## NUCLEAR POWER PLANTS GOING BEYOND 40 YEARS:

THE ISSUES OF THE 4th PERIODIC SAFETY REVIEW OF THE FRENCH 900 MWe NUCLEAR POWER REACTORS



Always... safer

The issues of the 4th periodic safety review

Consultation and public inquiry

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**In what conditions can the 900 MWe nuclear power plants**, which are the oldest in the French nuclear fleet, **continue to operate?** How to guarantee management of the ageing of materials and systems after 40 years of operation?

How to ensure that the safety of the facilities progresses even further, more specifically by comparison with the most recent reactors? Alongside other stakeholders, ASN is contributing to the consultation on these questions, under the auspices of the HCTISN (High Committee for Transparency and Information on Nuclear Security).\*

Measures to improve safety and decision-making procedures, involvement of the general public, a review of the situation of other countries in Europe and around the world... **these are all keys to understanding the issues for the fourth periodic safety review of the French 900 MWe NPPs.** 



## 40 years, and then?

In France, the NPPs undergo an in-depth periodic safety review every 10 years, in order to check their level of safety and make any necessary improvements.

he oldest of EDF's thirtyfour 900 MWe reactors. which were commissioned between 1977 and 1987, are now reaching 40 years of operation: the periodic safety review is designed to determine in what conditions these reactors could continue to operate beyond 40 years. In France, the authorisation to create a nuclear facility is given by the Government, based on the opinion of ASN, which examines the licensee's application. This "green light" is given with no duration limit, but is the safety is examined every 10 years with an in-depth review of the facility, called the **periodic safety review**. Each time, the preparatory work entails extensive exchanges between EDF, the reactor licensee and ASN, to define the

review programme and the safety levels required for the next ten years of operations.

#### A LENGTHY PROCESS

In 2013, EDF sent ASN the **major objectives** to be reached for the periodic safety review of the 900 MWe reactors, in other words, the works and inspections it envisages in order to be able to continue to produce electricity in the best conditions of safety, after 40 years of service. ASN examined the guidelines proposed by EDF, calling on the expertise of the French institute for radiation protection and nuclear safety (IRSN\*) and its Advisory Committees (see box).

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ASN made a number of additional requests in its position statement in 2016.

EDF supplemented its programme of work and, at the beginning of 2018, sent ASN the measures it envisages taking in order to meet the safety improvement objectives requested by ASN in 2016. EDF's objectives response

memorandum (NRO) thus details

the steps taken to reinforce safety. The risks of accident with or without core melt, rapid and unexpected emptying of a spent fuel pool, earthquake, fire, etc. are considered in this document. The ASN examination process is continuing with further expert consultations in 2019.

In 2020, ASN will issue a decision regarding EDF's programme for all the 900 MWe reactors. After consultation of the public on the *asn.fr* website, ASN will then regulate the continued operation of each reactor by means of technical requirements.

## **ASN encourages the involvement of the public** in the process for deciding on the conditions for continued operation of the 900 MWe reactors.

In 2016, the main observations from the general public collected during the consultation organised by ASN about its draft position statement concerning the generic guidelines for the 40-year periodic safety review concerned:

- the management of ageing in general and of the reactor vessels in particular;
- consideration of operating experience feedback in general and from Fukushima in particular;
- subcontracting and the qualification of the workers.





#### **CALLING IN THE EXPERTS**

When taking its decisions, ASN draws on outside technical expertise, in particular that of IRSN\*. ASN also calls on the opinions and recommendations of advisory committees of experts (GPE), from a variety of scientific and technical backgrounds, as well as of associations.

