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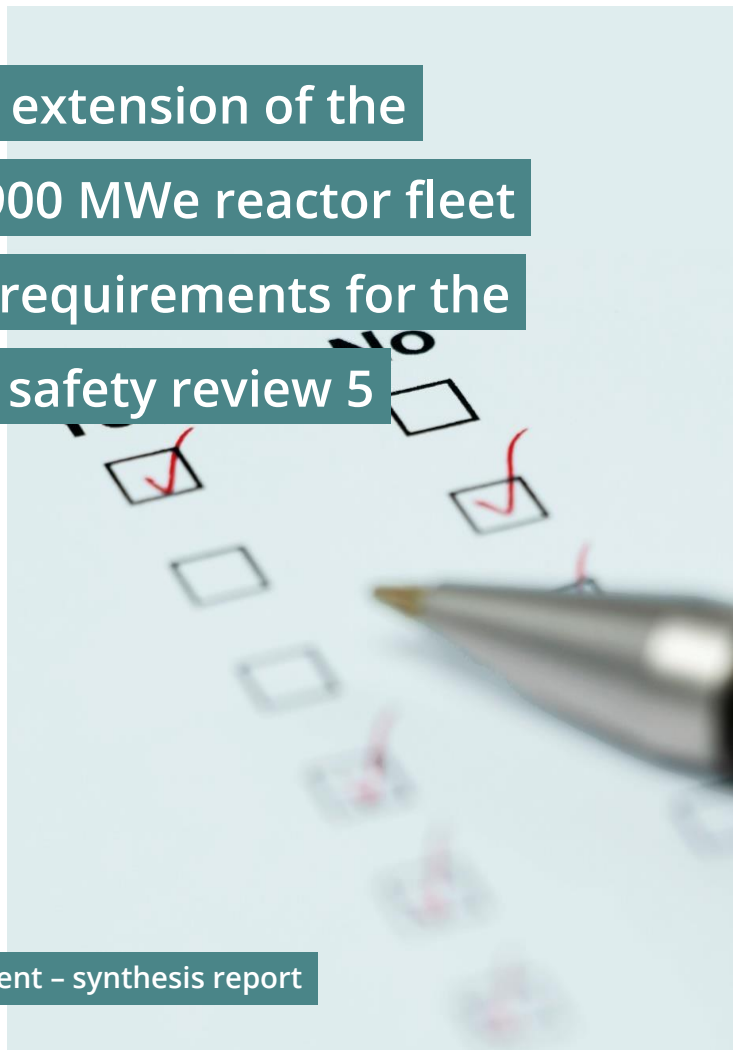
Lifetime extension of the French 900 MWe reactor fleet

Generic requirements for the periodic safety review 5



Expert statement – synthesis report

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LIFETIME EXTENSION OF THE FRENCH 900 MWE REACTOR FLEET GENERIC REQUIREMENTS FOR THE PERIODIC SAFETY REVIEW 5

Expert statement

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SUMMARY

ASN presented its draft general recommendations in preparing the 5th periodic review of the 900 MWe reactors. For that, a public consultation was initiated.

Fulfilment of recommendations related to the 4th periodic review

EdF propose a review of compliance of the 900MWe reactors, as during the last years several important issues of safety relevant non-compliance became obvious. Such a review is of important safety relevance and related activities should be performed in due time.

Preparation work for the 5th periodic review of the 900MWe reactors should be based on an assessment of the status of implementation of all those measures required by ASN in 2021 and adopted with new deadlines in 2023. Other documents published for the consultation process in preparing the 5th periodic Review does not include substantial information about the implementation of the generic requirements. It is not yet clear whether all 900MWe reactors will comply with the requirements at the end of the 4th periodic review and where a deviation occurs.

Taking into account the overall aim of the 4th periodic review, to upgrade the 900MEe reactors close to the safety standard of the EPR, the remaining difference in safety in comparison to the EPR has not been described yet. However, this difference should be a basis assessment, when defining the requirements for the 5th periodic review.

EdF proposed and ASN accepted to address impacts of the further acceleration of climate change effects, influencing the operation and safety of the 900MWe reactors, being more intensified assessed during the 5th periodic safety review.

A prerequisite for determining the scope of further necessary measures should be based on a review of the existing ASN regulatory framework, and where necessary adopting this framework to the latest standards defined by WENRA and IAEA. Mainly in the areas of earthquake assessments the French regulatory framework need to be revised.

Assessing the condition of installations

As part of the PSR5-900, EdF is putting in place two **new compliance verification procedures**: the “multiannual compliance programs" and the "compliance site visits". ASN considers that these new provisions are likely to strengthen the control of installation compliance. However, ASN considers that the approach needs to be supplemented. It is recommended that the focus of compliance verification procedures is on preventing events rather than, as proposed by EdF, on reacting to events. The additions requested from ASN, and the views expressed by IRSN are already moving in this direction.

Addressing the problems associated with the aging of structures, systems and components (SSCs) is a major challenge for the PSR5-900. ASN's proposal to expand **ageing management** compared to the PSR4-900 is supported. As suggested by ASN, the focus must be on components that are associated with potential hazards. It is recommended that ASN further specify this general request and highlight certain components.

EdF states that for 900 MWe reactors, analysis of the phenomena highlighted by **stress corrosion cracking** (SCC) on auxiliary lines does not call into question the loads used in the regulation reference files. According to ASN, EdF´s conclusion is called into question by the results to date of checks following the discovery of stress corrosion cracking. ASN's far-reaching additional request is in line with the high safety relevance of these cracks and is therefore supported. Whether this demand is adequately implemented by EdF can only be assessed once the strategy has been presented. It is additionally recommended that a full analysis on the causes of the cracks will be taken in account in order to implement preventive protection against such damage and its effects.

Safety Reassessment

In May 2025, EdF plans to present its overall **climate monitoring** approach. ASN requests for a strengthening of the planned five-year climate monitoring for hazards sensitive to climate change and asks, for example, for an annual reassessment of the reference levels. It is important to note that climate monitoring should be complemented by scientific monitoring of changes in a broader perspective. Although ASN request points in this direction, it is not possible at this stage to assess whether EdF's approach to climate monitoring will be adequate. Several recommendations are made on the important issue of extreme weather events.

With regard to **external flooding**, EdF made commitments as part of the assessments carried out prior to the PSR5-900 for reference risk situations (local rainfall, rising water table and flooding in large catchment areas). ASN demands that these commitments be taken into account for the PSR5-900. EdF does not plan to reassess the reference wave level used for the Blayais site. However, since the analyses were carried out in 2000, ASN requests a re-evaluation in the light of current knowledge.

