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COMMISSION STAFF WORKING DOCUMENT

Implementation of Directive 2009/71/Euratom establishing a Community framework for the safety of nuclear installations amended by Directive 2014/87/Euratom

Accompanying the document

Report from the Commission to the Council and the European Parliament

on the progress made with the implementation of Directive 2009/71/Euratom establishing a Community framework for the safety of nuclear installations amended by Directive 2014/87/Euratom

{COM(2022) 173 final}

STAFF WORKING DOCUMENT

I. INTRODUCTION

1.1. <u>Objective and structure of the Staff Working Document</u>

This Staff Working Document accompanies and supports the *Commission's second report to the Council and the European Parliament on progress made with the implementation of Directive 2009/71/Euratom amended by Directive 2014/87/Euratom (Directive)* and provides a more detailed, article-by-article analysis of the Member States' implementation approaches, relying primarily on the reports submitted by the Member States to the European Commission in 2020[1].

This document is structured in two sections - the section on 'Nuclear Safety Governance' covers Articles 4 ('Legislative, regulatory and organisational framework'), 5 ('Competent regulatory authority'), 7 ('Expertise and skills in nuclear safety') and 8 ('Transparency') of the Directive, and the section on the 'Safety of Nuclear Installations' covers Articles 6 ('Licence holders'), 8a ('Nuclear safety objective'), 8b ('Implementation of the nuclear safety objective'), 8c ('Initial assessments and periodic safety reviews'), 8d ('On-site emergency preparedness and response'), and 8e ('Peer-reviews') of the Directive.

It should be noted that the Member States with nuclear installations have the obligation of transposing and implementing all Articles of the Directive, with due account of a graded approach. In line with this graded approach, the implementation of the provisions of the Directive depends on the potential magnitude and nature of risks posed by the nuclear installations that the States plan or operate. In addition, taking into account that the provisions of the Directive linked with the existence of nuclear installations do not apply to those Member States without nuclear installations, those Member States are exempted from the obligation of transposing and implementing Articles 6 ('Licence holders'), 8a ('Nuclear safety objective'), 8b ('Implementation of the nuclear safety objective'), 8c ('Initial assessment and periodic safety reviews') and 8d ('On-site emergency preparedness and response') of the Directive.[2]

1.2. <u>Overview of the nuclear installations in the EU</u>

Article 3 of the Directive specifies the types of nuclear installations coming within its scope, i.e. nuclear power plants (NPPs), enrichment plants, nuclear fuel fabrication plants, reprocessing plants, research reactor facilities, spent fuel storage facilities, as well as storage facilities for radioactive waste that are on the same site and are directly related to the aforementioned nuclear installations. Furthermore the Directive covers all stages of the lifecycle of nuclear installations (siting, design, construction, commissioning, operation, decommissioning).

The present-day situation in the Member States is diverse, from those with one or more of each type of these installations, to those without any installations. According to their national

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1 Concerning the United Kingdom, considering that the obligation of applying the Euratom legislation applied until 31 December 2020, and the national report was submitted in 2020, the information presented was considered in the Commission's review.

2 The quantitative references to the number of Member States e.g. majority, in this Staff Working Document, were made with due consideration of this differentiated application.

energy policies, some Member States have plans to pursue nuclear energy generation through continued operation of existing NPPs or to construct new NPPs. Others have decided to discontinue operations after a certain date, or have prohibited the construction of new plants. The majority of NPPs are sited in those countries that took a prominent role in the development of nuclear technology in Europe in the 1950's - 1960's, and, consequently, these countries account for the majority of installations under shutdown or decommissioning.

Annex 1 provides a summary of information on nuclear installations by country and by type, as reported.

II. NUCLEAR SAFETY GOVERNANCE (Articles 4, 5, 7 and 8 of the Directive)

2.1. LEGISLATIVE, REGULATORY AND ORGANISATIONAL FRAMEWORK (Article 4)

2.1.1. National framework (Article 4, paragraph 1, first sentence)

According to Article 4, paragraph 1 of the Directive, Member States should establish and maintain a national legislative, regulatory and organisational framework for the nuclear safety of nuclear installations ('national framework').

All Member States report that they have a national framework in place to carry out the activities covered by the Directive. However, the scope and the level of detail varies significantly between the Member States. The national frameworks have been developed in different ways, depending on the countries' nuclear profiles and national administrative systems. Generally, the national frameworks of Member States with nuclear installations tend to be more complex and include more levels of legislation and implementing regulations, as well as administrative documents and practices. The Member States without nuclear installations address nuclear safety-related issues mainly through legislation on radiation protection, supplemented by provisions in the areas of health, environment or civil protection.

2.1.2. Allocation of responsibilities and coordination (Article 4, paragraph 1, letter (a))

Article 4, paragraph 1, letter (a) of the Directive requires that the national framework provides for the allocation of responsibilities and coordination between relevant State bodies.

The Member States report on their administrative and organisational structure, where the competent regulatory authority (referred to, throughout the Staff Working Document, as 'regulatory authority' or 'regulator') plays a key role in regulating nuclear safety matters. While, as a rule, a single regulatory authority concentrates the core regulatory competences, such competences are shared in some Member States by more than one entity. In this respect, the Directive leaves the precise organisation of the regulators to the decision of the Member States ('an authority or a system of authorities').

Several Member States indicate situations where interfaces exist between the regulatory authorities, other bodies and various ministries (such as the ministries having energy, environment, health or interior affairs in their portfolio) which also play a role in the overall institutional framework aimed at ensuring nuclear safety. To illustrate this aspect, the area of emergency preparedness and response (EP&R) is one where, typically, there are strong links between various national bodies, such as between regulators and civil protection services, national defence bodies, state inspection services, relevant ministries etc. In this context, some Member States also mention cooperation with regions and local authorities or with specialised advisory bodies and experts. For Member States without nuclear installations, cooperation between counterpart regulators of other Member States is particularly important for responding to potential radiological or nuclear emergencies originating outside of their borders. Generally, Member States define the individual responsibilities of the relevant institutions involved in the area of nuclear safety in legal provisions. In some reported cases, the interfaces between these bodies are described in inter-institutional agreements/memoranda of understanding[3] which constitute the basis for such cooperation and coordination arrangements.

2.1.3. Nuclear safety requirements (Article 4, paragraph 1, letter (b))

Article 4, paragraph 1, letter (b) of the Directive requires that the national framework provides for national nuclear safety requirements, covering all stages of the lifecycle of nuclear installations.

Member States indicate the main legal texts laying down national nuclear safety requirements, which are generally made publicly available. While in most cases these requirements are incorporated into legally binding provisions (e.g. laws, decrees or regulations), some Member States opted to define more detailed non-binding regulatory guidance (e.g. recommendations, guidelines) which aim to assist stakeholders to put the high-level legal requirements into practice. In some cases, nuclear safety requirements can also be incorporated into particular licences or made applicable through supervisory measures on an individual basis.

Depending on the countries’ nuclear energy profiles, these requirements are either focused on nuclear safety, or cover both nuclear safety and radiation protection aspects.

While, in general, the requirements address all stages of the lifecycle of nuclear installations, in a few cases, the reports have not explicitly referred to the existence of separate specific requirements relative to the decommissioning stage. Concerning their scope, they cover – besides NPPs – other types of nuclear installations, such as research reactors, depending on the national nuclear programme.

2.1.4. Licensing system (Article 4, paragraph 1, letter (c))

Article 4, paragraph 1, letter (c) of the Directive requires that the national framework provides for a system of licensing and prohibits the operation of nuclear installations without a licence.

The Member States have consistently reported that the operation of nuclear installations without a licence is prohibited under their legal frameworks. The national reports also provide descriptions of the licencing systems, giving various levels of detail. The general conclusion

[3] For instance, Belgium, Germany, Hungary, Spain
General Note: All National Reports are publicly available on the Europa website at the address https://ec.europa.eu/energy/topics/nuclear-energy/nuclear-safety_en. This Staff Working Document focuses on identifying trends across the Member States’ approaches in the Directive’s implementation, whilst giving examples of good national solutions for implementation of specific requirements of the Directive.

drawn from the reports is that there is a significant variety of licencing approaches and systems within the EU, and different types of licences and authorisations are issued at various stages.

The licensing process for a nuclear installation normally includes the following steps, depending on national legislation: siting and site evaluation, design, construction, commissioning, operation, decommissioning. Member States choose either to issue licences corresponding to each step of the licensing process or to divide these steps into several sub-steps or merge several steps (e.g. combined licences for construction and operation). Conditions may be attached to the licences granted, requiring that the licensee obtains further, more specific, authorisations or approvals before carrying out particular activities.

Concerning the authority granting the licences, the regulatory authority is generally empowered to make regulatory decisions and to grant, amend, suspend or revoke licences, conditions or authorisations, as appropriate. In a few cases, the licences are granted by the Government, based on a prior safety assessment performed by the regulator.

2.1.5. Regulatory control (Article 4, paragraph 1, letter (d))

Article 4(1) letter (d) requires that the national framework provides for a system of regulatory control of nuclear safety performed by the regulatory authority.

Member States present their systems of review and assessment that take place before issuing a licence (documentation reviews), once the licence is issued and then throughout operations (document-based reviews and on-site planned and unannounced inspections). Some Member States also refer to Periodic Safety Reviews (PSRs) in this context.

In this respect, the Member States have put in place various mechanisms, for instance legal requirements to carry out reviews/inspections at a specified frequency; formal procedures for carrying out inspections, including relevant handbooks and guidelines; a medium-term strategy (for a few years) and a short-term inspection plan (for example annual), which should be regularly revised to take into account feedback from previous periods; systematic follow-up of the recommendations' implementation; focus on particularly pertinent topics, such as ageing management; cooperation with Technical Support Organisations (TSOs) and relevant expert organisations.

2.1.6. Regulatory enforcement (Article 4, paragraph 1, letter (e))

Article 4, paragraph 1, letter (e) of the Directive requires that the national framework provides for effective and proportionate enforcement actions, including, where appropriate, corrective action or suspension of operation and modification or revocation of a licence.

The Member States have consistently enacted enforcement provisions, including sanctions, into their legal frameworks. Such requirements are included in specific legislative acts, such as those governing inspection activities, in general administrative acts, criminal codes or other legislation relative to criminal offences and, in some cases, in the regulatory authorities' management systems or guidelines. In most scenarios, the regulatory authority is the focal point of such actions; however, interfaces exist between the regulator and other law enforcement entities within the overall legal system, such as courts, prosecution agencies, other administrative and government bodies.

Member States inform that enforcement actions can be taken both preventively or in response to an identified breach. In the event of an emergency, actions can be taken directly by the regulatory authority or its inspectors.

Effective enforcement requires an adequate system of sanctions with sufficient deterrence potential. As far as sanctions are concerned, most Member States report that they follow a graded approach, depending on the severity of the breach. The possible sanctions range from issuing a warning, to requesting modification, suspension or revocation of a licence, and culminating to criminal sanctions in severe cases. In most cases, the national systems include a range of fines, which may be imposed either directly by the regulator, or by other relevant law enforcement bodies. A few Member States provide examples of enforcement actions carried out, to demonstrate the effectiveness of the system in practice.

2.1.7. National framework improvement (Article 4, paragraph 2)

Article 4, paragraph 2 of the Directive requires Member States to maintain and improve the national framework, taking into account operating experience, insights gained from safety analyses for operating nuclear installations, development of technology and results of safety research.

Most Member States have affirmed their commitment to ensure continuous updates of their national nuclear safety-related framework and shared their experiences and approaches in this respect. These updates are typically related to changes in the EU/Euratom-level framework; European activities, such as those at the level of the European Nuclear Safety Regulators Group (ENSREG) or the Western European Nuclear Regulators Association (WENRA); developments in international standards, particularly those issued by the International Atomic Energy Agency (IAEA); results of international reviews; feedback from experience (inspections, incidents, accidents). Reorganisations of the national administration or exchanges with other national authorities could also determine modifications of the national framework. Some Member States report that they are assessing the needs for amendments on a regular (e.g. annual) basis or that such assessments are part of the core processes incorporated in the regulatory authority's management systems. In some cases[4], the need for such regular review is laid down in relevant legislation or is included in policy and planning documents.

2.2. COMPETENT REGULATORY AUTHORITY (Article 5 of the Directive)

2.2.1. Regulatory independence

2.2.1.1. Functional separation and absence of instructions in the performance of the regulatory tasks (Article 5, paragraph 2, letter (a))

Article 5, paragraph 2, letter (a) of the Directive requires that the regulatory authorities are functionally separate from any other body or organisation concerned with the promotion or

[4] For instance, Bulgaria, Czech Republic, Finland, Hungary, Lithuania, Poland, Slovenia.

utilisation of nuclear energy. They should not seek or take instructions from any such body or organisation when carrying out the regulatory tasks. This requirement constitutes a fundamental condition for independent regulatory decision-making that is free from undue influence.

According to the national reports, all Member States have established a regulatory authority in the field of nuclear safety. Typically, Member States chose to establish a single regulatory authority. However, in some Member States, there is not a single regulator at national level, but a system of authorities sharing the key regulatory functions (rulemaking, licensing, assessment, inspection and enforcement), according to established internal arrangements. For instance, in some of these cases, the inspection-related tasks have been dissociated from the remaining responsibilities of the regulator and have been assigned to a separate authority. In the case of federal Member States, it has been reported that functional separation is guaranteed both at central and federal state/provincial level by means of legislation and organisational measures.

The legal status and structure of the regulatory authorities differ from one Member State to the other. Three main organisational schemes[5] can be distinguished[6] as described below:

i. Many Member States have established regulatory authorities as independent administrative authorities, completely separated in all aspects of their operation from any other government body or organisation, either concerned with the promotion or utilisation of nuclear energy or not. These regulatory authorities usually have their own legal personality, a certain (usually high) degree of administrative and financial autonomy, and report and are accountable directly to the Member State's Government, to the Prime Minister or both to the President and Government, without supervision by a Minister. Although the Directive requires that the regulatory authorities should be functionally separate from bodies or organisations concerned with the promotion and utilisation of nuclear energy and not from any other bodies in general, the Member States[7] following the first organisational model saw the added value of having an independent regulator, not only functionally but also legally distinct from other public or private entities.

[5] This categorisation is mostly relevant for the regulatory authorities of Member States with nuclear installations on their territory or plans to use nuclear energy in the future. As for the Member States that have neither nuclear installations nor any plans to include nuclear in their energy mix, the functional separation of these regulatory authorities is de facto ensured by the absence of any entities that promote or utilise nuclear energy. Their respective regulatory authorities are mostly concerned with radiation protection issues and EP&R arrangements to address the consequences of accidents and incidents occurring in nuclear installations in other Member States.