## **Always...** safer

When it comes to safety, ASN's goal is one of continuous improvement, taking account of the objectives set for the most recent reactors and of operating experience feedback from France and abroad.

o guarantee the safety of a nuclear reactor, two problems have to be examined: • it is necessary to ensure that the operation of the facility complies with the applicable safety rules and that the ageing phenomena affecting equipment and materials have been correctly identified, dealt with and managed. The licensee must demonstrate that it can guarantee this management

for the coming 10 years. In order to address this need, **the conformity check** comprises a hydrotest\* of the reactor coolant system and a test of the reactor's containment\*;

• the reactor baseline safety requirements in force at commissioning of the reactor may become obsolete in the light of lessons learned and changing knowledge and techniques. They must then be reassessed in order to "upgrade" them. The **safety reassessment** is a key aspect of the approach adopted in France. It states that **efforts must be made to ensure that the level of safety in the facilities designed several decades previously is brought more closely into line with that of the more recent reactors**.



For example, the work to be done by EDF will take account of the lessons learned from events which have affected reactors in France or abroad: fire, intense cold and heatwaves, river flooding, earthquakes, etc. It will also take account of risks linked to changes in the natural environment of the NPPs. The aim is to be able to deal with situations going well beyond those normally encountered. When they were built, the service life considered for the design of some equipment in the reactors was 40 years.

This is why the periodic safety review of the reactors beyond 40 years is more detailed than that which took place after 30 years of operation, because it also incorporates management of the ageing of equipment and materials. Moreover, in the same way as any periodic safety review, this review comprises other aspects more particularly related to radiation protection\*,

protection of the environment and the management of emergency situations.

#### REINFORCED REQUIREMENTS FOLLOWING THE FUKUSHIMA ACCIDENT

The fourth periodic safety reviews will also be an opportunity to complete the incorporation of the changes requested by ASN in the wake of the Fukushima accident.

The lessons learned from the Fukushima accident in March 2011 led to numerous safety improvements across the French nuclear facilities. ASN asked the nuclear facility licensees to carry out a series of **stress tests**\*. On the basis of the conclusions of these assessments and stress tests\* carried out Europe-wide and on the basis of the opinion of the advisory committees, **ASN asked EDF more particularly to deploy**:

 a hardened safety core of provisions and a local emergency centre to prevent an accident or mitigate its development in the event of an external hazard;

• a nuclear rapid intervention force.

## Periodic safety reviews between 2020 and 2031



## **The schedule** of the periodic safety reviews

The fourth periodic safety reviews for the 900 MWe reactors are scheduled by EDF between 2020 and 2031.

he 900 MWe reactors were commissioned between 1977 and 1987. EDF has drawn up a schedule which includes the transmission to ASN of the conclusions of the fourth periodic safety reviews of the reactors concerned. This schedule (opposite) was drawn up on the basis of the date of the previous periodic safety review. Reactor 1 of Tricastin NPP was the first to undergo its third periodic safety review

and will therefore be the first to undergo its fourth periodic safety review.

#### WHAT THE LAW SAYS

The 10-year frequency for periodic safety reviews of nuclear facilities was introduced by the Act on transparency and security in the nuclear field ("TSN" Act) of 2006.

All basic nuclear installations (BNI) on French territory are subject to this regulatory requirement.



After the Tricastin NPP in 2019, the fourth tenyearly outage inspections will follow at the rate of five to seven reactors per year, starting in 2020, and **2020 is tomorrow!** 



# From the generic to the specific

The safety improvement programme drawn up by EDF for the fourth periodic safety reviews reconciles an overall approach for all the 900 MWe reactors in France with aspects specific to each facility.

he oldest NPPs in France have 900 MWe reactors with the same design (we also use the term "plant series"). This is why the modifications decided on, notably within the context of a periodic safety review, generally apply to all the reactors with the same power.

This is the **generic** part of the dossier. As the sole licensee of the NPPs in the French nuclear fleet, EDF is responsible for their correct operation, their security and their safety. In this respect, it prepares and implements improvement programmes appropriate to each type of reactor. In 2013, EDF proposed general guidelines for the periodic safety review programmes for the 900 MWe reactors. ASN analysed the topics selected by EDF and issued a position statement in 2016 after consulting its technical support organisation, IRSN\*, as well as various advisory committees of experts, which it regularly questions.