The conclusions of the investigations carried out as part of the PSR4-900 showed that further studies were still needed on the risks associated with **internal hazards**. The deployment of a part of the measures is planned as part of the PSR6-900 by EdF. ASN requests that these studies be updated on a schedule that allows the associated changes to be implemented during PSR5-900.. EdF´s approach also raises the fundamental question of the time frame for completing the measures after a PSR. This should be defined for the PSR5-900. Furthermore, the question arises as to whether EdF plans to operate the 900 MW reactors for more than 60 years. This question could affect the scope of the work within the framework of the PSR5-900 and should therefore be clarified.

The regulatory requirements for the assessment of **natural hazards including earthquakes** are not regarded to be fully in line with WENRA Reference Levels and guidance. For earthquakes, France followed a deterministic approach for determining design parameters while WENRA requires definitions of design basis events for an occurrence probability of 10-4 per year. Defining the Design Basis Earthquake (DBE) on deterministic methods is no longer state of the art. Already in the Stress Tests in 2012, ENSREG recommended introducing Probabilistic Seismic Hazard Assessment (PSHA) to determine the DBE. **It seems that this recommendation is still not fully implemented**. Detailed results of the PSHA studies are not available to the authors of this report. It appears, however, that PSHA revealed ground shaking values for DBEs with occurrence probabilities of 10-4 per year well in excess of the deterministically derived values. Therefore, strict application of the WENRA (2014; 2021) requirements is expected to lead to DBE values that are higher than the deterministically derived ground shaking parameters for many nuclear sites.

The contents and procedures of PSR are only loosely defined in the French legal framework, leaving it to the nuclear regulator to specify conditions and contents of the review. The objectives of the PSR5 of the 900 MWe fleet were defined by ASN in a process that involved a proposal by EdF, a review and conclusive guidelines issued by ASN. **With respect to external hazards, ASN stipulates that definitions of design basis events and design extension considerations must follow the requirements set by WENRA.** The main implication of the objective for earthquake is that the deterministic approaches for hazard assessments, which are current French standards, are to be supplemented by PSHA.

ZUSAMMENFASSUNG

ASN legte seinen Entwurf allgemeiner Empfehlungen zur Vorbereitung der 5. periodischen Überprüfung der 900-MWe-Reaktoren vor. Zu diesem Zweck wurde eine öffentliche Konsultation eingeleitet.

Erfüllung der Empfehlungen zur 4. periodischen Überprüfung

EdF schlägt eine Überprüfung der Einhaltung der Vorschriften für die 900-MWe-Reaktoren vor, da in den letzten Jahren mehrere wichtige sicherheitsrelevante Verstöße offensichtlich wurden. Eine solche Überprüfung ist von großer sicherheitstechnischer Bedeutung und damit zusammenhängende Aktivitäten sollten rechtzeitig durchgeführt werden.

Die Vorbereitungsarbeiten für die 5. regelmäßige Überprüfung der 900-MWe-Reaktoren sollten auf einer Bewertung des Umsetzungsstands all jener Maßnahmen basieren, die von der ASN im Jahr 2021 gefordert und mit neuen Fristen im Jahr 2023 angenommen wurden. Derzeit enthalten andere Dokumente, die für den Konsultationsprozess bei der Vorbereitung der 5. periodischen Überprüfung veröffentlicht wurden, keine wesentlichen Informationen über die Umsetzung der allgemeinen Anforderungen. Es ist noch nicht klar, ob die 900MWe-Reaktoren am Ende der 4. periodischen Überprüfung alle die Anforderungen erfüllen werden und wo es zu Abweichungen kommen wird.

Unter Berücksichtigung des Gesamtziels der 4. periodischen Überprüfung, die 900MWe-Reaktoren an den Sicherheitsstandard des EPR heranzuführen, wurde die verbleibende Sicherheitsdifferenz im Vergleich zum EPR noch nicht beschrieben. Diese Differenz sollte jedoch eine Grundlage für die Bewertung bei der Festlegung der Anforderungen für die 5. periodische Überprüfung sein.

EdF schlug vor und ASN akzeptierte, die Auswirkungen der weiteren Beschleunigung der Auswirkungen des Klimawandels zu untersuchen, die den Betrieb und die Sicherheit der 900-MWe-Reaktoren beeinflussen und im Rahmen der 5. periodischen Sicherheitsüberprüfung eingehender bewertet werden.

Eine Voraussetzung für die Festlegung des Umfangs weiterer notwendiger Maßnahmen sollte eine Überprüfung des bestehenden ASN-Rechtsrahmens sein und, falls erforderlich, die Anpassung dieses Rahmens an die neuesten von WENRA und IAEO festgelegten Standards. Vor allem in den Bereichen der Erdbebenbewertungen muss der französische Rechtsrahmen überarbeitet werden.

Bewertung des Zustands von Anlagen

Im Rahmen der PSR5-900 führt EdF zwei neue Verfahren zur Überprüfung der Einhaltung von Vorschriften ein: die „mehrjährigen Konformitätsprogramme“ und die „Konformitätsbesuche vor Ort“. ASN ist der Ansicht, dass diese neuen Bestimmungen die Kontrolle der Einhaltung von Vorschriften durch die Anlagen wahrscheinlich stärken werden. ASN ist jedoch der Ansicht, dass der Ansatz ergänzt werden muss. Es wird empfohlen, den Schwerpunkt der Verfahren zur

Überprüfung der Einhaltung auf die Verhinderung von Ereignissen zu legen, anstatt, wie von EdF vorgeschlagen, auf Ereignisse zu reagieren. Die von ASN geforderten Ergänzungen und die von IRSN geäußerten Ansichten gehen bereits in diese Richtung.

Die Bewältigung der Probleme im Zusammenhang mit der Alterung von Strukturen, Systemen und Komponenten (SSCs) ist eine große Herausforderung für den PSR5-900. Der Vorschlag von ASN, das Alterungsmanagement im Vergleich zum PSR4-900 zu erweitern, wird unterstützt. Wie von ASN vorgeschlagen, muss der Schwerpunkt auf Komponenten liegen, die mit potenziellen Gefahren verbunden sind. Es wird empfohlen, dass ASN diese allgemeine Forderung weiter spezifiziert und bestimmte Komponenten hervorhebt.

EdF gibt an, dass bei 900-MWe-Reaktoren die Analyse der durch Spannungsrisskorrosion (SCC) an Hilfsleitungen hervorgerufenen Phänomene die in den Referenzdateien der Vorschriften verwendeten Lasten nicht in Frage stellt. Laut ASN wird die Schlussfolgerung von EdF durch die bisherigen Ergebnisse der Kontrollen nach der Entdeckung von Spannungsrisskorrosion in Frage gestellt. Die weitreichende zusätzliche Forderung von ASN steht im Einklang mit der hohen Sicherheitsrelevanz dieser Risse und wird daher unterstützt. Ob diese Forderung von EdF angemessen umgesetzt wird, kann erst nach Vorlage der Strategie beurteilt werden. Es wird außerdem empfohlen, eine umfassende Analyse der Ursachen der Risse zu berücksichtigen, um einen vorbeugenden Schutz gegen solche Schäden und ihre Auswirkungen zu implementieren.