[6] In recent years, it is noteworthy that in some Member States, reorganisations of their regulatory authorities have taken place, with the aim, inter alia, to strengthen the regulatory role and independence or to respond to recommendations arising from IAEA Integrated Regulatory Review Service (IRRS) missions. This occurred, for instance, in Hungary (2022), Austria (2020), Croatia (2019), Portugal (2018), Italy (2018), Netherlands (2017 and 2020).

[7] For instance, Bulgaria, Czech Republic, Ireland, France, Lithuania, Malta, Romania, Slovakia, Spain, Sweden, United Kingdom.

ii. Many other Member States have opted for the establishment of regulatory authorities as independent administrative authorities, which are not organisationally part of a specific Ministry, but fall under its supervision. These Ministries neither promote nor utilise nuclear energy and are typically dealing with environmental/climate matters, home affairs/interior, social affairs and health, education/research etc. Under this setup, the regulatory authorities are subject to varying degrees of supervision and control of their activities by the Ministries in question, with the supervision scheme usually consisting of a legality check of certain decisions taken by the regulators or in a broader monitoring of their activities. However, with a few exceptions, the Member States did not report extensively on the exact scope and nature of this supervision.

iii. Moreover, in a few Member States, the regulatory authorities are Directorates/Departments or Units/Services of Ministries that are not concerned with the promotion or utilisation of nuclear energy. In these cases, national legal provisions define the mandate and set out the allocation of responsibilities between those Ministries and/or other state bodies, so that there is a clear division of the role and responsibilities of each government entity when carrying out nuclear safety-related functions.

When regulators take the form of independent administrative authorities (models i and ii), they are usually led by management boards or equivalent bodies with extended decision-making powers. They are also supported by internal committees/expert groups of advisory/consultative function, which usually hold significant technical and scientific expertise.

The requirement of functional separation does not exclude the existence of appropriate, well-defined cooperation arrangements. In this sense, it has been reported by a few Member States that, where coordination is needed between state bodies with a role to play in nuclear-safety related matters, their high-level national provisions defining the mandates of these different state bodies are complemented by documented arrangements, setting out in detail the specific allocation of responsibilities between them. Such complementary arrangements are conducive to removing uncertainties and ambiguities and thus preventing both potential gaps and overlaps in the implementation of the regulators' duties.

Furthermore, regulatory authorities may also cooperate, where appropriate, with external TSOs and/or external technical experts/consultants on issues within their competence in order to support their regulatory functions. Member States report that in these cases, the regulators maintain at all times their effective independence and ownership of the decisions made and the measures taken.

Generally, Member States adhere to the principle of not seeking or taking instructions from any other body or organisation (promoting or utilising nuclear energy) deriving from their overall regulatory architecture which empowers the regulators to discharge their responsibilities in an independent manner, and functional separation. However, a few Member States[8] have in place provisions explicitly stipulating the obligation.

[8] For instance, Cyprus.

2.2.1.2. Regulatory decisions founded on robust and transparent nuclear safety-related requirements (Article 5, paragraph 2, letter (b))

Article 5, paragraph 2, letter (b) of the Directive requires that the regulatory decisions must be based on clearly defined and transparent nuclear safety-related requirements and procedures. The objective is to ensure consistency and predictability in regulatory decision-making and to avoid subjectivity or the risk of subordination to undue external influence.

Most Member States report on general legal provisions requiring that all decisions of state bodies be duly justified, that new pieces of legislation be accompanied by impact assessment reports identifying the social, environmental or economic impact of the legislation, that some or all decisions of the regulatory authorities can be contested pursuant to established administrative procedures etc.

The vast majority of Member States report that the decision-making, regulatory oversight and inspection of their regulatory authorities is based on policies and processes formalised in their management systems or in supervision manuals/handbooks/guidelines. Several mechanisms to ensure the objectivity of the decision-making are described. For instance, in Member States whose regulatory authorities are overseen by collegiate management bodies, the decisions are taken by the plenary, which in principle minimises subjectivity in decision-making. Many Member States[9] explained that they consult external qualified technical experts or TSOs, local/regional committees, or internal technical bodies with scientific expertise during the decision-making procedure. Such arrangements ensure that decisions take account of the state of the art scientific and technical knowledge and involve all actors who can provide a meaningful and technically sound contribution to the process.

As regards the requirement to base the regulatory decisions on “robust” nuclear safety-related requirements, all the Member States report that they abide by international principles and standards and by EU/Euratom legislation. The nuclear safety-related requirements are reflected in high-level national legislation, in underlying implementing provisions (decrees, regulations, ordinances etc.) as well as in technical documents based on scientific knowledge and lessons learned from operating experience (recommendations, guidelines, manuals, practical arrangements etc.) These documents, together with the licencing terms and conditions, are intended to provide a robust and detailed basis for taking objective and consistent decisions, without the danger of being influenced by other outside factors.

As regards the requirement to base the regulatory decisions on “transparent” nuclear safety-related requirements, the Member States report that their nuclear safety legal framework, as well as their most important regulatory decisions (especially those pertaining to licencing) and policy documents, are published. Some Member States extend the public right to information by allowing interested parties/stakeholders to have access to the applicants’ licencing files, while a few countries have legislation in place stipulating that all documents of all public authorities, including of the regulatory authorities, can be freely accessed by citizens upon request.

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[9] For instance, Belgium, Cyprus, Germany, Spain, Finland, France, Netherlands, Slovenia.

Transparency in regulatory decision-making is ensured through various means, such as the states' participation in relevant international instruments[10], as well as through publication of the licensing-related procedures and information on the regulators' websites[11] or dedicated social media accounts; press releases; press events; newsletters issued by the regulators; public announcements on the results of supervision activities; public consultations associated to the licensing process or relating to draft nuclear safety legislation; meetings with regional/municipal institutions, or with the general public as well as with other persons in the vicinity of the nuclear installations; annual activity reports submitted to the Government or to the supervising Minister etc.

2.2.1.3. Dedicated and appropriate budget allocations and responsibility for the implementation of the allocated budget (Article 5, paragraph 2, letter (c))

Article 5, paragraph 2, letter (c) of the Directive requires that the regulatory authority should have sufficient financial resources for the proper discharge of its assigned responsibilities and the responsibility for the implementation of the allocated budget.

In terms of financing models, two main approaches were identified. In the first model, the financing of the regulatory authorities is based on a combination of financial allocations from the State budget and fees collected from licence holders or other revenues from charges for services such as technical support or training. Under this first model, the fees are either directly paid to the regulators' budget or they become part of the State budget, from which the regulators are subsequently financed. In the second model, the financing of the regulatory authorities relies on State budget allocations. The distribution of Member States between the two models is almost equal.

On the financing from the State budget, several Member States describe in more detail the different stages of the procedure of allocating funds to the regulatory authorities. Generally, regulators' involvement is mainly in the initial planning phase when they estimate the amounts necessary for fulfilling their regulatory duties, and in the final implementation phase when they use the allotted resources. In the planning phase, the plans are typically drawn up on an annual basis; nevertheless, certain Member States inform of the elaboration of multiannual plans[12], usually with a three-year perspective. In the implementation phase, several Member States confirm that the regulatory authorities are autonomous in implementing their own budget; the internal distribution of funds to concrete activities is done, for example, through annual plans drawn up by the regulators.

On the financing from fees, the Member States' reporting indicates the types of activities for which fees are collected and the relevant legal instruments setting out calculation methods or,

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[10] For example, the UNECE Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters ("Aarhus Convention"), the Convention on Environmental Impact Assessment in a Transboundary Context ("Espoo Convention" and its amendment) and its associated Protocol (UNECE Kiev Protocol on Strategic Environmental Assessment to the Convention on Environmental Impact Assessment in a Transboundary Context).

[11] For instance, Belgium, Czech Republic, Denmark, Germany, Spain, France, Italy, Lithuania, Netherlands, Slovenia, Slovakia.

[12] For instance, Czech Republic, Cyprus, Lithuania.

in some cases, fixing the amounts of the fees. In some cases, financing from fees and other services represents the main share of the regulatory authorities' budget.

An important aspect is ensuring that the budget available to the regulators is adequate. The majority of Member States rely on the general budgetary procedures. Only a few Member States[13] have adopted specific legal requirements imposing that the financing of the regulatory authorities should be adequate. Some Member States[14] also have supporting internal regulatory procedures detailing the regulators' budgetary process.

Several Member States inform that they can request additional resources, in case new tasks or unforeseen circumstances arise. In this respect, a number of countries[15] refer to the submission of annual reports to the national Governments or Parliaments, where they inform on the budget implementation and use the opportunity to highlight future – at times supplementary - financial needs. Besides the aforementioned annual reports which can contain financial projections, some Member States point out other methods, such as levying special fees from the licensees[16], setting out state mechanisms, usually in the framework of the state budget procedure, to ensure a flexible response to such situations[17], using the system of multiannual planning or rebalancing funds among activities[18], appealing to the state reserve[19] or even allocating some non-limited credits for covering exceptional situations[20].

The expenditure of the budget allocated is, as some Member States report, monitored permanently though key performance indicators[21], annual reports, or audits conducted by relevant state offices. Transparency is ensured through the publication of these reports or audit conclusions[22].

To illustrate their national approaches, the majority of Member States offer precise recent figures on the regulators' budgets, sometimes split among the various regulatory activities; in several cases, these figures show an increase of the financial resources, throughout the period covering, usually, the preceding two to three years.

In a number of instances, Member States include express statements concluding that the current financial resources are adequate to allow the performance of the regulatory duties. The Member States do not report difficulties with respect to the adequacy of the regulatory

13 For instance, Bulgaria, Croatia, Cyprus, Germany, Greece, Malta, Netherlands, Portugal, Romania.

14 For instance, Germany, Netherlands.

15 For instance, Greece, Hungary, Italy, Sweden.

16 For instance, Belgium.

17 For instance, Cyprus, Denmark, Lithuania, Poland, Slovenia.

18 For instance, Poland, Slovenia.

19 For instance, Poland.

20 For instance, Luxembourg.

21 For instance, Cyprus.

22 For instance, Spain.

budget. Nevertheless, several IRRS mission results or information contained in regulators' annual reports highlight that additional work is needed to ensure adequate financing of regulatory activities.

2.2.1.4. Appropriate human resources in terms of numbers and qualifications (Article 5, paragraph 2, letter (d))

Article 5, paragraph 2, letter (d) of the Directive requires that the regulatory authorities employ an appropriate number of staff with qualifications, experience and expertise necessary to fulfil their obligations. The Directive also refers to the possibility of using external scientific and technical resources and expertise in support of the regulatory functions.

The Member States inform of the regulatory authorities' human resources, in line with two criteria - numbers and qualifications.

Concerning the first criterion of staff numbers, several Member States refer to the applicability of the general public administration rules for civil servants setting out the overall national staffing policies; in some cases, the general framework establishes the number of civil servants posts.

The regulators typically play a key role in evaluating their own staffing needs. This systematic approach is carried out through planning (which, usually, feeds into the financial needs' planning), both on an annual basis and on a multi-annual basis (typically covering a three-year period), complemented by other operational plans or by ongoing evaluations of staffing levels. These planning strategies allow the authorities to estimate their needs, looking at possible changing workloads due to supplementary tasks and activities[23].

Concerning the second criterion of staff qualifications, the reports indicate, on the one hand, the situation at the time of recruitment, and, on the other hand, the post-recruitment situation, when the staff benefits from training both at the entry into service, and, subsequently, on a continuous basis, throughout the entire professional activity.

The majority of the Member States report that they have recruitment criteria for the staff to be employed in the regulatory authorities, consisting essentially of educational, expertise and professional experience criteria. In this respect, it was reported that expert positions in the areas of nuclear safety and radiological protection are mainly occupied by highly qualified persons, with higher education degrees, and with significant specialisations and professional experience in the relevant domains.

After recruitment, the regulators' new staff undergo initial induction training programmes. Furthermore, throughout their career, the staff follow regular specialised training, as part of the employer's in-house programmes. This is supplemented by participation in outside courses organised by national universities or research institutes, by international institutions such as the IAEA, the Organisation for Economic Co-operation and Development / Nuclear Energy Agency (OECD/NEA), EU and by taking part in practical exercises particularly in the area of EP&R or by learning from operational and regulatory experience feedback; several

[23] For instance, Germany.

Member States[24] informed that informatics tools and e-learning training modules are also used. Cooperation arrangements with various institutions or counterparts are in place. Some Member States offered more detailed information with respect to the specific training offered to the nuclear inspectors.

Several Member States indicate that the regulatory authorities are supported by external expertise or have the possibility of taking advantage of such advice, whenever needed. This advice is provided, on the one hand, by entities such as scientific councils, committees, institutes or TSOs that are specifically established with the aim of advising the regulators, and, on the other hand, by outside experts or consultants for specific projects. Certain Member States[25] indicate that the regulators require high levels of technical and scientific qualifications from these external experts, and that, in some cases, they define in their procedures the scope and functions of this support. On occasion, the preservation of regulatory independence and autonomous decision-making when using external expertise was expressly affirmed.

In terms of reflecting the requirement of having adequate human resources, the situation is similar to the one of the appropriate financial resources. The majority of Member States rely on the general State legislation applicable to all civil servants, while only a few Member States enacted dedicated legal requirements, specifying the need for adequate regulatory staff in terms of numbers and qualifications[26]. Some Member States complement these general or specific requirements with internal regulatory procedures[27].

The majority of the Member States offer concrete details of the number of personnel employed, structured according to various criteria such as type of contracts, main regulatory duties or divisions of the organisational chart. Some Member States inform of increases in the number of employees or of the approval of new posts, which have been / are in the process of being filled through recruitment or mobility solutions. However, there were also reports on staff reductions due to the national policy of no further development of the nuclear programme.

Overall, a number of Member States report that the current numbers of personnel are sufficient to carry out the regulatory duties. However, several Member States consider that maintaining appropriate staffing is a permanent challenge and underline difficulties in attracting and keeping sufficient and/or qualified staff; in some cases, this shortage is covered by resorting to external expertise. Similar challenges are confirmed by IRRS reports or annual reports produced by the regulators.

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[24] For instance, Slovakia.

[25] For instance, Belgium, Bulgaria.

[26] For instance, Bulgaria, Cyprus, Germany, Greece, Malta, Netherlands, Portugal, Romania.

[27] For instance, Germany, Netherlands.

2.2.1.5. Provision for the prevention and resolution of conflicts of interest (Article 5, paragraph 2, letter (e))

Article 5, paragraph 2, letter (e) of the Directive requires that the regulatory authorities should establish procedures for the prevention and resolution of any conflicts of interest. The Directive's preamble identifies two cases where special attention should be given, namely the rotation of staff with executive responsibility between the nuclear industry and the regulators, and the situation of organisations that provide the competent regulatory authority with advice or services.