The Environment Code defines the conditions for a periodic safety review of the nuclear facilities and stipulates the role of each of the stakeholders: the licensee, who is responsible for the safety of its facilities, ASN, which is responsible for ensuring that the licensee implements the means needed to ensure a high level of safety, IRSN\*, ASN's technical support organisation, the local information committees (CLI\*) and so on.

GENERIC

Over and above the issues concerning all the 900 MWe reactors, account must be taken of the particularities of each NPP, installed in a specific environment, for example on the coast or on a river. Therefore, safety improvement measures decided on for all the reactors in the same plant series must be supplemented by provisions particular to each nuclear facility: this is the **specific** aspect, which takes account of the risks inherent in the site on which the reactor is installed (flooding, earthquake, etc.).

In the same way as any periodic safety review, the 10-year extension is based both on the characteristics of the reactors of the same plant series and on an analysis of the particular facility. It leads to a range of requirements issued by ASN, to be implemented by the licensee over a period of several years, under the supervision of ASN: civil engineering work, upgrading of the organisation, installation or replacement of safety equipment, steps to improve prevention of a natural hazard or consolidate spent fuel storage, etc. For each site, the ASN requirements will ensure long-term improvement of the safety of the facility.

## GENERIC GUIDELINES

#### Compliance with the design baseline requirements:

- > Anticipate equipment wear and tear
- > Check the leaktightness of the containment\*
- > Carry out the hydrotest\*

#### Safety improvement:

- > Guarantee the supply from electricity sources
- > Optimise the corium catcher\* in the event of core melt
- > Minimise core melt risks
- > Ensure safe conditions for fuel storage

#### **REINFORCED CONSULTATION**

The periodic safety review process incorporates several phases of **public consultation** about ASN's generic opinions (position on the EDF safety general guidelines, ASN position on the generic phase, etc.) along with meetings in the field with the local information committees\*.

## Similarly, a **public inquiry will be organised for each reactor**,

during the specific phase, following which ASN will draw up its requirements. Throughout the process, **the local information committees\*** – which regularly bring together the licensee, ASN, members of associations and local residents – contribute to the debates and to the decisions.



SPECIFIC

## **Major issues** for safer NPPs

The 40-year periodic safety review is a wide-ranging inspection. It is an in-depth examination of the facility, with an appropriate programme of inspections: the aim is to ensure that the works decided on by ASN will be performed in accordance with the intended programme and schedule. These works will be checked in the field by ASN, which will ensure that they are correctly performed in all the facilities concerned.

## > Conformity issues

## The hydrotest\*

Among the key checks in the periodic safety reviews, the hydrotest is a strength test consisting in subjecting the reactor coolant system to a pressure 1.2 times that for which it is designed.



## Preserving the reactor vessel

The reactor vessel cannot be replaced. The challenge is mainly to limit its ageing by modifying the core configuration inside the vessel.



## Anticipating equipment wear and tear

This entails precise and exhaustive knowledge of the degradation mechanisms (wear, corrosion, etc.) at work in the equipment of an NPP.

## Checking the leaktightness of the containment\*

The pressure is increased in the reactor building to check the tightness of its containment in the event of an accident.

## > Safety improvement issues

## Improving the robustness of electricity sources

The aim is to ensure that electricity sources are available in all situations and to increase their autonomy.

## Reducing the risk of spent fuel pool emptying

The aim is to add extra cooling and make-up systems for the spent fuel pool.





## Adding an extra system enables heat to be removed from the containment in the event of core melt

The aim is to significantly reduce releases to the environment in the event of core melt.



In the event of core melt leading to vessel melt-through, the molten fuel residues (corium) must be cooled to prevent this highly radioactive material from affecting the environment by passing through the basemat\*.

\* See glossary p. 24

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## GENERIC PHASE OF THE 40-YEAR PERIODIC

Partial conclusions of the generic EDF studies



## Work on a large-scale

The periodic safety review<sup>\*</sup> is a process which begins well before the assessment of the facility (the ten-yearly outage inspection<sup>\*</sup>) and the work which will enable the reactor's safety to be improved. This work is carried out over a period of several years and must receive ASN authorisation before it can be started. In the same way as for requirements concerning the conformity of the facility, this aspect of the periodic safety review<sup>\*</sup> will be the subject of field checks by the ASN inspectors.

