
4	Fessenheim	9th - 27th March 1992	-
3	Blayais	13th - 31st January 1992	-
2	Saint Alban	20th October - 10th November 1988	-
1	Tricastin	4th - 29th October 1985	-

The conclusions of the last OSART missions

- **Dampierre (mission from 31st August to 17th September 2015)**

The OSART team underlined the site's performance with regard to integration of the operating experience feedback from the EDF reactor fleet as a whole, the innovations in the communication and training actions to develop the safety culture, and the transmission of knowledge and trans-generational know-how in a context of a high level of NPP personnel renewal. The OSART mission moreover made suggestions and recommendations concerning: the application of error-reduction practices for operation of the installations (particularly during changes in reactor status), the depth of the safety analyses to characterise the deviations, management of waste storage and packaging on the facilities, and the availability and operability of the emergency response resources.

- **"Corporate OSART" EDF SA (mission from 24th November to 9th December 2014)**

Initiated in 2013, the "Corporate" missions are carried out in the licensee's head office departments. For the first mission of this type in France, the assessment focused on the centralised functions of EDF's general organisation, which have an impact on all aspects of nuclear reactor operating safety. Aspects such as managerial management of the company, independence of verification, human resources, communication, maintenance, technical support, operating experience, emergency situation and severe accident management were reviewed.

Among the Group's good practices brought to light, the OSART team praised the training programme put in place by EDF, its Nuclear rapid intervention force (FARN) for responding to emergency situations, and its good relations with the entities involved in safety at all levels. It considers that EDF can improve its scheduling and documenting of changes planned for in the NPPs during reactor outages, and in the generalisation of incident analysis methods.

- **Flamanville – reactors 1 & 2 (mission from 6th to 23rd October 2014)**

On this site the OSART team identified good practices, such as the good management system and the well-established monitoring of personnel skills. It did however also identify room for progress in maintenance practices, in application of the NPP's procedures and in investigating more deeply the causes of operating events.

The reports for all these missions are made public and available on the ASN website: http://www.french-nuclear-safety.fr/International/Multilateral-relations-outside-Europe/The-International-Atomic-Energy-Agency-IAEA/The-IAEA-audits-in-France.

APPENDIX 6 – BIBLIOGRAPHY

6.1 Documents

/1/ Convention on Nuclear Safety (CNS), September 1994.

/2/ Guidelines regarding National Reports under the Convention on Nuclear Safety, IAEA - INFCIRC/572/Rev.4, January 2013.

/3/ Convention on Nuclear Safety – National Report for the Second Extraordinary Meeting, August 2012.

/4/ ASN Annual Report 2015, April 2016 : http://www.asn.fr/Informer/Publications/Rapports-de-l-ASN

/5/ EDF – The Inspector General's Report on Nuclear Safety and Radiation Protection, 2015. https://www.edf.fr/sites/default/files/contrib/groupe-edf/producteur-industriel/nucleaire/Actualit%C3%A9s/2015_rapport-igsnr.pdf

/6/ CEA – Annual Report 2014: http://www.cea.fr/multimedia/Pages/editions/institutionnel/rapport-annuel-2014.aspx

/7/ ILL – Annual Report 2015: https://www.ill.eu/fileadmin/users_files/Annual_Report/AR-15/index.html

6.2 Websites

The abovementioned documents, or at least the essential of their content, as well as other relevant information concerning the subject of this report are available on the Internet. The following sites can be consulted in particular:

- Légifrance : www.legifrance.fr
- ASN : http://www.french-nuclear-safety.fr/
- IRSN : www.irsn.fr
- SFRO : www.sfro.org
- CEA : www.cea.fr
- EDF : www.edf.fr
- Flamanville 3 EPR information site: http://energies.edf.com/edf-fr-accueil/la-production-d-electricite-edf/-nucleaire/le-nucleaire-du-futur/epr-flamanville-3/flamanville-3-en-images-120266.html
- ILL : www.ill.fr
- ANDRA : www.andra.fr
- AIEA : www.iaea.org

APPENDIX 7 – LIST OF ABBREVIATIONS

Table 21: List of Abbreviations

AAR	Automatic reactor trip system
AIP	Activity important for protection
ALARA	As Low As Reasonably Achievable
ANDRA	French national agency for radioactive waste management
AP	Advanced Process
APE	State-based approach
ASG	Auxiliary feedwater system
ASN	Autorité de Sûreté Nucléaire (French nuclear safety authority)
ASND	Defence Nuclear Safety Authority
ATEX	Explosive atmospheres regulations
BK	Fuel Building
BMI	Bottom-mounted instrumentation
BNI	Basic Nuclear Installation
CCC	Emergency coordination centre
CCL	Local emergency management centre
CEA	French Alternative Energies and Atomic Energy Commission
CHRS	Containement Heat Removal System
CIC	Interministerial crisis committee
CLI	Local Information Committee
CODIRPA	Steering committee for managing the post-accident phase of a nuclear accident or a radiological emergency situation
COFRAC	French Accreditation Committee
COFSOH	Steering Committee for Social, Organisational and Human Factors
CSP	PWR main secondary system
CSPRT	Higher council for the prevention of technological risks
CSA	ANDRA's Aube waste repository
DAC	Creation Authorisation Decree
DCO	Chemical Oxygen Demand
DGSCGC	General Directorate for Civil Security and Emergency Management
DPN	EDF nuclear operation division
DPSN	CEA's nuclear safety and protection division