Neubewertung der Sicherheit

Im Mai 2025 plant EdF die Vorstellung seines Gesamtkonzepts für die Klimaüberwachung. ASN fordert eine Stärkung der geplanten fünfjährigen Klimaüberwachung für Gefahren, die empfindlich auf den Klimawandel reagieren, und fordert beispielsweise eine jährliche Neubewertung der Referenzwerte. Es ist wichtig zu beachten, dass die Klimaüberwachung durch eine wissenschaftliche Überwachung von Veränderungen in einer breiteren Perspektive ergänzt werden sollte. Obwohl ASN in diese Richtung weist, ist es zum jetzigen Zeitpunkt nicht möglich zu beurteilen, ob der Ansatz von EdF zur Klimaüberwachung angemessen sein wird. Es werden mehrere Empfehlungen zu dem wichtigen Thema der extremen Wetterereignisse abgegeben.

Im Hinblick auf externe Überschwemmungen hat sich EdF im Rahmen der vor dem PSR5-900 durchgeführten Bewertungen für Referenzrisikosituationen (lokale Niederschläge, steigender Grundwasserspiegel und Überschwemmungen in großen Einzugsgebieten) verpflichtet. ASN fordert, dass diese Verpflichtungen für die PSR5-900 berücksichtigt werden. EdF plant keine Neubewertung des Referenzwellenpegels, der für den Standort Blayais verwendet wird. Da die Analysen jedoch im Jahr 2000 durchgeführt wurden, fordert ASN eine Neubewertung unter Berücksichtigung des aktuellen Wissensstands.

Die Schlussfolgerungen der im Rahmen des PSR4-900 durchgeführten Untersuchungen zeigten, dass weitere Studien zu den Risiken im Zusammenhang mit

internen Gefahren erforderlich sind. Die Umsetzung eines Teils der Maßnahmen ist im Rahmen des PSR6-900 durch EdF geplant. ASN fordert, diese Studien nach einem Zeitplan zu aktualisieren, der es ermöglicht, die damit verbundenen Änderungen während des PSR5-900 umzusetzen. Der Ansatz von EdF wirft auch die grundlegende Frage nach dem Zeitrahmen für den Abschluss der Maßnahmen nach einem PSR auf. Dieser sollte für den PSR5-900 festgelegt werden. Darüber hinaus stellt sich die Frage, ob EdF plant, die 900-MW-Reaktoren länger als 60 Jahre zu betreiben. Diese Frage könnte sich auf den Umfang der Arbeiten im Rahmen des PSR5-900 auswirken und sollte daher geklärt werden.

Die regulatorischen Anforderungen für die Bewertung von Naturgefahren, einschließlich Erdbeben, stehen nicht vollständig im Einklang mit den WENRA-Referenzwerten und -Leitlinien. Bei Erdbeben verfolgte Frankreich einen deterministischen Ansatz zur Bestimmung der Auslegungsparameter, während WENRA die Definition von Bemessungsbasisereignissen für eine Eintrittswahrscheinlichkeit von 10-4 pro Jahr verlangt. Die Festlegung des Bemessungserdbebens (DBE) auf der Grundlage deterministischer Methoden ist nicht mehr Stand der Technik. Bereits bei den Stresstests im Jahr 2012 empfahl ENSREG die Einführung einer probabilistischen seismischen Gefährdungsanalyse (PSHA) zur Bestimmung des DBE. Es scheint, dass diese Empfehlung noch immer nicht vollständig umgesetzt wurde. Detaillierte Ergebnisse der PSHA-Studien stehen den Autoren dieses Berichts nicht zur Verfügung. Es scheint jedoch, dass die PSHA Bodenerschütterungswerte für DBE mit Eintrittswahrscheinlichkeiten von 10-4 pro Jahr aufgedeckt hat, die weit über den deterministisch abgeleiteten Werten liegen. Daher ist zu erwarten, dass die strikte Anwendung der WENRA-Anforderungen (2014; 2021) zu DBE-Werten führt, die für viele kerntechnische Anlagen höher sind als die deterministisch abgeleiteten Bodenerschütterungsparameter.

Die Inhalte und Verfahren der PSR sind im französischen Rechtsrahmen nur vage definiert, sodass es der Atomaufsichtsbehörde überlassen bleibt, die Bedingungen und Inhalte der Überprüfung festzulegen. Die Ziele der PSR5 der 900-MWe-Flotte wurden von der ASN in einem Prozess definiert, der einen Vorschlag von EdF, eine Überprüfung und abschließende Leitlinien der ASN umfasste. In Bezug auf externe Gefahren schreibt die ASN vor, dass die Definitionen von Auslegungsstörfällen und Überlegungen zur Erweiterung der Auslegung den Anforderungen der WENRA entsprechen müssen. Die wichtigste Auswirkung des Ziels für Erdbeben besteht darin, dass die deterministischen Ansätze für Gefahrenbewertungen, die den aktuellen französischen Standards entsprechen, durch PSHA ergänzt werden müssen.

1 INTRODUCTION

The ASN is submitting for public consultation its draft position on the guidelines for the generic phase of the fifth periodic safety review (PSR) of 900 MWe reactors operated by EdF (ASN 2024).[1] In case of a severe accident in a French NPP, significant impacts on Austria cannot be excluded. Therefore Austria is participating in this consultation by submitting this report.

In France, 56 nuclear power plants (NPPs) are in operation, including 32 900 MWe reactors that will soon reach 50 years of operation. The following table lists the French 900 MWe reactors and shows the start of operation.

Table 1: List of 900 MWe reactors in France in operation (Source: IAEA 2024)

900 MWe site	Unit no.	Start of operation
Bugey	2	1979-03-01
Bugey	3	1979-03-01
Bugey	4	1979-07-01
Bugey	5	1980-01-03
Dampierre	1	1980-09-10
Gravelines	1	1980-11-25
Gravelines	2	1980-12-01
Tricastin	1	1980-12-01
Tricastin	2	1980-12-01
Dampierre	2	1981-02-16
Tricastin	3	1981-05-11
Dampierre	3	1981-05-27
Gravelines	3	1981-06-01
Gravelines	4	1981-10-01
Tricastin	4	1981-11-01
Dampierre	4	1981-11-20
Blayais	1	1981-12-01
Blayais	2	1983-02-01
Saint-Laurent	B1	1983-08-01
Saint-Laurent	B2	1983-08-01
Blayais	4	1983-10-01
Blayais	3	1983-11-14
Chinon	B1	1984-02-01
Cruas	1	1984-04-02

[1] THE ASN consultation documents are written in French language. For the purpose to elaborate the Expert Statement these documents were translated using the “deepl pro” online tool. All citations referring to ASN consultation documents have used these translations.