### SAFETY REVIEW

ASN particular opinions

on the EDF studies, further to the opinion of the IRSN\* and Advisory Committees



SPECIFIC TRICASTIN 1 PHASE

\*\*GPE: Advisory committees of experts

\*\*\*NRO: see box p.16

#### Before the reviews start, a

framework and a method were defined for this periodic safety review\*, on the basis of the two complementary aspects: the generic nature of the reactors and the aspects specific to each facility. Between 2014 and 2015, ASN thus asked its technical support organisation, IRSN\*, and the Advisory Committee it frequently questions, to analyse the **orientations** proposed by EDF for these reviews. After the steps involved in the Generic Guidance File and then the Objective Response Memorandum and following the consultation overseen by the HCTISN\* and the studies made necessary by these steps, ASN will issue its **requirements** at the end of 2020 for performance of the work needed in all the 900 MWe NPPs.

The ASN opinion and requirements regarding this generic phase will also be the subject of a public consultation.

#### An open process

The experts, some of whom are members of civil society and environmental associations, are consulted within the context of the Advisory Committees ahead of ASN's decision regarding the improvement works to be carried out. When it drafted its position statement on the EDF generic guidance file, ASN also consulted the public in early 2016 and took account of the pertinent comments.

## **Consultation** and public inquiry

ASN regularly consults the public about its draft resolutions. The consultation process regarding the periodic safety reviews, in which ASN takes part, is placed under the auspices of the HCTISN\*, with the presence of two guarantors\*.

What is the purpose? To make information accessible and collect the public's opinion on-line and during the local consultation meetings to be organised.

n exceptional review means exceptional consultation procedures! In 2016, ASN expressed its wish to see the public involved in the drafting of its position on the "major objectives" defined by EDF. This approach is continuing with regard to the preparation of its generic opinion which will concern all the 900 MWe reactors, which it intends to publish in 2020. The HCTISN\* therefore hoped that the public would be extensively involved throughout the consultation period, which will last six months, until the spring of 2019. The public will be able to hold discussions with experts from EDF, ASN and IRSN\*

during public meetings, ask them questions and access online information on a platform specially created for this consultation.

The public will be asked to help determine the **priorities** for the safety improvement debates, on the basis of 15 topics defined by EDF in its objectives response memorandum (NRO). For the HCTISN\*: "Consultation will be a success if it leads to new proposals as part of the examination of the continued operation of the plants

**concerned"**. Finally, for each NPP, a public inquiry will be held in order to obtain the opinions and questions of all parties regarding the improvements planned by EDF in its conclusions report.

### The objectives response memorandum (NRO)

The NRO proposed by the NPPs licensee (EDF) defines priorities for the periodic safety review step. Some of the priorities identified as contributing to improved safety for the facilities commissioned 40 years ago entail changes that are essential:

- deal with large-scale natural hazards (heat wave, intense cold, fire, flooding, etc.);
- be able to cool the contents of the spent fuel pool in all circumstances, through redundant back-up systems or the creation of lighter, more mobile systems;
- be able to cool the corium\*, the fuel residue created in the event of a core melt (in other words a severe accident);
- make improvements for the management of accident situations.



Every year, ASN conducts an opinion survey among the general public, local residents and the informed public regarding nuclear safety in France and their positions regarding nuclear energy.

The French NPPs were initially designed for a service life of 40 years. Most of them are today between 30 and 40 years old. Today there are proposals for extending this service life by 10 years or more. Are you in favour of or opposed to this extension?



are favourable. Finally, the closer the public lives to a nuclear facility, the more favourable they are to its continued operation: 62% of those living near nuclear facilities are favourable.