The Member States inform of their national frameworks governing the topic of conflicts of interest, typically structured as a 'pyramid' with two interconnected levels. The first level comprises general legally binding legislation, applicable to all civil servants, including therefore the majority of the regulatory authorities' staff. Such framework provisions are laid down in legal instruments setting out overall rules on the conduct of civil servants and in legal instruments drawing up national anti-corruption rules. The second level supplements the first with specific requirements, tailored to the regulators' concrete responsibilities, tasks, activities and relations with other actors from the nuclear sector. Such rules are included in sector-specific legally binding nuclear energy-related legislation[28] and/or in codes of ethics or internal procedures adopted by the regulatory authorities and binding on their own personnel[29] or in contractual relations binding on the parties.

Based on the aforementioned national frameworks, the Member States describe various mechanisms to prevent conflicts of interest of the regulatory authorities' staff, covering various employment stages. Such mechanisms include submitting declarations of income and interests upon recruitment and periodically thereafter[30]; adhering to the internal codes of ethics and procedures established by the regulators; prohibiting participation in decisions or activities where the staff member or a related party has a private interest; prohibiting exploitation of the regulatory position for private interests; prohibiting receipt of unlawful profits or benefits from the performance of the regulatory activities; prohibiting holding office in political entities; prohibiting membership of the management or supervisory bodies of commercial entities, including licensees (n.b. in some case, exceptions are possible when the person is nominated by the appointing authority and is representing the State, potentially creating ambiguity with regard to regulatory independence); restricting performing other gainful activities, subject to conditions and exceptions, for example, for research or teaching activities; verifying continuously the conflicts of interest situations, for instance, through annual interviews or justifications of the performed services; imposing confidentiality obligations; ensuring that decision-making undergoes several approval stages. Some Member States also inform on the existence of independent State entities dealing with conflicts of interests of civil servants. Transparency measures are also reported by several Member States, such as publishing the declarations of interests.

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[28] For instance, Belgium, Hungary, Italy, Netherlands, Spain.

[29] For instance, Bulgaria, Czech Republic, Estonia, France, Germany, Hungary, Ireland, Latvia, Netherlands, Romania, Slovakia, Slovenia, Spain, Sweden.

[30] For instance, Bulgaria, Greece, Ireland, Lithuania, Romania.

As regards the resolution of conflicts of interest, several Member States require the concerned employees to abstain from the participation in the related regulatory decision or procedure; other Member States require the staff member who is aware of a potential conflict or even in doubt, to immediately notify the employer - usually, these notifications are addressed to the line managers or other hierarchical superiors; some Member States inform of the possibility to exclude the concerned individual from the relevant procedures and ensure adequate substitution.

Several Member States[31] mention that the regulators provide training of personnel on the applicable conflict of interest prevention and resolution rules.

In terms of follow-up, a range of Member States inform of disciplinary measures applicable in case the rules relating to conflicts of interest are not respected, culminating with dismissal, and of the possibility to appeal against the decisions of the regulatory authorities.

To prevent the rotation of staff with executive responsibility between the nuclear industry and the regulators (both directions), several Member States inform of "cooling-off" periods, limiting employability applicable either at the entry into service (if the person seeking employment with the regulator had previously worked in an entity supervised by the regulator) or upon leaving employment (if the former employee of the regulator intends to subsequently work in an entity supervised by the regulator). In some cases, such restrictions apply to all civil servants of the regulatory authority[32], while, in other cases, they refer expressly to the persons exercising positions with executive responsibility[33]. In all circumstances, precise time periods are defined. In addition, during the performance of their duties, the persons with executive responsibility are subject to general rules relating to conflict of interest. Some Member States have specific provisions in place, for example prohibitions of 'outside' employment, participation in decision-making or use of information, which are adapted to the characteristics of these types of functions. A few Member States clearly define the procedures[34] for appointment, suspension and dismissal of the regulatory personnel with executive responsibilities, which has the advantage of strengthening legal certainty, predictability and protecting against discretionary staff changes.

As a particular case, several Member States report also on the measures taken for nuclear safety inspectors. Examples include prohibiting an inspector to inspect the same licence holder more than twice in a row; defining dedicated ethics rules; imposing stricter requirements concerning the declarations of interests; ensuring the rotation of the responsible coordinating inspector.

To prevent potential conflicts of interest for organisations providing the regulatory authorities with advice or services, a number of Member States present their measures, which include prohibiting the appointment of representatives of licence holders as members of advisory

[31] For instance, Bulgaria, Estonia, France.

[32] For instance, Finland, Hungary, Lithuania.

[33] For instance, Hungary, Lithuania, Romania.

[34] For instance, Spain, Netherlands.

bodies[35]; adopting regulatory guidance detailing the rules applicable in case of recourse to external expertise[36]; defining clear selection requirements; requiring declaration of interests both before and after the start of the assignment[37]; imposing adherence to the applicable impartiality and ethics rules, in some cases through contractual stipulations[38]; applying general procurement rules and developing implementing guidelines at the regulator's level; prohibiting experts who had already participated in preparing documentation for a licence holder to take part in reviewing or evaluating the same issue[39]. The ultimate responsibility of the regulatory authority for the decisions taken was affirmed on several occasions.

2.2.1.6. Provision of nuclear safety-related information without clearance (Article 5, paragraph 2, letter (f))

Article 5, paragraph 2, letter (f) of the Directive requires the regulatory authorities to provide safety-related information to the public, media or other governmental bodies, without review or clearance from any other body or organisation (including other public authorities). This provision is intrinsically linked to Article 8 on transparency as regards the information to be provided by the regulatory authorities on nuclear installations' normal operating conditions as well as in the case of incidents and accidents.

All Member States report that they have put in place mechanisms for the dissemination of nuclear safety-related information by their regulatory authorities, including the publication of safety-relevant documents on the website of the regulators; press releases and conferences; media events; newsletters; news flashes; reports; information about the PSRs; public on-site meetings; campaigns; surveys; arrangements for answering citizens' enquiries etc.

According to Member States' reports, the absence of 'clearance' from any other State bodies when disseminating such information is in most cases not expressly stipulated in national legislation, but it can be inferred from the institutional setup and the specific tasks assigned to the regulatory authorities, which include communication activities in their areas of competence.

2.2.2. Regulatory powers and tasks (Article 5, paragraph 3 – in connection with Article 4, paragraph 1)

Article 5, paragraph 3 of the Directive requires that the regulatory authorities should be entrusted with the necessary legal powers for the proper discharge of their assigned responsibilities. It also defines the main regulatory tasks - proposing, defining or participating in the definition of national nuclear safety requirements; ensuring the licence holder's compliance with these requirements and the terms of the relevant licence; verify such compliance through regulatory assessments and inspections; proposing or carry out effective and proportionate enforcement actions.

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[35] For instance, Bulgaria.

[36] For instance, France.

[37] For instance, Finland, Lithuania, Sweden.

[38] For instance, Belgium, Germany, Netherlands, Spain.

[39] For instance, Lithuania.

As regards Article 5, paragraph 3, letter (a) of the Directive, the Member States' reports illustrate that regulators are closely involved in the definition of nuclear safety requirements and are responsible for laying down licencing conditions. Member States are free to decide how these requirements are adopted and applied, in line with Article 4, paragraph 1, last sentence of the Directive.

More specifically, the reports indicate that the regulatory authorities are competent for the preparation of nuclear safety requirements that take into account operating experience, insights gained from safety analyses of operating nuclear installations, development of technology and results of safety research. These requirements may take different forms depending on the institutional arrangements in each Member State, the regulators' status within this setup and the respective law-making procedure. In principle, primary legislation (laws) is drafted by the regulatory authority itself and then adopted by the Parliament, with or without the intermediate approval/control by the supervising government entity (in case there is one). Alternatively, the regulatory authority may be consulted during the legal drafting procedure, which is initiated and carried out by the relevant Ministry.

As far as the establishment of secondary nuclear safety-related legislation is concerned (decrees, regulations, ordinances, decisions etc.), this is usually drafted by the regulatory authorities and approved by the corresponding supervising government entities or, less frequently, it can be drafted and adopted by the regulators themselves.

Where regulatory authorities play a major role is in the adoption of documents of a technical nature interpreting and implementing the existing nuclear safety higher level requirements (such as regulatory decisions, guidelines, manuals, handbooks, recommendations, instructions, circulars, technical standards etc.) and pertaining to the different operational aspects of the regulatory process.

At the same time, regulators are frequently consulted during the drafting of legislation touching upon nuclear safety-related issues, for which other State bodies are primarily responsible and hold the right of legislative initiative. An example would be the establishment of radiation protection-related provisions on EP&R arrangements by civil protection authorities.

As regards Article 5, paragraph 3, letter (b) of the Directive, the regulator has to require that the licence holder complies with the safety requirements and demonstrates such compliance. All Member States report that, based on their national legal framework, licence holders are bound by the nuclear safety legislation in force and by the terms/conditions of their licences. Compliance with the safety requirements is demonstrated through the assessment of documentation that is required to be attached to a licence application, through safety assessments and safety reports. The Member States' legislation refers to safety analysis reports corresponding to the different stages of the lifecycle of a nuclear installation and to PSRs, during which the licence holders, under the supervision of the regulatory authorities, systematically and periodically reassess the nuclear safety of the nuclear installation, at least once every ten years.

As regards Article 5, paragraph 3, letter (c) of the Directive, which is intrinsically linked to letter (b) thereof, supervision by the regulatory authorities is essentially carried out on the basis of the analysis and evaluation of documents submitted by the licence holders and of the information collected during inspections. Regulatory review is ensured by means of planned, unannounced, and special/reactive inspections, which could be triggered by incidents, exceptional situations of intervention in the event of radiological emergencies, safety concerns etc.

In many Member States, these inspections are carried out in line with established inspection plans, inspection manuals, or concrete rules included in the regulators' management system, usually following relevant ISO standards. The regulatory authorities usually follow a graded approach as regards the frequency of supervision and inspections, which is based on the safety significance or hazard potential of the nuclear installation in question. Regulatory authorities also opt for resident inspectors on site in specific nuclear installations for the daily monitoring of activities and of compliance with the established requirements. Inspections are concluded with a final report summarising the relevant findings.

As regards Article 5, paragraph 3, letter (d) of the Directive, Member States report that the regulatory enforcement decisions are made by inspectors, based on their professional experience and judgment and, in some occasions, taking account of the advice received from external experts participating in the inspection, such as TSOs or independent technical experts.

There is a large variety of enforcement actions, which are consistently used by the Member States; these consist of issuing official warnings, ordering provisional measures, imposing corrective technical or administrative modifications to the installation, ordering the cessation of its operation, the amendment or revocation of a licence, imposing administrative fines or even penal sanctions etc. It has been reported in a few Member States that there is an appeal procedure against enforcement actions.

In light of the Directive's stipulation that the enforcement actions must be "effective and proportionate", many Member States report to be applying a "graded" approach in their enforcement policy, implying the application of enforcement actions that are commensurate to the nature, duration, severity of the detected infringement.

2.3. EXPERTISE AND SKILLS IN NUCLEAR SAFETY (Article 7 of the Directive)

Article 7 of the Directive requires all parties to make arrangements for the education and training for their staff having responsibilities related to the nuclear safety of nuclear installations so as to obtain, maintain and to further develop expertise and skills in nuclear safety and on-site emergency preparedness.

Typically, the Member States inform of their requirements, both of a legally binding nature, and non-legally binding guidance containing more detailed provisions.

The education and training programmes are generally implemented through annual training plans, medium and long-term strategies and the identification of needs. They include both theoretical and practical exercises.

The regulatory authorities and the licence holders ensure that all personnel performing safety-related duties, including contractors[40], are adequately trained and qualified. The qualifications are regularly reviewed, in some Member States every two to five years. Performance interviews during the year support the identification of the development needs.

Some regulators implement a policy of skills and knowledge transfer by more experienced workers to newer employees to ensure continuity at the level of the organisation and preserve experience and established good practice. The recruitment of young professionals joining the regulatory authority is based on education requirements being met; this includes in particular nuclear safety officers and inspectors, and radiation protection experts.

An important issue highlighted by Member States is the ageing of the nuclear workforce and the need to retain knowledge and expertise, including in the field of decommissioning. Solutions imply, for instance, the establishment of a 'national nuclear knowledge management programme' in co-operation with relevant stakeholders[41], the development of dedicated university courses[42], the preparation of 'needs assessments' involving the relevant actors[43]. In addition, there are a number of relevant initiatives at EU level, such as the European Human Resources Observatory for the Nuclear Sector (EHRO-N).

2.4. TRANSPARENCY (Article 8 of the Directive)

2.4.1. Provision of nuclear safety-related information (Article 8, paragraphs 1 and 2)

Article 8 of the Directive lays down the obligation of providing information in relation to normal operating conditions of nuclear installations, as well as providing prompt information in case of incidents and accidents. In the first case, information is to be provided to workers and the general public, with specific consideration to local authorities, population and stakeholders in the vicinity of a nuclear installation; in the latter case, competent regulatory authorities of other Member States in the vicinity of a nuclear installation are also to be informed. The obligation to provide information rests on both the regulatory authority and on the licence holder.

In most cases, legal provisions defining the tasks of the regulatory authority include the obligation to disseminate information on the nuclear safety of nuclear installations and its regulation. The regulators are also bound by general legislation on the right to free access to information and legislation on access to information on environmental aspects.

As regards the regulatory authorities, the communication practices identified include establishing a communication policy document for the regulatory authority[44]; publishing annual reports and results of regular inspection reports on the website[45]; making information

[40] For instance, Italy, Slovakia.

[41] For instance, the Netherlands.

[42] For instance, Finland.

[43] For instance, Germany.

[44] For instance, Hungary.

[45] For instance, Belgium, Bulgaria, Czech Republic.

on the website available in more than one language[46]; integrating social media into the communication channels; maintaining contacts with the press and organising workshops for journalists; establishing special websites following major events, such as the Fukushima accident[47]; offering opportunities to provide feedback and ask questions; establishing bodies for information, consultation and debate on the risk associated with nuclear activities[48].

As regards the licence holders, in some cases the Member States' reports provide examples of interactions with the public similar to those of the regulators, such as opening and maintaining visitor centres[49]; distributing printed information magazines and brochures; setting up consultative bodies to reinforce the relations with local residents[50]; organising meetings at schools and universities; organising site visits, thematic events and open days.

Concerning communication in case of incidents or accidents, the reports present various solutions, usually integrated within the EP&R framework, and in many cases involving different national entities responsible for civil protection and crisis management activities. Some Member States provide examples of initiatives, such as an educational film intended for the population of the municipality with the aim of raising awareness of the procedures in the event of a nuclear accident at the plant or implementing a system for informing the public via SMS[51].