Chinon	B2	1984-08-01
Cruas	3	1984-09-10
Gravelines	5	1985-01-15
Cruas	4	1985-02-11
Cruas	2	1985-04-01
Gravelines	6	1985-10-25
Chinon	B3	1987-03-04
Chinon	B4	1988-04-01

In France, the operating life of a nuclear reactor is not defined *a priori*. However, in accordance with article L. 593-18 of the French Environment Code, the operator of a basic nuclear installation must carry out a periodic safety review (PSR) of its installation every ten years. The purpose of the periodic review is to check that the installation complies with the applicable rules and to update the assessment of the risks and drawbacks it presents for public safety, health and hygiene or the protection of nature and the environment, taking into account in particular the state of the installation, experience gained during operation, advances in knowledge, including knowledge of climate change and its effects, and the rules applicable to similar installations. It must also take account of international best practice.

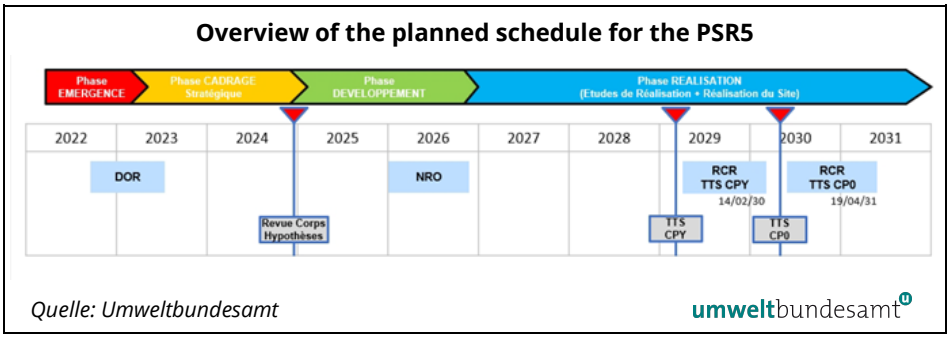
As with previous PSR, in order to take advantage of the standardised nature of its reactors, EdF plans to carry out the fifth PSR of its 900 MWe nuclear reactors in two stages:

1. a so-called "generic" periodic review phase, which covers subjects common to all 900 MWe reactors, in terms of both risk management and control of the disadvantages[2] presented by the facilities. This generic approach makes it possible to pool studies on the control of ageing, obsolescence and compliance of the facility, as well as studies on the safety reassessment and the design of any modifications to the facilities. The ASN is expected to finalize generic conditions for the 900-MW reactors to operate for up to 60 years in 2028.
2. a "specific" periodic review phase, covering each reactor individually, **between 2030 and 2041**. This phase enables the specific characteristics of the facility and its environment to be taken into account, such as, for example, the level of natural hazards to be considered, local issues, other uses of water resources and the condition of the facility. The fifth tenyearly outage programmes will take place between 2029 (reactor no. 1 at the Tricastin site) and 2040 (reactor no. 4 at the Chinon B site).

[2] These disadvantages include, on the one hand, the impacts caused by the installation on health and the environment due to water withdrawals and discharges, and, on the other hand, the nuisances that it may cause, in particular by the dispersion of pathogenic microorganisms, noise and vibrations, odors or flying dust.

The following figure gives an overview of the schedule.

Figure 1 : Overview of the planned schedule for the PSR5.



The generic periodic review phase begins with the definition of the assigned objectives. In this regard, EdF has submitted a "*periodic review orientation file*" (EdF 2024) which sets out the objectives it proposes. In view of the major modifications implemented as part of the fourth periodic review, which will **continue until 2036** for the last reactor, EdF plans to focus this review:

- checking that installations comply with applicable requirements, maintaining equipment qualification and managing ageing to ensure operation for up to 60 years;
- reassessing the management of risks and drawbacks, anticipating the effects of climate change (external aggression, water resources, etc.) and taking into account the lessons learned from the Le Teil earthquake at the Cruas and Tricastin sites.

In its draft position (ASN 2024b), the ASN considers that the general guidelines adopted by EdF for this review are relevant and consistent with the current state of knowledge. This fifth PSR should make it possible to consolidate the major safety improvements made to the reactors during their fourth PSR and to take greater account of the effects of climate change. However, ASN is asking EdF to supplement or clarify some of these general objectives.

Additional statements by the Institut de Radioprotection et de Sûreté Nucléaire (IRSN 2024) and the Standing Advisory Group for Nuclear Reactors (GPR 2024) were published as part of the consultation process and were considered by the Austrian expert opinion.

From 15 October to 11 November 2024, the ASN is consulting the public on EdF's dossier and the draft ASN position on the guidelines for the generic phase of the fifth periodic reviews of 900 MWe reactors operated by EdF.

Austria already took part in the consultation on the PSR4 for the 900 MWe reactor fleet (UMWELTBUNDESAMT 2019a, 2021a, 2021b) as well as on the PSR4 for the 1300 MWe reactor fleet (UMWELTBUNDESAMT 2024).

The Experts Statement related to the PSR4 of the 1300 MW fleet[3] is based on detailed analysis, which had a focus on the following subjects:

- Report 1: Periodic Safety Review Process Report
- Report 2: Operational Experience Report
- Report 3: Hazards Report
- Report 4: Retrofit to State-of-the-Art Report

For the consultation at hand, the Federal Environment Agency coordinated the preparation of this expert opinion on behalf of the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology.

Method: The present work provides an expert opinion to the consultation process. Selected aspects of the objectives of the PSR5 were investigated.

In particular:

As part of the fourth periodic safety review, the ASN requested the implementation of major modifications to increase the safety of the 900 MWe reactors. Details were defined in its decision dated from 23. February 2021[4]. (EdF 2023) requested to postpone some of the deadlines defined in the decision from 2021. ASN accepted the request and released a revised decision[5], which manly changed the dates to fulfil the demands but did not change the content of the required generic modification demands.

In July 2023 EdF sent its "safety review orientation dossier" (DOR) presenting the generic studies for this level that it intends to carry out. The scope proposed by EdF in its dossier is twofold. The first aspect is to ensure that the plants comply with their requirements. It also includes new means for controlling the compliance of installations. These provisions complement the current operating provisions (periodic tests, maintenance, requalification, rounds, etc.). EdF are putting in place two main compliance verification procedures, in addition to the standard operating procedures: multiannual compliance programmes" and "compliance" site visits.