APPENDIX 7 – List of abbreviations

DUS	Ultimate backup diesel generator set
EBIDTA	Earnings before interest, taxes and amortization
ECOT	Reactors' conformity check programme
ECS	Stress tests
EDF	Électricité De France
EIP	Equipment important for protection
ELC	Local emergency response team
ENSREG	European Nuclear Safety Regulators Group
EPIC	Industrial and commercial public institution
EPRI	Electric Power Research Institute
ESE	Events Significant for the Environment
ESPN	Nuclear pressure equipment
ESR	Events Significant for Radiation protection
ESS	Events Significant for Safety
ETC	Emergency Technical Centre
ETC-N	National emergency technical team
EUR	European Utility Requirements
EVU	Ultimate heat evacuation
FARN	Nuclear rapid intervention force
FMECA	Failure Modes, Effects and Criticality Analysis
FROG	Framatome Owners Group
GCT	Turbine bypass system
GPD	Advisory Committee of Experts for Waste
GPE	Advisory Committee of Experts
GPEC	Planning of jobs and skills management
GP ESPN	Advisory Committee for nuclear pressure equipment
GPR	Advisory Committee of Experts for nuclear reactors
GPU	Advisory Committee of Experts for Plants
GSR	General Safety Requirements
HCTISN	High Committee for Transparency and Information on Nuclear Security
HERCA	Heads of European Radiological Protection Competent Authorities
HFR	The High-flux Reactor located close to CEA's Grenoble site
IAEA	International Atomic Energy Agency
ICPE	Installation Classified on Environmental Protection grounds

APPENDIX 7 – List of abbreviations

ICRP	International Commission of Radiation Protection
IGN	The General and Nuclear Inspectorate of the CEA's Risk Control Sector
I&C	Instrumentation and Control
ILL	Laue–Langevin Institute
IMS	Integrated management system
INES	International Nuclear Events Scale
INEX	International Nuclear Emergency Exercice
INPO	Institute of Nuclear Power Operators
INSAG	International nuclear safety advisory group
IO	ITER Organization
IPS	Important for Safety
IRRS	Integrated Regulatory Review Service
IRS	NEA's International Reporting System database
IRSN	French Institute for Radiation Protection and Nuclear Safety
ITER	International Thermonuclear Experimental Reactor
ITS	Temporary Safety Instructions
JHR	Jules Horowitz Reactor
LHA / LHB	Backed-up electrical distribution switchboards
MARN	Nuclear Risk Management Aid Committee
MDEP	Multinational Design Evaluation Programme
MEEM	Ministry of the Environment, Energy and the Sea
MHPE	Maximum historically probable earthquake
MPS	Main Primary System
MSS	Main Secondary System
NEA	Nuclear Energy Agency
NPE	Nuclear Pressure Equipment
NPP	Nuclear Power Plant
OECD	Organisation for Economic Co-operation and Development
OEF	Operating Experience feedback
OHF	Organisational and Human Factors
OPECST	Parliamentary Office for the Evaluation of Scientific and Technical Choices
OSART	Operational Safety Review Team
OSRDE	Safety, Radiation Protection, Availability, Environment Observatory

APPENDIX 7 – List of abbreviations

PAR	Passive autocatalytic recombiners
PC	Command post
PCC	Control command post
PCD	Strategic management command post
PCD-N	National strategic management command post
PCD-L	Local strategic management command post
PCL	Local command post
PCM	Resources command post
PCO	Operational command post
PCR	Person Competent in Radiation protection
PCS	Emergency control station
PCT	Technical command post
PDCC	Nuclear engineering key skills development plan
PIC	Complementary investigation programme
PLC	Programmable logic controller
PNGMDR	National radioactive materials and waste management plan
PPE	Multi-year energy programming
PPI	Off-site emergency plan
PSA	Probabilistic Safety Analysis
PSAR	Preliminary Safety Report
PTR	Primary system borated water tank
PUI	On-site emergency plan
PV	Report
PWR	Pressurised Water Reactor
RANET	Response Assistance Network
RCC	Design and construction rules
RCN	Act 68-943 of 30th October 1968 on civil liability in the nuclear energy field (known as the “RCN” Act)
RCV	Chemical and Volume control system
RDS	Safety report
REN	Nuclear sampling system
RFS	Basic safety rules
RGE	General operating rules
RGV	Replacement of the steam generators

APPENDIX 7 – List of abbreviations

RHF	High flux reactor (HFR)
RJH	Jules Horowitz research reactor project on the CEA Cadarache site
RNM	French national network of environmental radioactivity measurements
RRA	Residual heat removal system
RRI	Component cooling system
SA	Severe Accident
SAI	Internal Authorisation System
SAMG	Severe Accident Management Guidelines
SAT	Systematic Approach to Training
SBNI	Secret BNI
SBO	Station Blackout
SDIS	Departmental fire and emergency service
SG	Steam Generator
SGDSN	General Secretariat for Defence and National Security
SGTR	Bundle tubes
SIC	Silver-Indium-Cadmium alloy
SISERI	Total exposure dose recorded system managed by IRSN
SNM	Military nuclear systems
SOH	Socio-Organisational and Human
SSE	Safe Shutdown Earthquake
STE	Operating Technical Specifications
TAS	The emergency turbine generator set
TECV	Act 2015-992 of 17th August on energy transition for green growth, known as the "TECV Act".
TPS	Steam generator turbine-driven auxiliary feedwater pump
TSN	Act 2006-686 of 13th June 2006 concerning transparency and security in the nuclear field, known as the "TSN Act".
USIE	Unified System for Information Exchange in Incidents and Emergencies
UNSCEAR	United Nations Scientific Commission on Effects of Atomic Radiation
VD	ten-yearly outage
WANO	World Association of Nuclear Operators
WENRA	European Nuclear Regulators' Association
WNA	World Nuclear Association

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