### **Survey methods**

The last ASN opinion survey was carried out from 24 October to 29 November 2017, by telephone or in person. It concerned a national sample of 2,029 people representative of the general public and those living in the vicinity of an NPP (348 local residents queried), as well as 303 people ("informed public") considered to be opinion shapers (journalists, national or local elected officials. heads of associations or militants, CLI\* Chairs, health professionals, teachers, etc.).



303 persons





Do you think that this extension should be with the same safety requirements as those applied until now, or with reinforced safety requirements in line with those applied to the most recent nuclear facilities?



The informed public believes that extending the life of the NPPs can be envisaged **provided that the safety requirements are reinforced**.



With regard to major projects – for example such as extending the life of an NPP, its commissioning or the management of radioactive materials and wastes - do you think that ASN should consult...?



## What happens elsewhere?

40 years? 30 years? 60 years? What is the lifetime of the nuclear reactors in other countries? Is this duration regulated by law? Are periodic safety reviews carried out? Even if there are international or European recommendations and regulations, each country has its own rules concerning the operating conditions of its NPPs.

France: the regulations require the licensee of nuclear facilities to conduct an in-depth periodic safety review every 10 years. This is also the case in other European countries that operate NPPs: a European directive of 2009 (2009/71/ Euratom) sets out the principle of an in-depth assessment of the facilities "at least every 10 years" (see box).

United States: every 20 years, the nuclear power plants renew their operating license. Reviews are held mainly to ensure that the effects of equipment ageing have been anticipated. The lifetime of the NPPs is limited, but this duration is a long one. Most of the plants are already authorised to operate for 60 years. Continued operation up to 80 years is being examined.





### **INTERNATIONAL REGULATORY ORGANISATIONS**

#### International Atomic Energy Agency (IAEA\*): SSG-25 Safety Guide on PSR

The concept of the periodic safety review comprises a check on the conformity of the facility and should lead to safety improvements being proposed.

#### • Europe: Directive 2009/71/Euratom

Under the regulatory oversight of the competent authority, a licensee systematically and regularly (at least every 10 years) assesses the safety of the nuclear facility.

This reassessment aims to verify conformity with the existing design and identifies improvements to be made to address problems linked to ageing, operating experience acquired, the most recent research results and changes to international standards...



**South Korea:** a periodic safety review is held every 10 years to assess the facility's ability to function for a further 10 years.



China: to be allowed to continue to function, nuclear reactors are required by the regulations to conduct a "periodic safety review" every 10 years.

Japan: a periodic safety review is held every 5 years. The law stipulates a service life of 40 years for Japanese reactors. They may not function beyond this period, unless a 20-year service life extension application is submitted. So far, three reactors have submitted such an application.

# **Your questions,** our answers

DURING THIS FOURTH PERIODIC SAFETY REVIEW, IS IT ASN WHO DECIDES WHETHER OR NOT TO SHUT DOWN A REACTOR?

ASN can suspend the operation of a reactor at any moment in the event of serious and imminent danger. This is part of its duty of permanent oversight of nuclear facilities. A decision such as this is possible during a periodic safety review and at any time during the life of the reactor. Reviews are however an opportunity to reinforce the safety level of the reactors, notably these fourth periodic safety reviews. If EDF were to consider that, for technical or economic reasons, it could not implement ASN's requirements, the reactor would be shut down. Lastly, final shutdown of a nuclear reactor for energy policy reasons is decided on by the Government and not by ASN.

Why does ASN not make its position known regarding the continued operation of a reactor immediately following its ten-yearly outage inspection\*?

The licensee transmits the review conclusions report about 6 months after the reactor's ten-yearly outage inspection. This includes the results of the checks carried out during this ten-yearly outage inspection.

This report is examined by ASN and the proposed works are submitted to the public inquiry. ASN then issues a position statement on continued operation up until the next periodic safety review.

Pending ASN's decision and until such time as the work is performed, the reactor can continue to operate. In the same way as after each refuelling outage (or every 12 to 18 months), its restart remains subject to ASN approval.



Could our NPPs Operate for up to 60 or 80 years?