As far as international cooperation is concerned, Member States frequently make reference to the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (as well as the IAEA USIE[52] and RANET[53] systems), as well as to the EU systems (ECURIE, EURDEP)[54]. Regional initiatives are also mentioned; for instance, the shared joint agreement between Nordic Competent Authorities, referred to as 'Nordic Manual', which is an implementation agreement of a commonly agreed protection strategy ('Nordic Flagbook'). Bilateral agreements are also commonly in place between neighbouring countries.

Some Member States refer to their legislation introducing the principle of public access to official documents and some provide examples of grounds for refusal or restriction of provision of information to the public. Such grounds include, for instance, physical protection of radioactive materials, industrial ownership or classified information.

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[46] For instance, Bulgaria, Czech Republic, France.

[47] For instance, Czech Republic.

[48] For instance, France.

[49] For instance, Netherlands, Slovenia, Slovakia.

[50] For instance, Slovakia.

[51] For instance, Czech Republic.

[52] IAEA Unified System for Information Exchange in Incidents and Emergencies (USIE).

[53] IAEA Response and Assistance Network.

[54] European Community Urgent Radiological Information Exchange (ECURIE), European Radiological Data Exchange Platform (EURDEP).

2.4.2. Cooperation between regulatory authorities (Article 8, paragraph 3 – in connection with Article 5, paragraph 2)

Article 8, paragraph 3 of the Directive introduces the requirement that the regulatory authorities engage in cooperation activities on the nuclear safety of nuclear installations with counterparts of other Member States in the vicinity of a nuclear installation, *inter alia*, via the exchange and/or sharing of information.

Most Member States report having in place provisions in their legal framework laying down the general cooperation obligation of their regulator with similar authorities of neighbouring (or other) Member States. They complement this information with a detailed list of the specific bilateral and multilateral agreements that they have entered into and specify the modalities of how this cooperation is implemented in practice.

According to the national reports, Member States are signatories to international nuclear safety treaties (such as the Convention on Nuclear Safety, the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency) and have participated in the ConvEx exercises under the IAEA auspices. At the same time, they are members, where relevant, of the various EU (e.g. ECURIE, EURDEP) and international accident management and reporting systems (e.g. USIE, RANET, IRS, EPRIMS)[55]. They also regularly take part in various fora and working platforms of the EU, IAEA, OECD, Heads of the European Radiological Protection Competent Authorities (HERCA) and WENRA, where national experts meet their peers and share information and expertise.

Member States' regulatory authorities also take part in bilateral and multilateral meetings with neighbouring countries based on bilateral agreements, to share information and experience. Among some Member States with common borders, there is continuous exchange of technical data, with the aim of informing and answering the questions of residents and/or local and national representatives[56]. In some cases there is also exchange of information on the licensing processes of nuclear installations (or on modifications thereof) that are in progress and are of interest to neighbouring Member States[57].

There are also some cases of Member States[58] that have adopted arrangements with both neighbouring and non-neighbouring countries, located within and outside EU, using similar NPP technology.

Other collaborative activities between regulators, which go beyond the pure exchange of information, include joint inspections[59], mutual training, exchange of personnel, cross-

[55] IAEA Unified System for Information Exchange in Incidents and Emergencies (USIE), IAEA Response and Assistance Network (RANET), IAEA Incident Reporting System (IRS), Emergency Preparedness and Response Information Management System (EPRIMS).

[56] For instance, between Belgium, Germany and the Netherlands.

[57] For instance, between Sweden, Denmark, Finland and Norway.

[58] For instance, countries operating or intending to operate "Water-Water Energetic Reactors" ('VVER'), such as Finland and Hungary; countries intending to operate "European Pressurized Water Reactors" ("EPR), such as France and Finland; and countries operating CANDU reactors (Romania).

participation of experts in national emergency plan exercises, joint commissions and expert groups with neighbouring Member States.

2.4.3. Public participation in the decision-making on the licensing of nuclear installations (Article 8, paragraph 4)

Article 8, paragraph 4 of the Directive reflects the need to ensure that the general public is given the appropriate opportunity to participate effectively in the decision-making process related to the licensing of nuclear installations.

All Member States with nuclear installations have procedures in place to consult the public on the main phases of the licensing of a nuclear installation (siting, construction and decommissioning). However, differences exist in cases where additional consultations can also relevantly be organised. Hence, some Member States report on consultations conducted when important changes in the operation of the nuclear installations are envisaged (e.g. service life extension of the reactor, steam generator replacement and power uprates).

To implement the Directive's obligation, most Member States couple, to a varying degree, their consultation processes with the information and consultation obligations laid down in the international environmental legislation such as the Espoo[60] or Aarhus[61] Conventions or the EU environmental acquis, such as the Environment Impact Assessment Directive[62]. Pursuant to this framework, Member States have the obligation to consult their population and other States potentially affected, on any project that may have significant adverse effects on the environment; this includes, as appropriate, projects to construct nuclear installations or associated major changes or extensions to them. Although the environmental consultations may include relevant information available and obtained through risk assessments pursuant to the nuclear safety legislation, such as measures envisaged to prevent or mitigate the significant adverse effects of major accidents / disasters on the environment and details of the preparedness for and proposed response to such emergencies, there is a lack of clarity whether such consultation mechanism address all relevant nuclear safety-significant factors. Only a few Member States report having in place specific nuclear safety consultation processes[63].

Several consultation practices were identified, including early announcements of the consultation process in the press and dedicated websites; detailing the consultation modalities e.g. scope of the decision at stake, availability of documents, deadlines; making available non-technical summaries to facilitate a good understanding by the public at large; organising public hearings; involving independent expert panels which participate to the public debates[64]; consulting and exchanging information through the local information committees

[59] For instance, between Belgium and the Netherlands.

[60] Convention on Environmental Impact Assessment in a Transboundary Context.

[61] Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters.

[62] Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment, as amended.

[63] For instance, France, Hungary.

[64] For instance, Denmark.

established by the licensees in accordance with the legal requirements[65]; giving opportunities for appeals on the decision taken.

III. SAFETY OF NUCLEAR INSTALLATIONS (Articles 6, 8a – 8d of the Directive)

3.1. LICENCE HOLDERS (Article 6 of the Directive)

3.1.1. Licence holder's prime responsibility for nuclear safety (Article 6, letter (a))

Article 6, letter (a) of the Directive assigns the licence holders the prime responsibility for the nuclear safety of a nuclear installation, which cannot be delegated. This includes responsibility for the activities of contractors and sub-contractors whose activities might affect the nuclear safety of a nuclear installation.

In general, the Member States with nuclear installations lay down legal provisions acknowledging the prime responsibility of the licence holder for nuclear safety; in some cases, this is complemented by an express prohibition of the delegation of responsibility. However, with some exceptions[66], Member States provided less detailed information on the implementation of the licensees' responsibility as regards the activity of contractors and sub-contractors. Furthermore, in some cases, reference was made to the connected area of liability for damage caused by nuclear installation (nuclear liability).

3.1.2. Licence holders' safety assessments (demonstrations of safety in support of a licence application and regular safety assessments) (Article 6, letters (b) and (c))

When applying for a licence, the applicant is required to submit a demonstration of nuclear safety whose scope and detail is appropriate to the potential magnitude and nature of the hazard of the nuclear installation and the site. Furthermore, licence holders are required to regularly assess, verify, and continuously improve, as far as reasonably practicable, the nuclear safety of their nuclear installations in a systematic and verifiable manner. This includes measures for the prevention of accidents and mitigation of the consequences of accidents, including verification of the defence-in-depth provisions.

The Member States report that the licensing steps for a nuclear installation typically involve siting and site evaluation, design, construction, commissioning, operation, and decommissioning. Each of these steps requires the submission of a suitable site evaluation or safety report, detailing the site characteristics, and design and safety features for regulatory evaluation. Those countries with NPPs in operation or under decommissioning describe in detail the processes and requirements for licensing to ensure adequate safety demonstration throughout the life of the installation. Most countries specify legally binding requirements in regulations, but others have a non-prescriptive system based on guidelines setting out the regulatory expectations.

The national requirements, regulations and guidelines generally define the type of safety demonstration in terms of the credible faults, hazards, design safety criteria, applicable

[65] For instance, France.

[66] For instance, Spain, Slovakia.

standards, risk limitation to workers and the public, and plant conditions to keep within an acceptable operating envelope for relevant processes, activities, and modifications. For NPPs, these are typically based on the IAEA safety standards and WENRA safety reference levels.

The safety demonstration is intended to show how the defence-in-depth principle has been applied, and that operational limits for normal operation, abnormal operation and design basis accidents would not be exceeded. Deterministic and probabilistic safety assessments methods are typically used to analyse internal and external hazards and initiating events that could trigger accident sequences, and to demonstrate the capability of safety systems, and the measures available to mitigate accident consequences. The safety demonstration for NPPs aims to show that the design has sufficient robustness to allow shutdown and cooling of the reactor from any operating state, and that the safety functions in related facilities such as the spent fuel storage facility would be maintained. Safety demonstrations are generally updated in line with operating experience, new safety analysis, research findings, plant ageing and the outcome of PSRs.

Analyses are also undertaken for more severe faults outside of the design basis, including severe accidents which could lead to large releases of radioactivity. The safety analyses include potential failures of the physical barriers to the release of radioactivity, the magnitude and characteristics of the releases, the determination of accident management strategies to reduce the risk, as well as the necessary instrumentation, equipment, and accident management guidelines needed to cope with such accidents. In some Member States, numerical targets of the deterministic and probabilistic criteria are applied to demonstrate that radiological hazards are being adequately controlled and risks reduced to as low as reasonably practicable. In many countries, in line with current IAEA standards and WENRA guidance, the severe accident analyses aim to show that potential severe accident states have been ‘practically eliminated’, i.e. it is physically impossible for the accident state to occur or that it can be considered to be extremely unlikely with a high degree of confidence.

Member States describe various activities conducted by licensees and regulators to verify that measures are in place for the prevention and mitigation of accidents, and the application of defence-in-depth measures, including reviews, inspections and control activities. Regulators may engage independent external experts for specialist analysis and reviews. Some countries report that the results of reviews and inspections carried out by the regulatory authority are documented and made available to the public (e.g. information on the PSRs or the actions envisaged by the licensees[67]). Safety indicators and event analysis are used to assess operational safety. Operating experience from events reported at European and international level (IAEA, OECD/NEA) is also taken into account.

The reports describe that structures, systems and components of relevance to nuclear safety are required to be designed, manufactured, assembled, and tested so as to ensure their reliable functioning. Licensees are required to ensure that the manufacturers and suppliers of safety classified equipment, materials and accessories provide quality documentation on the results of quality checks and tests of properties of components, equipment, and materials.

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[67] For instance, Belgium.

3.1.3. Licence holders' financial and human resources (Article 6, letter (f))

All Member States have requirements in place to ensure the availability of adequate financial resources for the licence holders, with several countries reporting that the requirement to demonstrate this aspect is already part of the initial licence application. The regulator may assess the financial resources of the licence holder during the licence application, or assistance is sought from the appropriate ministry (concerning financial resources when issuing a licence for the first time).

Several States report that they require that the financial resources of the licensee should cover all stages of the lifecycle of a nuclear installation[68], including final costs of decommissioning and remediation and should also enable it to cope with a wide range of reasonably foreseeable economic risks[69].

While, generally, the Member States have requirements in place, albeit diverse in nature, their level of detail of reporting on implementation varies. Various solutions exist to assess the level of the licensees' financial resources. These include annual and longer-term business /investment plans[70]; the review of the licensee's investment projects related to safety by the regulator[71]; requirements for regulatory authorisation in case of changes that may impact the licensee's financial resources, such as changes of ownership or corporate structure[72]; use of a risk-based approach to examine the level of liquidity and solvency of the licence holder to operate the installation safely[73]; regulatory inspections covering the financial situation etc. In some Member States, there may not be an explicit review of on-going availability of financial resources by the regulator, but rather the review is carried out indirectly through supervision of how the licence holders fulfil their safety obligations[74]. Ultimately, there may be the possibility to revoke a licence if the financial security is deemed inadequate[75].

As with financial resources, Member States have requirements in place to ensure the provision of adequate human resources, which may also be addressed as part to the initial licencing process. The licence holder is normally required to have an adequate number of qualified personnel suitable for their tasks, under different operating conditions. Significant functions with respect to safety within NPPs are designated, and the competences of the persons working in such positions are verified.

Detailed guidance exists in some Member States for qualifications and proficiency (tests) of staff, including for specific shift operator functions in NPPs; these can be laid down in

68 For instance, France, Slovenia.

69 For instance, France.

70 For instance, Bulgaria, Slovenia.

71 For instance, Bulgaria.

72 For instance, Germany.

73 For instance, Netherlands.

74 For instance, Sweden, United Kingdom.

75 For instance, Germany.

separate procedures, but also in the Safety Assessment Report (SAR) or PSRs for the installation[76] or other documents required for licencing[77]. The regulator reviews compliance with the guidance. The licence holder must demonstrate the provision of a sufficient number of qualified personnel for the operation of its nuclear installation on a permanent basis. Organisational and substantial changes in the organisation need to be also evaluated[78].

As for financial resources, human resources are reviewed by the regulators, for instance though annual meetings of the regulator with senior management of the licence holder or through the regulator’s inspection programmes.

Licence holders generally have the obligation to set out the requirements on financial and human resources, placed on contractors. These may be part of the licensee’s management system[79]. Contractors are often required to have a certified quality management programme. The requirements on contractors may be extended to suppliers and both contractors and suppliers may be subject to oversight by the regulator[80].

3.2. NUCLEAR SAFETY OBJECTIVE FOR NUCLEAR INSTALLATIONS AND THE IMPLEMENTATION OF THE OBJECTIVE (Article 8a and 8b of the Directive)

Article 8a of the Directive requires that that nuclear installations be designed, sited, constructed, commissioned, operated and decommissioned with the objective of preventing accidents and, should an accident occur, mitigating its consequences and avoiding early radioactive releases and large radioactive releases. Whilst the objective applies fully to ‘new’ installations (those receiving a construction licence for the first time after 14 August 2014), it is also to be used as a reference for existing installations for the timely implementation of reasonably practicable safety improvements[81]. The requirements of Article 8a represent an essential first step to reflect the important lessons of the Fukushima nuclear accident on accident prevention, mitigation, protection of the containment boundary and minimising effects on the population and surroundings.