The second aspect is dedicated to external hazards. Hazards to be reassessed under the PSR5-900 are:

- those potentially affected by climate change, namely: extreme heat, external flooding, lowest safe water levels and silting. Probabilistic safety studies associated with these hazards will be carried out, and any modifications resulting from their findings will be deployed during PSR5 900;

[3] See at: https://www.umweltbundesamt.at/frankreich-kkw-1300

[4] https://www.umweltbundesamt.at/fileadmin/site/themen/energie/kernenergie/verfahren/frankreich/asn-bescheid-2021-dc-0706.pdf

[5] https://www.asn.fr/l-asn-reglemente/bulletin-officiel-de-l-asn/installations-nucleaires/decisions-individuelles/decision-n-2023-dc-0774-de-l-asn-du-19-decembre-2023

- those for which a change is expected due to the environment of the facility or site: damage caused by the drift of an oil slick, by the industrial environment and communication routes, and by falling aircraft.

The French nuclear safety authority (ASN) considers that EdF´s proposal to focus the safety reassessment mainly on external hazards related to climate change and to take into account the lessons learned from the Le Teil earthquake is acceptable. Knowledge of the effects of climate change at regional level has increased. The consequences of climate change are becoming increasingly apparent. The continued operation of nuclear power stations in France means that it is needed to take account of the risks.

ASN asked the Institut de Radioprotection et de Sûreté Nucléaire (IRSN) for its opinion on the guidelines proposed by EdF for the fifth periodic review of 900 MWe reactors (IRSN 2024). In accordance with the referral from the ASN, the standing advisory group of experts for nuclear reactors with the participation of members of the standing advisory group of experts for nuclear pressure equipment, examined the guidelines planned by EdF for the PSR5-900 (GPR 2024).

In chapters 4 and 5, ASN´s Position to EdF´s guidelines for the generic phase of the PSR5-900 is briefly summarized and assessed. Recommendations are made in some cases.

2 GENERAL RECOMMENDATIONS

There are two topics regarding the scope of the PSR5-900 that could be added.

Safety of the design (Safety level 1 to 3)

The French 900 MW reactors deviate significantly from the requirements for the safety of NPPs that currently apply and have been applied. For example, the independence of the safety levels is not consistently ensured at the NPPs with 900 MW reactors. The required functional separation of the systems concerned (affected are systems of the 3rd safety level that are also used for functions of the 1st safety level) would be very complex from a technical point of view. (UMWELTBUNDESAMT 2021a)

However, it should be evaluated in the context of the PSR5-900 if potential improvements could be technically implemented.

Storage of spent fuel elements

As part of the „Hardened Safety Core" an additional cooling system for the spent fuel pond (SFP), make-up water system and an emergency water source should be implemented as a result of the PSR4-900. Those significant upgrades could reduce the risk of uncovering the spent fuel assemblies in many accident situations. ASN however criticized the limited target which was set for the intended safety level. EdF's range of investigations on possible accident situations in the SFP is insufficient so far. EdF has to complete the list of situations, which can lead to a loss of water or to insufficient cooling of the fuel assemblies in the SFP with the goal of identifying possibly necessary measures.

ASN requests extensive submissions, however already limited the necessary upgrades by calling them "proportionate". Therefore, it was not possible in the frame of the PSR4-900 to assess the safety level, which will finally be achieved at this point. To avoid a release from the SFP in case of a severe accident in the long-term, it is necessary to establish a safe status without the water boiling. EdF has yet to prove whether this status can be achieved for all accident scenarios. (see requirement [PISC-B])

Also concerning fires, the safety level which was reached with upgrades does not fulfill currently required safety levels. For accident situations due to explosions and leakage further studies and possible upgrades are expected; only then the achieved safety level can be evaluated. EdF also investigated the consequences of the crash of a commercial airplane on the spent fuel building. According to EdF it would not lead to an uncovering of the spent fuel assemblies in the SFP. This statement cannot be justified with the existing studies on airplane crashes and cannot be assessed with an explanation of the assumptions (e.g. on the airplane type) the study used.

Overall, releases from the spent fuel pond as consequences of accidents with significant impacts also on Austria cannot be excluded. (UMWELTBUNDESAMT 2021a)

Thus, it should be evaluated in the context of the PSR5-900 if potential improvements could be technically implemented.

3 STATUS OF THE MODIFICATIONS OF THE PSR 4

3.1 ASN decision from 2021 and 2023 related to the generic modifications required within the framework of the PSR4

Motivation/ Observation:

2024 ASN published its draft on the generic issues to be addressed within the framework of the 5th periodic review of 900MWe reactors.[6].

Within the 4th periodic review of the 900MWe reactors the overall target to bring the 900MWe reators near to the safety level of the EPR, was stressed. Having looked at the documents published to prepare the 5th periodic review, this overall target is no longer mentioned.

It seems to be important to note, that at date no comprehensive report is available which describes to what extent the requirements defined in the revised decision from 2023 ware already met, will be met and/or cannot be met, either in time or in general.

In 2021 ASN [7]defined as a requirement (the revised decision from 2023 did not change this requirement in general)

"Device for solidifying the corium

[AG-A] I.- The operator shall install technical equipment to keep the tank shaft dry, to spread the corium spreading of the corium at the bottom of the tank shaft and the neighbouring space as well as for the renewed passive flooding of the corium by the water, in fulfilment of the order [ECS-ND16] in the annex to the decisions of 21 January 2014, which prevents the foundation from being breached in the event of a in the event of a partial or total core meltdown.

II - The operator:

1. by 31 December 2022 at the latest, the operator shall submit to the nuclear supervisory authority a detailed the Nuclear Supervisory Authority a detailed project design to reinforce the foundations of the reactor buildings made of very siliceous concrete from 2025. This draft project includes a study to improvement of radiation protection for the parties involved;

2. by 30 June 2023 at the latest, the operator shall submit to the nuclear regulatory authority the conclusions of its study programme on the behaviour of the foundations in accident situations with core meltdown, based on tests. On the same date, it shall comment on the need Reinforcement of the foundations of reactor buildings with very siliceous concrete;

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[6] https://www.french-nuclear-safety.fr/asn-informs/news-releases/asn-consults-the-public-on-the-guidelines-for-the-5th-periodic-review-of-900-mwe-reactors

[7] https://www.umweltbundesamt.at/fileadmin/site/themen/energie/kernenergie/verfahren/frankreich/asn-bescheid2021-uebersetzung.pdf

3. it reinforces the foundations where necessary.

III - The operator reinforces the walls between the space for the in-core instrumentation system (RIC) and the area of the seepage shafts at the bottom of the containment of the reactor building in order to minimise any risk of leakage. risk of leakage"

In none of the yet published documents related to the public consultation some substantial information can be found about the degree of fulfilment of this requirement. The documents published so far do not include information to assess how and if the generic requirements related to the 4th periodic review are already fulfilled or will not be met.