The ten-yearly outage inspection for Tricastin 1 will begin in 2019, in other words before ASN has issued its overall opinion. Is this not a contradiction? There are no regulations setting the lifetime of the French NPPs. However, each periodic safety review is an opportunity to define the conditions in which continued operation for a maximum of 10 years would be possible. At present, EDF envisages extending the lifetime of certain NPPs up to 60 years: if this were to be the case, this would require the performance of a 50-year periodic safety review, with modifications designed to guarantee and raise their level of safety.

The ten-yearly outage inspection is simply one of the steps in the periodic safety review. ASN's opinion on the generic phase of the periodic safety review, scheduled for the end of 2020, will be issued well before its position statement on the continued operation of Tricastin reactor 1, scheduled for 2022.

## Glossary

**Basemat:** thick, reinforced concrete foundation slab providing a stable support under the reactor building.

**CLI:** Local information committee. Set up for each nuclear power plant, the CLI brings together the licensee, ASN, the representatives of the local authorities in the vicinity of the plant and the local residents, along with members of associations.

**Containment:** leaktight concrete shell containing the reactor vessel, the reactor coolant system, the steam generators and the main elements important for safety in a pressurised water reactor.

**Corium:** mass of molten fuels and nuclear reactor core structural elements mixed together, which could form in the event of a severe accident.

**Divergence:** beginning of the chain reaction process in a reactor; beginning of reactor activity.

**EPR:** new type of nuclear reactor incorporating numerous improvements in terms of safety, fuel use and economic operation. An EPR reactor is under construction at Flamanville.

**Guarantors:** the consultation takes place under the auspices of two guarantors, freely appointed by the HCTISN from among the national list of guarantors drawn up by the National Public Debates Commission. The guarantors are involved in the entire process. They ensure that it takes place satisfactory, verifying that the public receives all pertinent information and guaranteeing their effective participation in the consultation, notably through the expression of observations and proposals. They also draw up a consultation report which will be made public on the HCTISN website.

**HCTISN:** High Committee for Transparency and Information on Nuclear Security.

**Hydrotest:** required every 10 years by the regulations, the hydrotest is an overall strength test which involves subjecting the system to a pressure 20% higher than its design pressure.

**IAEA:** International Atomic Energy Agency, an intergovernmental organisation created in 1957, which is part of the United Nations Organisation. Its role is to foster and promote the safe, secure and peaceful use of nuclear technologies worldwide. With 170 member countries, the IAEA is the main forum for cooperation in the field of nuclear activities. The IAEA produces and updates a body of nuclear safety standards. **IRSN:** Institute for Radiation Protection and Nuclear Safety; an industrial and commercial public institution (EPIC) which more particularly provides ASN with technical expertise.

**Periodic safety review:** in-depth examination of a nuclear facility, scheduled by the regulations every 10 years, designed to ensure the conformity of the facilities, the management of the ageing of the facility's components (materials, equipment, systems, etc.) and to raise their level of safety. This review may lead to major works in those areas in which the regulatory and technical requirements have changed significantly.

Radiation protection: radiation protection is defined as being all the rules, procedures and means of prevention and monitoring designed to prevent or mitigate the harmful effects of ionising radiation directly or indirectly affecting humans, including in the event of adverse environmental impacts.

**Stress tests:** two weeks after the Fukushima accident, the European Council meeting of 24 and 25 March 2011 decided that stress tests should be performed in European NPPs in order to take account of the first lessons learned from the accident which occurred in Japan. In France, the stress tests were known as the "Évaluations complémentaires de sûreté (ECS)" on the nuclear facilities in the light of the Fukushima disaster. By comparison with the European framework, the French exercise was extended to include all nuclear facilities and enhanced by incorporating social, organisational and human factors. 80 priority facilities, including the NPPs, were examined in 2011 and all underwent specific inspections.

**Ten-yearly outage inspection:** lengthy reactor outage (about five months) during which the licensee carries out checks and modifications in order to reinforce the safety level. The ten-yearly outage inspection is one step in the periodic safety review and leads to a conclusions report sent to ASN.



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