3.2.1 Overview of the implementation of the nuclear safety objective at national level

The majority of Member States opted to reflect the nuclear safety objective by using, in legally binding instruments, similar wording to the Directive. In addition, some Member States supported these high-level requirements by implementing regulations and regulatory guidance, interpreting or quantifying the terms, or laying down regulatory criteria or licence conditions for the demonstration of the requirements[82]. For example, in one Member State[83],

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[76] For instance, Belgium.

[77] For instance, Spain.

[78] For instance, Finland, Romania.

[79] For instance, Bulgaria.

[80] For instance, Hungary, Romania.

[81] A similar objective for new NPPs is formulated in the principles of the Vienna Declaration for Nuclear Safety

[82] For instance, Belgium, Finland, Netherlands, Poland, Romania, Sweden, Slovakia

the regulator has issued more detailed recommendations on demonstrating the practical achievement of the objective; this is realised through quantitative criteria in terms of the magnitude and probability of an early or large release that would require off-site emergency measures without sufficient time to implement them, or which would require protective measures that cannot be limited in space or time. Probabilistic dose targets for accident sequences are further specified.

Several Member States indicate that they have incorporated in their regulations or guides safety objectives for new NPPs, similar to those established by WENRA, which explicitly call for the practical elimination of "accidents with core melt which would lead to early or large releases"[84]. The practical elimination objectives, which are also expressed in the latest IAEA safety standards[85], apply to new NPPs, whereas for deferred and existing plants they should be used as a reference for identifying reasonably practicable safety improvements. Use of the practical elimination concept is particularly evident in those Member States that are pursuing the construction of new NPPs.

3.2.2. Interpretation of the different terms and concepts of the nuclear safety objective

Following adoption of the Directive, the European Commission facilitated exchanges amongst national authorities with a view to promoting an ambitious interpretation of the high-level requirements in Article 8a. The outcomes of this work show that the underlying concepts are still evolving. Several terms, such as 'early radioactive releases' and 'large radioactive releases' do not have precise definitions in existing European and international standards. Based on qualitative supporting guidance, there is scope to develop the implementation approaches in a more quantitative way. Even though some countries have defined quantitative radiological acceptance criteria corresponding to large releases[86], and others addressed both large and early releases[87], there is not a consistent approach regarding quantification of this concept.

Besides the above views on quantification of the terms 'early' and 'large' radioactive releases, there are other differences in the Member States' approaches. For instance, some Member States rely on much earlier versions of the concept, which primarily addressed early large releases. Some consider that accident sequences (or events, or accidents) that lead to early or large releases should be avoided or practically eliminated, whilst others apply this notion directly to early and large releases.

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[83] Romania.

[84] For instance, Bulgaria, Czech Republic, Finland, France, Hungary, Slovenia, United Kingdom

[85] IAEA Safety Standards Series No. SSR-2/1 (Rev. 1), Safety of Nuclear Power Plants: Design Specific Safety Requirements, 2016.

[86] For instance, Finland, Sweden.

[87] For instance, Hungary.

3.2.3. Application of the nuclear safety objective to new nuclear installations

In those countries pursuing the construction of new NPPs, according to the Member States concerned, the designs of new reactors have robust design features to protect against extreme hazards in order to prevent severe accidents and mitigate their consequences.

3.2.4. Application of the nuclear safety objective to existing nuclear installations

In relation to operating NPPs, Member States indicate that practical safety improvements have been identified and implemented. The safety upgrades to existing installations refer to increased protection and mitigation measures against severe accidents, and typically include:

- Passive autocatalytic hydrogen recombiners;
- Water make-up to ensure in-vessel core cooling;
- Filtered containment venting systems to preserve containment function;
- Mobile diesel generators to ensure the power supply in case of station blackout;
- Improved instrumentation for monitoring safety parameters in severe accident situations.

Many Member States indicate that safety upgrades are systematically identified in the scope of the ten-year PSR, and that, in addition, the post-Fukushima EU Stress Tests yielded additional insights that led to implementation of improvements in the resistance to external hazards (seismic hazards, flooding, severe weather), loss of safety systems, and severe accident management[88]. Another Member State developed guidance for the design of new pressurised water reactors, in line with the provisions of the Directive, whilst indicating that its recommendations may also be used as a reference to seek safety improvements to reactors in operation, for example during periodic safety reviews[89].

3.2.5. Development of the ‘reasonably practicable’ concept

On the implementation of the ‘reasonably practicable’ safety improvements to existing nuclear installations, none of the reporting countries provide further information on their rationale and regulatory expectations related to such improvements. Some countries explain that it is not possible to formulate comprehensive and unambiguous criteria, and these improvements and their timeliness have to be evaluated on a case-by-case basis.

However, the lack of clearly defined criteria or regulatory expectations risks to result in diverse implementation approaches for similar safety challenges. Experience from the EU Stress Tests showed that even for similar reactor technologies, some licensees of NPPs have only recently adopted specific safety improvements associated with containment integrity or the avoidance of large releases through the implementation of passive autocatalytic combiners

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88 For instance, Belgium, Czech Republic, Germany, Hungary, Netherlands, Slovenia, Slovakia, Spain, Sweden, United Kingdom.

89 France, ‘Design of pressurized water reactors - Guide Nr 22’, 18/07/2017 (INIS-FR--17-0820).

or filtered containment venting, whereas other countries already had installed them several decades ago in response to accidents and operating experience[90].

Several ways of tackling the implementation of these issues are reported. As an example, the regulatory framework of a Member State[91] requires taking into account the state of the art in science and technology in implementing the safety objective for existing installations. This is a challenging requirement but could be considered as the basis of a methodology of determining reasonable practicality, taking account of technical advances and risk acceptability factors. Some regulators[92] report that they follow closely the events and the international operational experience feedback, as well as the scientific and technological development through international contacts and research programmes to be able to evaluate the aspects of reasonable practicability and timeliness of the improvements.

3.2.6. Implementation of the nuclear safety objective through defence-in-depth measures

Article 8b, paragraph 1 requires that the principle of defence-in-depth, which consists of the implementation of successive and sufficiently independent levels of defence, is applied. Defence-in-depth is applied to minimise the impact of extreme external and unintended man-made hazards; prevent abnormal operation and failures; control abnormal operation and detect failures; control accidents within the design-basis; control severe conditions, including prevention of accident progression and mitigation of the consequences of severe accidents; and establish on-site emergency response organisational structures.

According to Member States' reports, defence-in-depth remains a fundamental and well-established concept both in the regulations and in actual practices, applied equally to both new and existing installations. These are implemented to prevent and detect incidents; implement measures to prevent incidents leading to accidents; control accidents that could not be avoided or, failing that, limit their worsening; and manage accident situations that could not be contained so as to limit the consequences. According to these reports, many safety improvements had already been performed prior to the formal reinforcement of the defence-in-depth concept in the Directive[93].

Member States report that the implementation of this principle is based, in particular, on the choice of a suitable site, taking into account, in particular, the risks of natural or industrial origin affecting the installation; a prudent design approach, involving adequate safety margins; and using adequate physical redundancy, diversification and physical separation of the important elements for protection that perform the safety functions necessary for the demonstration of nuclear safety. In order to achieve a high level of reliability and to ensure the necessary functions, measures are applied to ensure the quality of the design, construction,

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90 For instance, Sweden.

91 For instance, Germany.

92 For instance, Finland.

93 For instance, Belgium, Czech Republic, Germany, Hungary, Netherlands, Slovenia, Slovakia, Spain, Sweden, United Kingdom.

operation, shutdown, decommissioning, maintenance and monitoring of the installations, as well as the management of possible incident and accident situations. Furthermore, the function of containment of radioactive substances is ensured by the use of one or more sufficiently independent successive barriers between those substances and the population and the environment and, if necessary, by a dynamic containment system. The number and effectiveness of such arrangements are proportionate to the scale and impact of potential radioactive releases, including in the event of an incident or accident.

Within the defence-in-depth principle, the concept of “design extension conditions” (DECs) has been developed to reflect more challenging events than those considered in the design basis as an integral part of the safety approach. The DEC concept has as its goal a comprehensive consideration of events associated with safety objectives whose achievement is expected to be demonstrated. Member States have progressively incorporated the concept into their national requirements, but provided less detail on its demonstration in practice.

3.2.7. Implementation of the nuclear safety objective through safety culture

Together with defence-in-depth, an effective nuclear safety culture is regarded as a fundamental factor in achieving a high level of nuclear safety and its continuous improvement. The Directive provides, pursuant to Article 8b, paragraph 2, that Member States should ensure that the national framework requires that the regulatory authority and the licence holder “take measures to promote and enhance an effective nuclear safety culture”. Important elements which help to achieve a strong nuclear safety culture include, in particular, effective management systems, appropriate education and training and arrangements by the licence holder to register, evaluate and document internal and external safety significant operating experience and effective resolution of issues that have been raised.

The Member States concerned by reporting, structured their explanations, in principle, in accordance with the four safety culture elements laid down in the Directive.

3.2.7.1. Management systems

The Member States indicate, generally, two types of instruments laying down safety culture rules. The first level consists of nuclear safety legislation setting the framework by clarifying the entities concerned by the requirement to develop management systems or by defining key principles, requisites and features of a safety culture architecture. The second level is more detailed and is composed of a comprehensive suite of internal policy statements, procedures, guidelines, action plans, roadmaps, supplemented by other tools like record-keeping and reporting databases, training, publications or reports. Generally, safety culture is documented, as presented above. However, particularly in respect to the regulators, a few Member States express the view that management systems do not need to be formalised, as they result from practical application or from international reviews.

The information on management systems refers, in the majority of cases, to both licence holders and regulatory authorities, while, in some cases, the information focusses on the measures taken at the licensee level (on which regulators have a supervisory role).

Overall, priority to nuclear safety appears to be an underlying principle, which is either expressly affirmed in the various documents or it results from the entire safety culture philosophy.

The management systems comprise, usually, two main categories of measures. The first category addresses aspects related to shared attitudes, norms, beliefs and values of all employees fostering a strong safety culture. Such measures include clear reporting lines and communication channels; adherence to agreed rules and procedure; personal accountability for nuclear safety; contribution to the continuous improvement of safety; systematic decision-making feedback on the work results; incentives for performance; continuous learning. Certain Member States emphasise the role of managers as leaders and models demonstrating commitment to safety in their decisions and behaviours[94]. In this framework, there are also elements supporting a "questioning attitude" of the staff members, such as freely expressing opinions and positions; identifying non-compliance issues; reporting them to the line managers or other levels of the hierarchy without restrictions; proposing correcting actions. The second category comprises procedural requirements defining the workflows of the licensee's activities and their regulatory review[95].

Safety culture is usually subject to monitoring and evaluation. Several tools were indicated, combining regular internal and external scrutiny. The internal level comprises, typically, self-assessments, surveys, questionnaires, internal audits or management reviews; in the case of licensees, a number of Member States confirm that contractors and suppliers are required to abide by the same rules, and are thus also covered by such assessments[96]. Under the external level, generally, regulatory authorities evaluate the licensees' safety culture measures by collecting and analysing observations from inspections, documentation, events and other interactions or using indicators to assess trends; this is followed by feed-back and discussions with the licensees. Additionally, several Member States inform of assessments conducted by outside assessors or by international bodies as part of a peer review, such as the IAEA IRRS or OSART missions or during events discussing country-specific traits.

Several Member States emphasise the role of international guidance, such as from WENRA, IAEA, OECD/NEA or US NRC, in supporting them to develop the safety culture requirements, particularly the management systems. A range of Member States refer to training on safety culture matters offered to the employees[97].

3.2.7.2. Arrangements on significant operating experience

Overall, Member States report that licence holders have in place operational feedback programmes and processes covering several elements, namely the collection, record keeping, analysis and documentation of operating experience (both internal and external), the detection, notification and distribution of relevant information, and the continuous

[94] For instance, Lithuania.

[95] For instance, Austria, Denmark.

[96] For instance, Czech Republic, Finland, Hungary.

[97] For instance, Czech Republic, Finland, Lithuania.

improvement of the mechanism. Several Member States set out processes of verification and use of the records, typically by the regulatory authorities, at the time of inspection or reporting. International cooperation is a major component, with several arrangements of experience sharing and exchange being quoted, such as the IRS (Incident Reporting System), WANO networks or the JRC Clearinghouse.

3.2.7.3. Reporting of safety significant events

Generally, Member States mention that licence holders put in place procedures defining and documenting the detection, reporting and follow-up of events. Some of the measures include definition of criteria for reportable events; guidance for using the INES scale; event detection and description; methods to analyse events; rules on use, storage and dissemination of information; procedures and clear deadlines for reporting to the regulatory authorities (and other relevant authorities, if necessary); guides on the types of remedial measures; monitoring the implementation of measures; evaluation of operational events feedback effectiveness and trends; sharing information between each other. The regulators have an oversight role, by inspecting the progress of the events management and the sufficiency of the remedial measures taken, keeping their own records of events or looking for possible associated generic issues[98]. Certain Member States inform of transparency measures, where information on events is included in annual reports or published on their websites.

3.2.7.4. Education and training

The relevant information is included in the Member States' reporting under Article 7 of the Directive.

<u>Progress with the post-Fukushima EU Stress Tests implementation</u>

Following the EU Stress Tests after the Fukushima Dai-ichi nuclear power plant accident on 11 March 2011, each participating country prepared its National Action Plan (NAcP). In addition to the European Union Member States, Switzerland and Ukraine participated in this activity.

Most significant safety improvements include e.g.:

- Installing means for managing severe accidents (including containment pressure control and hydrogen management),
- Installing additional means for heat removal functions,
- Installing additional means for ensuring emergency power.

Two workshops were held in 2013 and 2015 to review progress on the National Action Plans, and the requirement to update the action plans was agreed by ENSREG and was subsequently included in the ENSREG work programme. Participating Member States committed to update their NAcPs in 2017 to publish updates every 2 years, starting from 2017, until completion of their respective NAcPs. Those Member States that had not yet reported completion of their National Action Plans, submitted either their latest update at the end of 2021. ENSREG should adopt its "Post-Fukushima NAcP – Status Report" in 2022.

98 For instance, Finland.

In general, countries have shown that most of their actions have been implemented as planned. However, several countries reported delays compared to the original plans, and in the 2021 update a few actions may not be completed before the end of 2022. Several Member States have not yet reported the completion of their post-Fukushima National Action Plans. Some of the open actions concern significant safety improvements, e.g. emergency control centre, additional cooling measures, maintaining containment integrity, emergency power supply, seismic reinforcement, or spent fuel storage facility.