Recommendation: As a first step to define the generic requirements of the 5th periodic review it is of importance to analyse the fulfilment of the requirements defined by ASN in 2021 and revised in 2023. Which requirements are to be fulfilled, even with delay, and which requirements will not be met in time and/or in general. Related to those requirements, which will not be fulfilled, a further analysis should be elaborated to define the remaining differences in safety between the 900MEe reactors and the level of safety the EPR represents. In a further step it should be analysed, if and how a narrowing can be achieved in due time. If a remaining gap in safety level difference between the 900MWe reactors and the EPR remain, is has to be decided, if a further operation can be granted

4 ASSESSING THE CONDITION OF INSTALLATIONS

4.1 Installation compliance

4.1.1 Controlling compliance

As part of the PSR5-900, EdF is putting in place two main compliance verification procedures, in addition to the standard operating procedures:

- "Multiannual compliance programs" carried out throughout reactor operation, the topics of which are determined on the basis of analysis of operating experience feedback.
- On-site visits to a large part of the installation during the ten-yearly inspections. This is known as the "compliance site visit" approach. This approach stems from the so-called "innovative" approach introduced in response to requests from the ASN during PSR4-900. This approach is repeated by EdF for the PSR5-900, covering a wider range of systems than for the PSR4-900.

ASN considers that these new provisions are likely to strengthen the control of installation compliance. However, ASN considers that the approach of the multiannual compliance programs needs to be supplemented.

ASN asks to complete the methodology in order to include criteria enabling checks to be carried out on systems whose failure presents the highest safety issues, even in the absence of negative feedback associated with the operation of these systems. (**Request No. 1)**

ASN states defining the list of multiannual compliance programs solely on the basis of feedback does not allow account to be taken of changes to the standards, which may also justify compliance checks. ASN asks to supplement the methodology for drawing up these programs by including in the input data changes in requirements and operational criteria that have never been checked. **(Request No. 2)**

In view of the significant nature of the changes to the verification approach, EdF committed to draw up, by 30 June 2026, a qualitative and quantitative assessment of its new compliance management approach. This assessment will have to justify the effectiveness of this approach, the stated objectives and in relation to practices in previous reviews.

Assessment

The additions to the proposed approach by EdF, as requested by ASN, are suitable to significantly improve it. In IRSN's view, checking compliance with the plant as part of the site visits would make it possible to avoid waiting for a technical incident to occur in operation before initiating checks and also to check equipment that is not highlighted by feedback. This would improve the completeness of the approach.

Recommendation:

It is recommended that the focus of compliance verification procedures, both with regard to multiannual compliance programs and ‚compliance site visits, is on preventing events rather than, as proposed by EdF, on reacting to events. The additions requested by ASN and the views expressed by IRSN are already in this direction.

4.2 Controlling ageing and obsolescence

ASN´s Position

According to ASN, the approach to ageing control for the PSR5-900 is similar to the one implemented for the PSR4-900. In order to ensure that the ageing of all the structures, systems and components (SSCs) can be effectively controlled, ASN believe that the ageing control approach must take account of equipment linked to the risks of hazards in a documented approach that is appropriate to the safety issues involved. (**Request No. 3)**

Assessment

Addressing the problems associated with the aging of SSCs is a major challenge for the PSR5-900. ASN's proposal to expand ageing management compared to the PSR4-900 is supported. As suggested by ASN, the focus must be on components that are associated with potential hazards. (Request No. 3) This is because age-related effects can cause safety-related components to fail in the event of a hazard, and certain components may also be essential for managing the hazards.

Recommendation

It is recommended that ASN further specify this general request and highlight certain components, in particular those components of the original systems to which the “hardened safety core” is connected.

4.2.1 Updating the regulatory reference files for the primary and main secondary circuits

ASN´s Position

In order to meet the requirements, EdF must draw up regulatory reference files (DRR) justifying the maintenance of the integrity of the equipment in the primary and main secondary circuits. These files have to be updated at least at the time of the PSR. They are input data for the maintenance doctrines and the preventive maintenance programmes derived from them.

EdF states that for 900 MWe reactors, analysis of the phenomena highlighted by stress corrosion cracking (SCC) on auxiliary lines does not call into question the loads used in the regulation reference files and does not provide any additional information to be included in the update of these files. According to ASN, EdF´s conclusion is called into question by the results to date of checks following the discovery of stress corrosion cracking. For example, the discovery of fatigue cracks in welds where they were not feared shows that the current methods for estimating the risk of fatigue are not suitable for the effective prevention of this risk. The challenges arising from this observation are heightened by the prospect of 900 MWe reactors continuing to operate beyond 50 years, which is likely to give rise to new degradation phenomena or new sensitive areas.

Therefore, ASN requires that EdF specifies, as part of the PSR5-900 by December 31, 2025, the strategy for taking into account the feedback from the discovery of stress corrosion cracking and, more generally, of the risk of unanticipated degradation of the equipment in the primary and main secondary circuits, through the checks prescribed under the additional inspection program and the maintenance programs. **(Request No. 7)**

Assessment

ASN's far-reaching request is in line with the high safety relevance of these cracks and is therefore supported. Whether this request is adequately implemented by EdF can only be assessed once the strategy has been submitted.

Recommendation

It is recommended that a full analysis of the root causes of the cracks will be carried out and will be taken into account in order to implement preventive protection against such damage and its effects.

4.2.2 Mechanical strength of the reactor pressure vessel

The calculations of the mechanical strength of the steel show margins that are too small for some 900 MWe reactor pressure vessels, with the assumptions currently used. EdF has announced a revision of the formula for the embrittlement due to irradiation of reactor vessel steel and the application of this new formula from PSR5-900. ASN will examine these elements as part of the preparation of its position on the generic phase of the PSR5-900.

Recommendation

It is recommended that deadlines be set for the analyses related to the reactor pressure vessel.

5 SAFETY REASSESSMENT

5.1 Climate monitoring

ASN's Opinion

In May 2025, EdF plans to send a note outlining its overall climate monitoring approach. ASN calls for a strengthening of the planned five-year climate monitoring for hazards sensitive to climate change, there should be an annual reassessment of the reference levels. This reassessment will be based on monitoring of major climatic events and regional monitoring for rainfall and high temperatures; for hazards that are not sensitive to climate change, an analysis, for each year, of the monitoring of major climatic events or, failing that, an analysis of the annual reports on the hydrometeorological data should be produced. (**Request No. 10**)

Assessment

Both IRSN and GPR point out the same additions as ASN in its request No. 10. (GPR 2024, IRSN 2024) In addition, IRSN considers that EdF should describe the measures to be taken if the recorded values or the hazard values derived from them exceed the applicable reference levels.

It is important to note that climate monitoring should be complemented by scientific observation of changes in a broader perspective to identify potential local hazards. This is because observations of extreme weather events show that extreme values, such as heavy rainfall events, occur in areas where certain events were not previously expected. Deriving hazards based solely on historical data is not sufficient to assess potential hazards.