3.3. INITIAL ASSESSMENT AND PERIODIC SAFETY REVIEWS (Article 8c of the Directive)

Article 8c of the Directive requires that any issue of a licence to construct or operate a nuclear installation, is based upon an appropriate site and installation-specific assessment, comprising a nuclear safety demonstration with respect to the national nuclear safety requirements based on the nuclear safety objective. Furthermore, the licence holder, under the regulatory control of the regulatory authority, is required to re-assesses systematically and regularly, at least every 10 years, the safety of the nuclear installation to ensure compliance with the current design basis and to identify further safety improvements by taking into account ageing issues, operational experience, most recent research results and developments in international standards, using as a reference the nuclear safety objective.

3.3.1. Initial assessment

Member States have in place detailed licensing procedures for nuclear installations that typically require the applicant to provide an initial safety analysis report or safety demonstration for the siting and design, a preliminary analysis report for the construction, and an operational safety analysis report for commissioning and operation.

The national regulations typically specify the nature of the supporting documents needed to justify the safety features related to the project, especially in respect of external natural or industrial hazards. The installation-specific assessment aims to confirm that the impacts and the loads on structures, systems and components resulting from external events, internal events and realistic combinations of events are taken into account in the design basis and that defence-in-depth is implemented. In addition to deterministic event analysis to demonstrate that the most frequently expected events lead to minimal consequences, probabilistic analysis is also required to verify the effectiveness of the design against infrequent hazards and their combinations.

3.3.2. Periodic Safety Reviews

PSRs are of fundamental importance to nuclear safety, and applicable to all nuclear installations. These reviews contribute to achieving the nuclear safety objective in existing installations and often have an important role in the decision-making process for Long Term Operation (LTO)[99].

[99] For instance, Bulgaria.

All Member States with nuclear installations require PSRs every 10 years to continuously improve the nuclear safety for all operating and decommissioning nuclear installations. The aim is to update the assessment of the risks, taking into account the current conditions, operational experience from within the country and abroad, research results, and the developments in international nuclear safety standards. The review includes a verification of the compliance of the installation with the design basis including an assessment of ageing issues, and potential further safety improvements in line with current regulations. The licensee reports the review findings with the measures it intends to take to remedy any deficiencies or improvement actions to the regulatory authority, who may impose additional requirements.

To illustrate the actions carried out as part of the reviews, some Member States provide examples, such as the seismic upgrade of the reactor building to take account of the latest seismic standards[100], renovation of the instruments and control systems, the provision of additional cooling means, and improvements in fire protection[101]. Measures to increase the robustness of NPPs following the EU Stress Tests are also cited. Challenges are also mentioned including the management of ageing of materials and equipment reaching their design life, the reassessment of safety taking into account the enhanced requirements applicable to new reactors.

A few Member States quote requirements or guidelines requiring licensees to perform PSRs following a methodology based on the 14 safety factors described in the IAEA Safety Guides[102] and the WENRA reference levels. Despite its importance for safety reassessment and improvement, overall, Member States provide few details on the PSR's scope, methodologies, and effectiveness, as well as on how the nuclear safety objective is systematically used in the PSRs as a reference to identify safety improvements, including in the context of LTO. Few States report on measures taken at other installations, such as research reactors.

3.4. ON-SITE EMERGENCY PREPAREDNESS AND RESPONSE (Article 6(e) and 8d of the Directive)

Article 6(e) required licence holders to provide for appropriate on-site emergency procedures and arrangements, including severe accident management guidelines, for responding effectively to accidents in order to prevent or mitigate their consequences. Article 8d of the Directive requires that an organisational structure for on-site EP&R should be established with a clear allocation of responsibilities and coordination between the licence holders, and competent authorities and organisations, taking into account all phases of an emergency; there should be consistency and continuity between the on-site and the off-site components of the EP&R arrangements.

3.4.1. Licence holders' on-site emergency procedures and arrangements

All Members States with nuclear installations confirm that licence holders comply with their obligation to put in place on-site EP&R procedures and arrangements by referring to legal

[100] For instance, France.

[101] For instance, France.

[102] NS-G-2.10 superseded by SSG-25.

requirements supported by regulatory guidelines. No references to international peer-review missions addressing this topic, such as the IAEA Emergency Preparedness Review (EPREV) or IRRS missions were mentioned in the reports.

When establishing and further improving their EP&R arrangements, States report that the licensees' on-site procedures are developed under the supervision of the regulatory authorities, based on international relevant standards (IAEA, WENRA) and regular exercises. Member States report that these procedures cover all operating modes and severe accidents occurrences.

Even though this was a major finding from the Fukushima nuclear accident, not all Member States with nuclear installations reported that they addressed explicitly situations affecting several units simultaneously. As an exception, one Member State[103] explicitly refers to licensee's capability of dealing with simultaneous emergencies at all reactor units on a single site over a minimum period of one week. Other Member States report on specific arrangements such as additional capacities and equipment to cope with extreme natural events leading to station blackout and/or loss of cooling. Those capacities are present on site and/or are part of mobile external intervention resources[104] that can reach quickly the affected units.

The testing of the EP&R arrangements takes an important place in the reporting. Usually, they are reviewed and tested on a yearly basis by the licensee, under the supervision of the regulatory authorities. Larger exercises combining on-site and off-site aspects, performed at national level, sometimes involving neighbouring countries, are carried out typically once every three years. This allows the participation of all actors, at local and national level, and to test the consistency of procedures. Based on the lessons learned, improvements are implemented, including training of staff using severe accident simulation or the development of specific protocols for assistance between units on the same site to take full advantage of available support and qualifications[105].

Some Member States report on specific features that improve EP&R, for example ensuring quick access of the emergency teams and efficient intervention on the relevant parts of the installation or getting support from the 'Utilities Group' that gather deep knowledge of the design together with extended experience feed-back of each type of reactor.

Some Member States report that they integrate maximum radiation dose objectives for each phase of an emergency. Those objectives give clear targets consistent with mitigation actions and to help defining anticipative protection measures notably of intervention teams and of the population.

In some Member States[106], licensees include both operational procedures and emergency procedures in their management system, thus improving consistency.

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103 Sweden.

104 For instance, France, Sweden.

105 For instance, Czech Republic.

106 For instance, Hungary.

3.4.2. Consistency between on-site and off-site arrangements

In case of incidents or accidents, the licensees are responsible for their detection, to report immediately to the regulatory authorities and, when necessary, to the other national authorities involved. Licensees must also trigger action on-site to mitigate the incident or accident to protect workers and the population during all phases of the emergency.

The regulatory authorities, supported as appropriate by TSOs, have central roles in the EP&R arrangements, as well as in the coordination between on-site and off-site measures. Usually, as early as the site licensing stage, they approve the licensee's on-site emergency plan. Furthermore, they check the reviews and testing of these plans by the licence holder or perform technical simulation of crises, based on qualified models, to estimate the potential development of an emergency. In case an emergency occurs, regulators advise national emergency authorities, which include the health authorities. In parallel, they can carry out field measurements to complement the analysis.

In addition, Member States report that they have clear chains of command ensuring consistency and continuity between on-site and off-site EP&R. Less information is provided on the situations when conflicts could arise regarding decisions that could permanently affect the sites and the nuclear installations.

Communication remains central in all EP&R arrangements, including the national emergency plans. Several communication channels are used, such as regular telephone lines, mobile networks, dedicated secured lines or dedicated satellite channels or radio frequencies. Generally, there is also clear definition of 'who' informs 'who' between the relevant actors but also to the public; the latter includes redundancy between local and national information levels. In addition to providing appropriate information, some communication mechanisms aim at ensuring consistency between all the different levels and bodies delivering information[107].

Several Member States – both with and without nuclear installations - reviewed, and, where necessary, amended their national framework and EP&R arrangements to ensure consistency between the requirements of this Directive (covering only on-site arrangements) and those of the Basic Safety Standards Directive (covering both on-site and off-site arrangements). As a particular case, those Member States without nuclear installations or with installations at the decommissioning stage (with the spent fuel sent back to the country of origin) rely on the requirements of the Basic Safety Directive, corroborated with those of the Nuclear Safety Directive, but only to the practicable extent, commensurate with the [remaining] radiological risks.

3.5. PEER-REVIEWS (Article 8e of the Directive)

3.5.1. International peer reviews on the national framework and competent regulatory authorities (Article 8e, paragraph 1)

[107] For instance, Czech Republic, France, Romania.

Self-assessments and accompanying peer reviews of the legislative, regulatory and organisational infrastructure should be aimed at strengthening and enhancing the national framework of Member States. Article 8e, paragraph 1 requires Member States to perform self-assessments of their national framework and competent regulatory authorities and invite an international peer review of relevant segments thereof. This provision existed in the initial 2009 Directive and was not changed by the 2014 amendment. In this respect, the preamble of the 2009 Directive recognised the role of the existing peer review mechanisms already in place at IAEA, in particular the IAEA's Integrated Regulatory Review Service (IRRS), which several Member States had already made use of.

Consequently, the Member States' regulatory authorities in the framework of ENSREG made the unanimous recommendation, noted in the Memorandum of Understanding[108] between ENSREG and IAEA, that "in order to comply with Article 9(3) of the Directive, the best way forward is by cooperation between the EU Member States and the IRRS programme". The Memorandum sets out the responsibilities of ENSREG and IAEA in the delivery of IRRS missions to EU Members States and describes the three components of the EU IRRS programme, namely self-assessments, review missions and follow-up missions. The coordination of the IAEA IRRS programme related to the Directive's implementation is carried out by ENSREG and the IAEA. The Commission follows the programme's implementation, participates in some cases as observer to the missions, and provides financial support to the IAEA enabling performance of the EU missions.

The Directive's ten-year requirement came into force starting with the transposition deadline of 22 July 2011. In the ten-year period to 22 July 2021, all Member States should, as a minimum, have performed an initial IRRS mission. By March 2022, **all Member States have performed an initial IRRS mission.** Two Member States had originally planned missions for 2020, but had to postpone due to the Covid-19 pandemic. The rescheduled missions took place in 2021 and 2022 respectively.

As mentioned above, the programme includes IRRS follow-up missions, which should take place no later than four years after the initial mission to review progress in implementing its suggestions and recommendations. In general, Member States have followed this four-year periodicity, with the exception to date of three Member States. The current status of the IAEA IRRS programme for the Directive's implementation is presented in the table below.

IAEA IRRS missions carried out since 2011 (related to the Directive's implementation)

Member State	Initial IRRS mission	Follow-up IRRS mission
Austria	2018	
Belgium	2013	2017
Bulgaria	2013	2016

108 *"Memorandum of Understanding between ENSREG and the IAEA for International Peer Review Missions to the EU Member States" http://ensreg.eu/sites/default/files/MoU%20ENSREG%20IAEA%20European%20programme%20IRRS%20missions%20-%20signed.pdf.*

Croatia	2015	2019
Cyprus	2017	
Czechia	2013	2017
Denmark	2021	
Estonia	2016	2019
Finland	2012	2015
France	2014	2017
Germany	2019	
Greece	2012	2017
Hungary	2015	2018
Ireland	2015	
Italy	2016	
Latvia	2019	
Lithuania	2016	2020
Luxembourg	2018	
Malta	2015	2020
Netherlands	2014	2018
Poland	2013	2017
Portugal	2022	
Romania	2011	2017
Slovakia	2012	2015
Slovenia	2011	2014
Spain	2018	
Sweden	2012	2016
U.K.[109]	2019	N/A

All IRRS mission reports are published on the IAEA website[110], however not all EU Member States communicate their reports to the Commission, as required by the Directive.

[109] Concerning the United Kingdom, considering that the obligation of applying the Euratom legislation applied until 31 December 2020, and the national report was submitted in 2020, the information presented was considered in the Commission's review.

Peer reviews of the Member States' national framework and competent regulatory authorities through IRRS missions are referenced against the relevant IAEA Safety Standards, comprising 36 overarching requirements. The observations that may arise from a peer review are classed as;

- **Recommendations (R):** which reflect non-compliance with a requirement from the IAEA Safety Standards
- **Suggestions (S):** which identify opportunities for improvement
- **Good Practices (GP):** which identify regulatory practices superior to those observed elsewhere

Analysis of the 28 IRRS missions carried out from 2015-2019 in EU Member States showed 686 Observations in 12 Subject Group Areas (405 Recommendations, 243 Suggestions and 38 Good Practices).

Subject Group Areas	Observations			
	R	S	GP	Total
Responsibilities and Functions of the Government	81	39	5	**125**
Global Nuclear Safety Regime	10	8	2	**20**
Regulatory Body Responsibilities and Functions	44	27	7	**78**
Regulatory Body Management System	34	17	6	**57**
Authorization	41	29	3	**73**
Review and Assessment	28	9	4	**41**
Inspection	22	21	0	**43**
Enforcement	8	8	0	**16**
Regulations and Guides	98	44	3	**145**
Emergency preparedness and Response	38	37	7	**82**
Interface Nuclear Safety and Security	1	0	1	**2**
Activities for Embarking on a Nuclear Power Programme	0	4	0	**4**
	405	**243**	**38**	**686**

The 12 Subject Group Areas can be sub-divided into 58 subject groups. Among these subject groups, observations were most frequently made concerning; Framework for Safety, Coordination and Cooperation among Authorities, Regulatory Body Staffing and Competence, Establishment of the Regulatory Body Management System, Development of Authorization Process, Implementation of Authorization process, Development of Inspection Programme, Spent Fuel and Radioactive Waste Management Regulations and Guides, Radiation Safety Regulations and Guides and Emergency Planning.

It should be noted that those IRRS follow-up missions that took place during the period analysed showed a closure rate for the recommendations and suggestions made during the

[110] https://www.iaea.org/services/review-missions/calendar?type=3158&year%5Bvalue%5D%5Byear%5D=&location=All&status=All

initial missions of around 86%, showing the value of the peer review approach in increasing the overall level of nuclear safety.

EU Member States and IAEA can use analysis of the mission findings to identify trends and issues affecting national frameworks and regulatory bodies. However, care needs to be taken when looking at the numbers of findings, not to lose focus on those that might be those most significant for the overall level of safety, especially at the level of individual missions. As IAEA notes on each IRRS mission report: "The number of recommendations, suggestions and good practices is in no way a measure of the status of the national infrastructure for nuclear and radiation safety. Comparisons of such numbers between IRRS reports from different countries should not be attempted."

Alongside the IRRS programme, IAEA also developed the Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS) peer review programme, which enables EU Member States to meet their peer review obligations under Article 14, paragraph 3 of Directive 2011/70/Euratom[111]. Considering the existence of some overlaps between the IAEA IRRS and the ARTEMIS peer-reviews, a review process is ongoing to explore synergies and the potential benefits of combining the two processes in a single IRRS-ARTEMIS mission, where requested by a Member State. This follows a trial combined IRRS-ARTEMIS mission in 2018. The review is carried out jointly by the IAEA and ENSREG.

3.5.2. Topical Peer-Reviews (Article 8e, paragraphs 2 and 3)

In accordance with Article 8e, paragraphs 2 and 3 of the Directive, the Topical Peer Reviews (TPRs) should allow a regular review, coordinated by the Member States, of their national assessments "based on a specific topic related to nuclear safety of the relevant nuclear installations on their territory". Further details on the organisation of the process is provided in the Directive's preamble, recital (23), according to which the Member States should define the methodology, terms of reference and the timeframe of the peer-review. Reports on the findings of the TPRs should be produced. Furthermore, Member States should establish National Action Plans (NAcPs) for addressing any relevant findings, taking into account the results of the TPR reports.

First Topical Peer Review

The first TPR, conducted in 2017-2018, covered the 'ageing management' of reactors. The peer review focused on the overall ageing management programmes and to selected systems, structures and components (reactor pressure vessels, electrical cables, concealed pipework and concrete containment structures). The scope of the review was NPPs and large research reactors (≥1 MWth).

The TPR process and organisation was described in the Terms of Reference (ToR) prepared by ENSREG, and its technical scope in the Technical Specifications (TS) developed by

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111 Council Directive 2011/70/EURATOM of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste.

WENRA. Altogether, 16 Member States with NPPs and/or research reactors participated in this TPR together with 3 non-EU countries (Norway, Switzerland, Ukraine).

The 16 Member States performed self-assessments and published the results in their National Assessment Reports, which were subject to a peer review. The generic findings were categorised to good practices and expectations ("TPR expected level of performance"). The review also highlighted challenges where further work at European level is necessary.

Both the ToR and the TS were submitted to public consultation and two stakeholder meetings were organised by ENSREG in 2018. Stakeholders were also invited to submit questions based on the national assessment reports.

A TPR Report was established and country specific findings compiled to provide input for National Action Plans and ENSREG follow-up work.

According to the TPR Report, the main finding was that Ageing Management Programmes exist in all countries for NPPs and that no major deficiencies were identified in European approaches to regulate and implement such programmes at NPPs. However, the review identified areas where further work would enhance ageing management at the NPPs and in research reactors.

ENSREG drew up an Action Plan setting out the follow-up required, both at the EU level and by individual Member States. Accordingly, Member States published their TPR NAcP by September 2019. These were to be updated by May 2021. All Member States concerned provided either an update to their TPR NAcP, or a final closure report, allowing ENSREG to adopt and publish its First Topical Peer Review Status Report [112] in November 2021, setting out the progress made in implementing both the national and EU-level actions. The next TPR NAcP updates are due by the end of 2023, followed again by an ENSREG Summary Report by May 2024.

Concerning the first TPR, as already noted, all Member States with relevant installations participated. However, the Directive is clear that "all other Member States, and the Commission as observer, are invited to peer review the national assessment". With the exception of few Member States[113] that had participated in the first TPR, the reporting of the remaining Member States without installations relevant to the first TPR was mixed; one Member State did not take part as the exercise was not compulsory for research reactors under 1MWth; several others stated that the topic/obligation was not relevant, whilst the other Member States did not mention the TPR at all.

Second Topical Peer Review

ENSREG, in line with the requirement of the Directive has already started the process for the second TPR which will take place in 2023 (National Assessment Reports) and 2024 (Peer Review Workshop), with appropriate follow-up to any findings to take place in subsequent

[112] ENSREG 1st Topical peer review status report, November 2021
[113] Ireland, Luxembourg.

years. A timetable of the fundamental stages of the second TPR can be found in the ENSREG Work Programme 2021-23[114], which also gives the remaining steps of the follow-up from the first TPR.

In a similar process to that for the first TPR, at its November 2020 plenary ENSREG has endorsed WENRA's proposal of 'fire protection' as the topic for review. ENSREG has approved the timetable of the overall TPR process, and the TPR Terms of Reference are currently being drafted, drawing on the lessons learned from the first TPR, with a view to their adoption in the first half of 2022, along with the Technical Specification. One important lesson was earlier stakeholder involvement and the first stakeholder meeting was already held in June 2021.

3.5.3. Peer-Review in case of a serious accident (Article 8e, paragraph 4)

Article 8e, paragraph 4 of the Directive also directs Member States to invite an international peer review "in case of an accident leading to situations that would require off-site emergency measures or protective measures for the general public". No such peer review was required to date.

[114] HLG-p(2021-42)_169 ENSREG Work Programme 2021-2023

Annex 1 – Summary of information on nuclear installations in the EU

The information on the nuclear installations included in the tables below relies primarily on the national reports submitted by the Member States in 2020 (as at reporting date of July 2020, unless otherwise stated).

Table 1. Countries with nuclear power plants, and their status

Country	Site/reactor unit	Power reactor type	Capacity MWe	Status	Associated on-site facilities
Belgium	Doel 1	PWR	3000	Operational	Spent fuel storage
	Doel 2	PWR		Operational	
	Doel 3	PWR		Operational	
	Doel 4	PWR		Operational	
	Tihange 1	PWR	3000	Operational	Spent fuel storage
	Tihange 2	PWR		Operational	
	Tihange 3	PWR		Operational	
Bulgaria	Kozloduy unit 5	PWR	1000	Operational	Spent fuel storage; radioactive waste storage facilities
	Kozloduy unit 6	PWR	1000	Operational	
	Kozloduy unit 1	PWR	440	Decommissioning	
	Kozloduy unit 2	PWR	440	Decommissioning	
	Kozloduy unit 3	PWR	440	Decommissioning	
	Kozloduy unit 4	PWR	440	Decommissioning	
Czech Republic	Dukovany 1	PWR (VVER 440/213)	468	Operational	Spent fuel storage radioactive waste disposal facilities
	Dukovany 2	PWR (VVER 440/213)	471	Operational	
	Dukovany 3	PWR (VVER 440/213)	468	Operational	
	Dukovany 4	PWR (VVER 440/213)	471	Operational	
	Temelin 1	PWR (VVER 1000/320)	1027	Operational	Spent fuel storage
	Temelin 2	(PWR) VVER 1000/320	1029	Operational	
Finland	Loviisa 1	(PWR) VVER V-213	507	Operational	Spent fuel storage; radioactive waste disposal facilities
	Loviisa 2	(PWR) VVER V-213	507	Operational	
	Olkiluoto 1	BWR	890	Operational	Spent fuel storage; radioactive waste disposal facilities
	Olkiluoto 2	BWR	890	Operational	
	Olkiluoto 3	PWR/EPR	1600	Commissioning	
	Hanhikivi 1	PWR VVER-1200	1200	Pre-licensing	
France	Belleville 1	PWR-1300	1300	Operational	Spent fuel storage
	Belleville 2	PWR-1300	1300	Operational	Spent fuel storage
	Blayais 1	PWR-900	900	Operational	Spent fuel storage

	Blayais 2	PWR-900	900	Operational	Spent fuel storage
	Blayais 3	PWR-900	900	Operational	Spent fuel storage
	Blayais 4	PWR-900	900	Operational	Spent fuel storage
	Bugey 2	PWR-900	900	Operational	Spent fuel storage
	Bugey 3	PWR-900	900	Operational	Spent fuel storage
	Bugey 4	PWR-900	900	Operational	Spent fuel storage
	Bugey 5	PWR-900	900	Operational	Spent fuel storage
	Cattenom 1	PWR-1300	1300	Operational	Spent fuel storage
	Cattenom 2	PWR-1300	1300	Operational	Spent fuel storage
	Cattenom 3	PWR-1300	1300	Operational	Spent fuel storage
	Cattenom 4	PWR-1300	1300	Operational	Spent fuel storage
	Chinon B1	PWR-900	900	Operational	Spent fuel storage
	Chinon B2	PWR-900	900	Operational	Spent fuel storage
	Chinon B3	PWR-900	900	Operational	Spent fuel storage
	Chinon B4	PWR-900	900	Operational	Spent fuel storage
	Chooz B1	PWR-1500	1450	Operational	Spent fuel storage
	Chooz B2	PWR-1500	1450	Operational	Spent fuel storage
	Civaux 1	PWR-1500	1450	Operational	Spent fuel storage
	Civaux 2	PWR-1500	1450	Operational	Spent fuel storage
	Cruas 1	PWR-900	900	Operational	Spent fuel storage
	Cruas 2	PWR-900	900	Operational	Spent fuel storage
	Cruas 3	PWR-900	900	Operational	Spent fuel storage
	Cruas 4	PWR-900	900	Operational	Spent fuel storage
	Dampierre 1	PWR-900	900	Operational	Spent fuel storage
	Dampierre 2	PWR-900	900	Operational	Spent fuel storage
	Dampierre 3	PWR-900	900	Operational	Spent fuel storage
	Dampierre 4	PWR-900	900	Operational	Spent fuel storage
	Flamanville 1	PWR-1300	1300	Operational	Spent fuel storage
	Flamanville 2	PWR-1300	1300	Operational	Spent fuel storage
	Flamanville 3	PWR-EPR	1600	Construction	
	Golfech 1	PWR-1300	1300	Operational	Spent fuel storage
	Golfech 2	PWR-1300	1300	Operational	Spent fuel

					storage
	Gravelines 1	PWR-900	900	Operational	Spent fuel storage
	Gravelines 2	PWR-900	900	Operational	Spent fuel storage
	Gravelines 3	PWR-900	900	Operational	Spent fuel storage
	Gravelines 4	PWR-900	900	Operational	Spent fuel storage
	Gravelines 5	PWR-900	900	Operational	Spent fuel storage
	Gravelines 6	PWR-900	900	Operational	Spent fuel storage
	Nogent 1	PWR-1300	1300	Operational	Spent fuel storage
	Nogent 2	PWR-1300	1300	Operational	Spent fuel storage
	Paluel 1	PWR-1300	1300	Operational	Spent fuel storage
	Paluel 2	PWR-1300	1300	Operational	Spent fuel storage
	Paluel 3	PWR-1300	1300	Operational	Spent fuel storage
	Paluel 4	PWR-1300	1300	Operational	Spent fuel storage
	Penly 1	PWR-1300	1300	Operational	Spent fuel storage
	Penly 2	PWR-1300	1300	Operational	Spent fuel storage
	St. Alban 1	PWR-1300	1300	Operational	Spent fuel storage
	St. Alban 2	PWR-1300	1300	Operational	Spent fuel storage
	St. Laurent B1	PWR-900	900	Operational	Spent fuel storage
	St. Laurent B2	PWR-900	900	Operational	Spent fuel storage
	Tricastin 1	PWR-900	900	Operational	Spent fuel storage
	Tricastin 2	PWR-900	900	Operational	Spent fuel storage
	Tricastin 3	PWR-900	900	Operational	Spent fuel storage
	Tricastin 4	PWR-900	900	Operational	Spent fuel storage
	Fessenheim 1	PWR	880	Shutdown	
	Fessenheim 2	PWR	880	Shutdown	
	Chooz A, INB 163	PWR	305	Decommissioning	
	Bugey 1, INB 45	UNGG	540	Decommissioning	
	St Laurent A1, INB 46	UNGG	390	Decommissioning	
	St Laurent A2, INB 46	UNGG	465	Decommissioning	
	Chinon A1, INB 133	UNGG	70	Decommissioning	
	Chinon A2, INB 153	UNGG	180	Decommissioning	
	Chinon A3, INB161	UNGG	360	Decommissioning	
	Brennilis EL4, INB 162	HWGCR	70	Decommissioning	
	Superphénix, INB	FBR	1200	Decommissioning	

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Germany	Grohnde	PWR	1 430	Operational	Spent fuel storage
	Gundremmingen-C	BWR	1 344	Operational	Spent fuel storage
	Brokdorf	PWR	1 480	Operational	Spent fuel storage
	Isar-2	PWR	1 485	Operational	Spent fuel storage
	Emsland	PWR	1 406	Operational	Spent fuel storage
	Neckarwestheim-2	PWR	1 400	Operational	Spent fuel storage
	Krümmel	BWR	1 402	Shutdown	Spent fuel storage
	Philippsburg-2	PWR	1 468	Decommissioning	Spent fuel storage
	Gundremmingen-B	BWR	1 344	Decommissioning	Spent fuel storage
	Brunsbüttel	BWR	806	Decommissioning	Spent fuel storage
	Grafenrheinfeld	PWR	1 345	Decommissioning	Spent fuel storage
	Lower Weser	PWR	1 410	Decommissioning	Spent fuel storage
	Philippsburg-1	BWR	926	Decommissioning	Spent fuel storage
	Biblis-B	PWR	1 300	Decommissioning	Spent fuel storage
	Biblis-A	PWR	1 225	Decommissioning	Spent fuel storage
	Neckarwestheim-1	PWR	840	Decommissioning	Spent fuel storage
	Isar-1	BWR	912	Decommissioning	Spent fuel storage
	Lingen	BWR	268	Decommissioning	Spent fuel storage
	Gundremmingen-A	BWR	250	Decommissioning	Spent fuel storage
	Multipurpose research reactor	PWR (D_2O)	57	Decommissioning	
	Mülheim-Kärlich	PWR	1 302	Decommissioning	
	THTR-300[1]	HTR	308	Decommissioning	
	AVR	HTR	15	Decommissioning	
	Greifswald-5	WWER	440	Decommissioning	
	Greifswald-2	WWER	440	Decommissioning	
	Greifswald-3	WWER	440	Decommissioning	
	Rheinsberg	WWER	70	Decommissioning	
	Greifswald-4	WWER	440	Decommissioning	
	Greifswald-1	WWER	440	Decommissioning	
	Compact sodium-cooled nuclear installation	SNR	21	Decommissioning	
	Würgassen	BWR	670	Decommissioning	

	Stade	PWR	672	Decommissioning	
	Obrigheim	PWR	357	Decommissioning	
Hungary	Paks unit 1	PWR/ VVER-440/V-213	509	Operational	Spent fuel storage
	Paks unit 2	PWR/ VVER-440/V-213	504	Operational	
	Paks unit 3	PWR/ VVER-440/V-213	500	Operational	
	Paks unit 4	PWR/ VVER-440/V-213	500	Operational	
	Paks II (2 units)	PWR/ VVER-1200	1200	Prelicensing	
Italy	Caorso	BWR	870	Decommissioning	Radioactive waste storage
	Garigliano	BWR	160	Decommissioning	Radioactive waste storage
	Latina	Gas Graphite	160	Decommissioning	Radioactive waste storage
	Trino	PWR	272	Decommissioning	Radioactive waste storage
Lithuania	Ignalina unit 1	LWGR	1185	Decommissioning	Spent fuel storage; radioactive waste storage facilities
	Ignalina unit 2	LWGR	1185	Decommissioning	
Netherlands	Borssele	PWR	485	Operational	
	Dodewaard	BWR	55	Shutdown	
Romania	Cernavoda 1	PHWR	707	Operational	Spent fuel storage; radioactive waste storage facilities
	Cernavoda 2	PHWR	707	Operational	
Slovakia	Bohunice 3	PWR/ VVER-440/V213	505	Operational	Spent fuel storage; radioactive waste storage facilities
	Bohunice 4	PWR/ VVER-440/V213	505	Operational	
	Mochovce 1	PWR/ VVER-440/V213	470	Operational	Radioactive waste storage
	Mochovce 2	PWR/ VVER-440/V213	470	Operational	
	Mochovce 3	PWR/ VVER-440/V213	440	Construction	
	Mochovce 4	PWR/ VVER-440/V213	440	Construction	
	Bohunice V-1	VVER-440/230	143	Decommissioning	
	Bohunice A-1	HWGCR	560	Decommissioning	
Slovenia	Krško	PWR	696	Operational	
Spain	Trillo 1	PWR		Operational	Spent fuel storage
	Almaraz 1	PWR		Operational	Spent fuel storage
	Almaraz 2	PWR		Operational	