Extreme weather and climate events are becoming increasingly frequent and severe. (IPCC 2021) As a result, the number of disasters and the scale of the damage caused have risen sharply in the EU over the last two decades. Unprecedented forest fires (in Greece and Spain in 2023, for example), floods (as in Italy and Slovenia in 2023, or in France in 2024), devastating heat waves and droughts (such as those that hit the whole of Europe in 2022 or Spain in 2024) are recent examples. (EU 2024)

Due to climate change persistent weather conditions are being observed more and more frequently in the northern hemisphere in the summer months. The long duration of specific meteorological conditions can lead to extreme results. The summer of 2016 showed that a single weather pattern can trigger both localized heavy precipitation with flash floods and regional precipitation with river

flooding.[8] The floods occurred in many places without warning. Almost at the same time, storms caused floods in France: initially only small rivers were affected, but later the Loire and the Seine also overflowed their banks. (BECKER et al. 2020)

On October 17, 2024, a slow-moving storm brought extremely heavy rains to parts of France, with the Ardèche Cévennes region experiencing rainfall totals as high as 700 mm. This led to widespread flooding.[9] (KOTHARI 2024)

In France, there are rules and guidelines for various external hazards. However, a guideline for extreme weather events does not yet exist in the French regulatory framework. In view of the increasing importance of extreme weather events for the safety of nuclear power plants, it would be relevant to safety if there were legally binding regulations for protection against extreme weather events in France.

For many, if not most, of the meteorological hazards, calculation of design basis events with occurrence probabilities of 10^{-4} per year cannot be achieved with an acceptable degree of certainty. This is due to short observation periods (reports typically covering much less than 100 years) and methodological limitations. For such hazards WENRA (2014; 2021) requires that "*an event shall be chosen and justified to reach an equivalent level of safety*" (SRL T4.2, TU4.2).

Recommendations

- On the basis of the IRSN´s opinion, it is recommended to present a catalogue of measures in preparation for the possibility that the reference level will be exceeded.
- It is recommended that EdF reliably ensure that the risk of extreme events in connection with climate change is not only assessed on the basis of observed local trends, but also on the basis of a comprehensive view of events, trends and forecasts.
- It is recommended to develop a guide on the protection of nuclear installations against extreme weather events that reflects the current scientific status and that must be applied within the framework of the PSR5-900. Climate change phenomena should be adequately addressed.
- It is recommended to require for the PSR5-900 that the selection of design basis events for extreme weather conditions complies with WENRA (2014; 2021) by demonstrating that the selected event leads to a level of safety equivalent to WENRA target (occurrence probability of 10^{-4} per year).

[8] From the end of May to mid-June 2016, a persistent large-scale weather situation with thunderstorms and intense rainfall caused both local flash floods and widespread flooding in Central Europe. The floods occurred in many places without warning. Almost at the same time, storms caused floods in France: initially only small rivers were affected, but later the Loire and the Seine also overflowed their banks.

[9] The heavy rainfall was caused by the interaction of a quasi-stationary low-pressure area, an unstable air mass from the Mediterranean, and a "cold drop" created by cyclonic vorticity.

5.2 External hazards

5.2.1 Earthquake: specific site effect for the Tricastin nuclear power plant

The regulatory requirements for the assessment of natural hazards including earthquakes are not regarded to be fully in line with WENRA Reference Levels and guidance. For earthquakes, France followed a deterministic approach for determining design parameters while WENRA requires definitions of design basis events for an occurrence probability of 10-4 per year. Defining the Design Basis Earthquake (DBE) on deterministic methods is no longer state of the art. Already in the Stress Tests in 2012 ENSREG recommended introducing Probabilistic Seismic Hazard Assessment (PSHA) to determine the DBE. It seems that this recommendation is still not fully implemented. Detailed results of the PSHA studies are not available to the authors of this report. It appears, however, that PSHA revealed ground shaking values for DBEs with occurrence probabilities of 10^{-4} per year well in excess of the deterministically derived values. Therefore, strict application of the WENRA (2014; 2021) requirements is expected to lead to DBE values that are higher than the deterministically derived ground shaking parameters for many nuclear sites.

The contents and procedures of PSR are only loosely defined in the French legal framework, leaving it to the nuclear regulator to specify conditions and contents of the review. The objectives of the PSR5 of the 900 MWe fleet were defined by ASN in a process that involved a proposal by EdF, a review and conclusive guidelines issued by ASN. With respect to external hazards, ASN stipulates that definitions of design basis events and design extension considerations must follow the requirements set by WENRA. The main implication of the objective for earthquake is that the deterministic approaches for hazard assessments, which are current French standards, are to be supplemented by PSHA.

In addition to the inadequate earthquake analyses, the design of the 900 MW reactors showed a number of weaknesses with regard to protection against a design basis earthquake (DBE). In addition, significant failure of the earthquake protection has already been identified during targeted investigations in some safety relevant components. It cannot be excluded that further deficits exist in other components or systems. Thus, it is recommended that in order to prevent similar defects concerning the seismic protection, a comprehensive inspection of all safety systems would have to be carried out.

In connection with the existing design deficits against external hazards, it is referred to the planned backfitting of the Hardened Safety Core (HSC). However, the envisaged reinforcement of the existing SSCs associated with the HSC is limited. Thus, it is recommended that EdF should reinforce the existing SSCs associated with the HSC to demonstrate their resistance to the SND using standard design methods. IRSN recommends for all new hard core equipment to carry out checks on 100% of welds in order to ensure that this equipment is highly robust to hazards. In addition, a 100% test of the welds of the existing components belonging to the HSC should be carried out.

5.2.2 External flooding

ASN´s Position

With regard to external flooding, EdF made commitments as part of the assessments carried out prior to the PSR5-900 for reference risk situations (local rainfall, rising water table and flooding in large catchment areas).

Subsequently, EdF indicates, with regard to the guidelines for the PSR5-900, that it would take into account any ASN requests and EdF commitments arising from the PSR4-1300 (commitments made in the context of the expert reports on rising water tables and flooding in a large catchment area). Furthermore, with regard to the assessment of local rainfall, although EdF plans to reassess the rainfall level for the PSR5-900, EDF have not formally confirmed that all the actions planned following the expert assessment will be implemented.

ASN requests that these commitments be taken into account for the PSR5-900. (**Request No. 14)** Also ASN requires the Cruas site to validate the new hydrogeological model used to re-evaluate the groundwater level. (**Request No. 15)**.

EdF has not planned to confirm the reference swell used for the "ocean waves" hazard at the Le Blayais site, stating that a previous sensitivity analysis showed the negligible influence of the swell at the site. In addition, EdF has indicated that the chops for river sites would only be reassessed if there were significant changes in the environment around the sites, the 100-year wind values used to calculate the reference chop will not be updated. However, ASN does not agree with this approach and notes that the sensitivity analysis on swell was carried out in 2000 and that the wind data used for chop dates comes from before 2010.