	Ascó 1	PWR	7394	Operational	Spent fuel storage
	Ascó 2	PWR		Operational	
	Cofrentes	BWR		Operational	
	Vandellos 2	PWR		Operational	
	José Cabrera	PWR	141	Decommissioning	Spent fuel storage
	Vandellos 1	PWR	480	Decommissioning	
	Santa María de Garoña	BWR	446	Shutdown	Spent fuel storage
Sweden	Forsmark 1	BWR	990	Operational	Radioactive waste storage
	Forsmark 2	BWR	1118	Operational	
	Forsmark 3	BWR	1172	Operational	
	Oskarshamn 3	BWR	1400	Operational	
	Ringhals 1	PWR	750	Shutdown (Dec2020)	
	Ringhals 3	PWR	1072	Operational	
	Ringhals 4	PWR	1117	Operational	
	Ågesta	PHWR	10	Decommissioning	
	Barsebäck 1	BWR	600	Decommissioning	
	Barsebäck 2	BWR	600	Decommissioning	
	Oskarshamn 1	BWR	473	Decommissioning	
	Oskarshamn 2	BWR	638	Decommissioning	
	Ringhals 2	PWR	852	Decommissioning	
United Kingdom	Dungeness B 1	AGR	615	Operating	Spent fuel storage
	Dungeness B 2	AGR	615	Operating	Spent fuel storage
	Hartlepool 1	AGR	655	Operating	Spent fuel storage
	Hartlepool 2	AGR	655	Operating	Spent fuel storage
	Heysham 1-1	AGR	625	Operating	Spent fuel storage
	Heysham 1-2	AGR	625	Operating	Spent fuel storage
	Heysham 2-1	AGR	680	Operating	Spent fuel storage
	Heysham 2-2	AGR	680	Operating	Spent fuel storage
	Hinkley Point B 1	AGR	655	Operating	Spent fuel storage
	Hinkley Point B 2	AGR	655	Operating	Spent fuel storage
	Hunterston B 1	AGR	644	Operating	Spent fuel storage
	Hunterston B 2	AGR	644	Operating	Spent fuel storage
	Torness 1	AGR	682	Operating	Spent fuel storage
	Torness 2	AGR	682	Operating	Spent fuel storage
	Sizewell B	PWR	1250	Operating	Spent fuel storage
	Hinkley Point C 1	PWR-EPR	1630	Construction	
	Hinkley Point C 1	PWR-EPR	1630	Construction	
	Berkeley 1	Magnox	138	Decommissioning	
	Berkeley 2	Magnox	138	Decommissioning	
	Bradwell 1	Magnox	123	Decommissioning	
	Bradwell 2	Magnox	123	Decommissioning	
	Calder Hall 1	Magnox	49	Defuelled	
	Calder Hall 2	Magnox	49	Defuelled	

	Calder Hall 3	Magnox	49	Defuelled	
	Calder Hall 4	Magnox	49	Defuelled	
	Chapelcross 1	Magnox	48	Decommissioning	
	Chapelcross 2	Magnox	48	Decommissioning	
	Dungeness A1	Magnox	225	Decommissioning	
	Dungeness A2	Magnox	225	Decommissioning	
	Hinkley Point A 1	Magnox	235	Decommissioning	
	Hinkley Point A 2	Magnox	235	Decommissioning	
	Hunterston A 1	Magnox	150	Decommissioning	
	Hunterston A 2	Magnox	150	Decommissioning	
	Oldbury 1	Magnox	217	Defuelling	
	Oldbury 2	Magnox	217	Defuelling	
	Sizewell A 1	Magnox	210	Defuelling	
	Sizewell A 2	Magnox	210	Defuelling	
	Trawsfynydd 1	Magnox	195	Decommissioning	
	Trawsfynydd 2	Magnox	195	Decommissioning	
	Wylfa 1	Magnox	490	Permanently shutdown	
	Wylfa 2	Magnox	490	Permanently shutdown	
	Dounreay	PFR	234	Decommissioning	
	Dounreay	DFR	11	Decommissioning	

Table 2. Central spent fuel storage facilities

Country	Facility type	Name/site	Status
Belgium	Central waste storage/treatment[115]	Belgoprocess site	Operational
Czech Republic	Spent fuel storage/radioactive waste storage	Řež site	Operational
France	Spent fuel storage	La Hague	Operational
Germany	Ahaus interim fuel storage facility (BZA)		Operational
	Interim fuel storage facility Gorleben (BZG)		Operational
	Interim fuel storage facility North (ZLN) Rubenow		Operational
Hungary	Interim Spent Fuel Storage Facility (ISFS)	Paks	Operational
Italy	Deposito Avogadro		Operational
	OPEC 1		Operational
	Fuel Pit Wells Storage Facility		Operational
Netherlands	HABOG facility		Operational
Slovakia	ISFS Jaslovské Bohunice		Operational
Sweden	CLAB interim storage spent nuclear fuel	Oskarshamn	Operational

Table 3. Research Reactor facilities

Country	**Name/site**	**Power(th)**	**Status**
Austria	Triga Mark II	250 kW	Operational
Belgium	Venus/Guinevere	500 kW	Operational
	BR1	2 MW	Operational

115 Very limited quantities of spent nuclear fuel from two Belgian research reactors that have been dismantled (BR3 and Thetis) are stored here.

Country	Name/site	Power(th)	Status
	BR2	120 MW	Operational
	BR3		Decommissioning
Czech Republic	LVR-15	10 MW	Operational
	LR-0	-	Operational
	ČVUT, Praha	1 kW	Operational
Denmark	Danish Reactor 2 (DR 2)	5MW	Decommissioned
	Danish Reactor 3 (DR 3)	10MW	Decommissioning
	Hot Cell facility		Decommissioning
Finland	FiR1, Triga Mark II	250 kW	Decommissioning
France	CABRI Test reactor (Cadarache), INB 24	25 MW	Operational
	High Flux Reactor (HFR), INB 67	57 MW	Operational
	Jules Horowitz (RJH), INB 172	100 MW	Under construction
	ITER International fusion reactor project, INB 174		Under construction
	Phénix, INB 71, Marcoule (CEA)		Shutdown/decommissioning
	Rapsodie, INB 25, Cadarache (CEA)		Shutdown/decommissioning
	Masurca, INB 39, Cadarache (CEA)		Shutdown/decommissioning
	ÉOLE, INB 42, Cadarache (CEA)		Shutdown/decommissioning
	Phébus, INB 92, Cadarache (CEA)		Shutdown/decommissioning
	Minerve, INB 95, Cadarache (CEA)		Shutdown/decommissioning
	Ulysse, INB 18, Saclay (CEA)		Shutdown/decommissioning
	Osiris, INB 40, Saclay (CEA)		Shutdown/decommissioning
	Orphée, INB 101, Saclay (CEA)		Shutdown/decommissioning
Germany	SUR Stuttgart (SUR S)	10^{-7} MW	Operational
	Research reactor Mainz (FRMZ)	0.1 MW	Operational
	SUR Ulm (SUR U)	10^{-7} MW	Operational
	SUR Furtwangen (SUR FW) Furtwangen (SUR FW)	10^{-7} MW	Operational
	Training reactor (AKR-2)	2 x 10^{-6} MW	Operational
	High flux neutron source Munich/Garching (FRM-II)	20 MW	Operational
	Berliner Experimentier-Reaktor II (BER-II)	10 MW	Shutdown
	Geesthacht 1 (FRG-1)	5 MW	Shutdown
	Geesthacht 2 (FRG-2)	15 MW	Shutdown
	SUR Aachen (SUR AA)	10^{-7} MW	Shutdown
	Research Reactor Munich (FRM)	4 MW	Decommissioning
	Research Reactor 2 (FR-2)	44 MW	Decommissioning
	DIDO (FRJ-2)	23 MW	Decommissioning
	Research and Measuring Reactor Braunschweig (FRMB)	1 MW	Decommissioning
	Research Reactor Neuherberg (FRN)	1 MW	Decommissioning
Greece	GRR-1	5 MW	Shutdown
Hungary	Budapest Research Reactor	10MW	Operational

Country	Name/site	Power(th)	Status
	Training reactor of the Budapest University of Technology and Economics	100kW	Operational
Italy	AGN 201 Constanza	0.02 kW	Operational
	Triga Mark II Lena Pavia	250 kW	Operational
	RSV Tapiro	5 kW	Operational
	SM-1	0	Operational
	Triga RC-1	1000 kW	Operational
	RB-3	0.1 kW	Decommissioning
	Ispra-1	5000 kW	Shutdown
	Essor	25000 kW	Shutdown
	L-54M Cesnef	50 kW	Shutdown
Latvia	Salaspils	2 - 5 MW	Decommissioning
Netherlands	HFR Petten	45 MW	Operational
	Technical University Delft HOR	2 MW	Operational
Poland	Maria	30 MW	Operational
	Eva	10 MW	Decommissioning
Portugal	RPI	1 MW	Decommissioning
Romania	Triga	14 MW	Operational
	VVR-S	2 MW	Decommissioning
Slovenia	TRIGA Mark II	250 kW	Operational
Sweden	R2	50MW	Decommissioning
	R2-0	1MW	Decommissioning
United Kingdom	BEPO Harwell		Decommissioning
	PLUTO Harwell		Decommissioning
	DIDO Harwell		Decommissioning
	SGHWR Winfrith		Decommissioning
	Dragon Winfrith		Decommissioning
	Consort II Imperial College		Decommissioning
	PFR, Dounreay		Permanent shutdown
	DFR, Dounreay		Permanent shutdown

Table 4. Fuel cycle installations (enrichment, fuel fabrication, reprocessing plants) and other facilities

Country	Name/site	Facility type	Status
Belgium	Belgonucleaire - MOX manufacturing plant, Dessel	Fuel fabrication	Decommissioning
	FBFC UO2 manufacturing, Dessel	Fuel fabrication	Decommissioning
Denmark	Fuel fabrication plant for DR2, DR3	Fuel fabrication	Decommissioning
France	Georges Besse 2, Pierrelatte, INB 168	Enrichment/processing of radioactive substances	Operational
	TU5 installation, Pierrelatte, INB 155	Radioactive substance processing	Operational
	Fuel fabrication plant, Romans-sur-Isère, INB 63	Fuel Fabrication plant	Operational
	Nuclear fuel fabrication unit, Romans-sur-Isère, INB 98	Fuel Fabrication plant	Operational
	Nuclear fuel fabrication plant, Melox, INB 151	Fuel Fabrication plant	Operational
	UP3 A, La Hague,	Reprocessing plant	Operational

Country	Name/site	Facility type	Status
	INB 116		
	UP2 800, La Hague, INB 117	Reprocessing plant	Operational
	STE3, La Hague, INB 118	Processing of radioactive materials	Operational
	Tanks B1 and B2, Malvési, INB 175	Conversion/packing storage of radioactive materials	Operational
	Installation for the Purification and Recovery of Uranium (IARU), Tricastin, INB 138	Factory	Operational
	AREVA Tricastin Analysis Laboratories (ATLAS), Tricastin, INB 176	Laboratory for the use of radioactive materials	Operational
	Tricastin Uranium Fleet, Tricastin, INB 178	Storage of radioactive materials	Operational
	P35, Tricastin, INB 179	Storage of radioactive materials	Operational
	La Hague (Orano Cycle) INB 33, INB 38, INB 47, INB 80	Spent fuel treatment/other	Shutdown/decommissioning
	Fontenay-aux-Roses (CEA) INB 165, INB 166	Laboratories/other	Shutdown/decommissioning
	Saclay (CEA) INB 49	Laboratories/research facilities	Shutdown/decommissioning
	Chinon (EDF) INB 94	Irradiated materials workshop	Shutdown/decommissioning
	Cadarache (CEA) INB 32 - ATPu INB 37B - STE INB 52- ATUE INB 53- MCMF INB 54 – LCP INB 56 -	Workshop; Effluent treatment station; Enriched uranium workshop; Radioactive substances depot; Laboratory; Storage of radioactive substances;	Shutdown/decommissioning
	Grenoble (CEA) INB 36 – STED INB 79 - Unité d'entreposage de déchets de haute activité	Transformation of radioactive substances; Storage of radioactive substances	Shutdown/decommissioning
	Tricastin (Orano Cycle) INB 105 – Comurhex INB 93 – Usine Georges Besse	Transformation of radioactive substances; Transformation of radioactive substances	Shutdown/decommissioning
Germany	URENCO uranium enrichment plant Gronau (UAG)	Uranium enrichment	Operational
	ANF fuel element production Lingen	Production of LWR fuel with low-enriched uranium dioxide	Operational
	WAK reprocessing plant Karlsruhe incl. VEK vitrification	Reprocessing plant	Decommissioning

Country	Name/site	Facility type	Status
	facility		
Italy	FN Bosco Marengo	Fuel fabrication plant	Decommissioning
	Eurex	Reprocessing	Decommissioning
	Itrec	Reprocessing	Decommissioning
Netherlands	Urenco, Almelo	Enrichment plant	Operational
Romania	Pitesti	Fuel fabrication plant, radioactive waste storage	
Spain	Juzbado	Fuel fabrication plant, radioactive waste storage	Operational
Sweden	Westinghouse, Västerås	Fuel fabrication plant	Operational
United Kingdom	Capenhurst	Fuel enrichment plant	Operational
	Springfields	Magnox fuel production plant	Decommissioning
	Springfields	Oxide fuel production plant	Operational
	Sellafield -Magnox fuel reprocessing plant	Reprocessing	Operational
	Sellafield – Oxide fuel reprocessing plant	Reprocessing	Operational
	Dounreay FCA	Reprocessing	Decommissioning