Therefore, ASN asks to re-examine the reference wave level used for the Blayais site and the 100-year wind speeds used for chop at river sites, in the light of current knowledge. (**Request No. 16)**

Assessment

ASN's additional requests appear reasonable, but this issue cannot be assessed until EdF submits the revised guidelines. Flooding is a risk that was taken into account in the design of French plants and reassessed during regular safety reviews or after certain exceptional events. In 2013, the ASN published Guide No. 13 (ASN 2013), which deals with the risk of external flooding. This guideline was developed in response to the flooding of the Blayais NPP site in 1999, which revealed significant deficiencies in the determination of potential water levels and the risks of external flooding. It was developed from 2005-2012 and must now be considered out of date. The assessment is based on deterministic methods considering margins and hazard combinations, with a “probabilistic” exceedance target of less than 10^{-4} per year, but using expert judgment instead of analyses with a validated methodology is possible. Furthermore, in the ASN Guideline No. 13 on the protection against external flooding, only the rise in sea level is taken into account as a value that is increasing due to climate change. (UMWELTBUNDESAMT 2024a)

The regulations concerning (ASN 2013) the protection of **external flooding** are not completely in line with WENRA (2014; 2021). Although the French practices account for all major phenomena and processes that combine to the flooding hazards at sites located at river or at the Atlantic coast, some of the phenomena are only considered for very short recurrence periods (e.g., local rainfall and waves 100 years; wind waves, 1000 years). In any case, it is clear that at the time of publication of ASN Guide No. 13 in 2013, WENRA Safety Reference Levels and Guidance, published in 2014 and 2015, could not be included in the French regulations.

Until 2011, the methodology used in France to assess natural hazards like external flooding, was based on a deterministic approach. Probabilistic analyses of external flooding in the PSR4-1300 are currently foreseen to only consider five scenarios calculated for specific NPP sites. Therefore, it should be explicitly required that the PSA be updated for all sites as part of the PSR4-900.

Recommendations

- The ASN guide No. 13 for the protection against external flooding should be updated. The relevant WENRA documents developed after the Fukushima accident should be systematically taken into account (WENRA 2021; 2020b). In particular, it should be required that the identification of relevant phenomena for the risk of flooding at specific locations be based on studies and analyses and not only on an "expert judgement".
- A comprehensive PSA for external flooding should be conducted in accordance with WENRA (2014; 2021) and WENRA (2020b) for all sites. Scenarios should not be excluded due to the lack of information. It is important to define appropriate requirements in the generic PSR5-900 in order to be able to adequately assess the site hazard in the context of the site-specific PSR.[10]

5.3 Internal hazards

5.3.1 Internal flooding and pipe failure

The conclusions of the investigations carried out as part of the PSR4-900 showed that further studies were still needed on the risks associated with flooding and high-energy pipe rupture. EdF states that certain studies are scheduled to be completed or updated according to a timetable that is decoupled from the PSR4-900 and PSR5-900 frameworks. The deployment of the necessary measures is planned as part of the PSR6-900, unless there are major safety issues. In the latter case, they will be integrated into the PSR5-900.

[10] This recommendation is a lesson learned from the evaluation by the author of the guidelines for PSR4-1300 (see UMWELTBUNDESAMT 2024a).

ASN considers that this approach would not be acceptable. ASN asks to update the internal flooding and high-energy pipe rupture studies, according to a timetable that will allow the changes they will entail to be implemented at the time of the PSR5-900. (**Request No. 17)**

IRSN states that additional information is still required, particularly on pipe failures (deflection, jet effect, rupture point). Also, GPR emphasized the need to update these studies, in accordance with a timetable that allows the implementation of the changes at the PSR5-900.

Assessment

The ASN's rejection of EdF's proposal to postpone the completion of the modification for the risk of internal flooding until the PSR6-900 is agreed. This also raises the fundamental question of the time frame for completing the measures after a PSR. This should be defined for the PSR5-900. Overall, a general time frame of five years seems appropriate. Furthermore, the question arises as to whether EdF actually plans to operate the 900 MW reactors for more than 60 years. This question could affect the scope of the work under PSR5-900 and should therefore be clarified in this context.

Recommendation

Given that the safety objectives in relation to the risk of internal flooding in PSR4-900 have not been fully met, the necessary studies and modifications should be carried out as soon as possible.

5.4 Specific features of the reactors at the Bugey nuclear power plant

The older reactors at the Bugey nuclear power plant have some notable differences compared with the 28 other 900 MWe reactors s. Therefore, ASN requires that a complete list of potential improvements related to the specific characteristics of the Bugey reactors be submitted before January 31, 2025. ASN also requests that a detailed description of the modifications be provided before June 30, 2026, along with an analysis of the advantages and disadvantages of all the improvements considered, including those that were not selected. These demands from ASN are to be endorsed, especially the last aspect.

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7 LIST OF FIGURES AND TABLES

8 GLOSSARY

ASG	Steam Generator Emergency Feedwater System
ASN	French Nuclear Safety Authority
BDFA	French active fault database
CAV	Cumulative Average Velocity
DAC	Design Acceptance Confirmation
DBE	Design Basis Earthquakes
DBF	Design Basis Flood
DEC	Design Extension Conditions
DUS	Ultimate Backup Diesel Generators
EDF	Electricité de France
ENSREG	European Nuclear Safety Regulators Group
EPR	European Pressurised Reactors
EUR	European Utility Requirements
FARN	Nuclear rapid intervention force
G	Ground acceleration expressed as a fraction of the acceleration of gravity of 9.81 m/s²
GPE	Advisory Board of Experts for ANS
HCTISN	High Committee for Transparency and Information on Nuclear Safety
HSC	Hardened Safety Core, in French: Noyau Dur
IAEA	International Atomic Energy Agency
INES	International Nuclear Event Scale
IRSN	Institute for Radiation Protection and Nuclear Safety
LLS	Emergency electricity system
LTE	Lifetime extension
LTO	Long Term Operation
MWe	MegaWatt electric
ND	Noyau Dur, in English: Hardened Safety Core
NPP	Nuclear Power Plant

NRO	Note de réponse aux objectifs”
PSA	Probabilistic safety analyses
PSHA	Probabilistic Seismic Hazard Assessment
PSR	Periodic Safety Review
ROSAU	Reduction of Severe Accident Uncertainties
SEG	Ultimate Heat Sink
SIS	Safety Injection System
SND	Séisme Noyau Dur, design basis earthquake for the HSC
SRL	Safety Reference Level
SSC	Structures, systems and components
TAC	Emergency electricity system on level 4
VD4	Visites décennales, ten-year-visits, no 4
VP	Volumetric protection
WENRA	Western European Nuclear Regulators´ Association

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