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**REPORT FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN
PARLIAMENT**

**on progress of implementation of Council Directive 2011/70/EURATOM and an
inventory of radioactive waste and spent fuel present in the Community's territory and
the future prospects**

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1. INTRODUCTION

Under Article 14(2) of the Directive 2011/70/Euratom¹ (hereinafter 'the Directive'), the Commission is required to submit to the European Parliament and Council, every three years, a report on progress made on the implementation of this Directive and an inventory of radioactive waste and spent fuel present in the Community's territory, including future prospects. This is the first time the Commission is in a position to provide a comprehensive overview to the European Union (EU) citizens on this important issue. Although the progress reported by the Member States is not always fully comprehensive and comparable, this report nevertheless provides a clear picture of the current situation and highlights areas where further improvements and attention are required.

All Member States generate radioactive waste, and 21 of them also manage spent fuel on their territory. Owing to its radiological properties and the potential hazard it poses to workers and the general public, it is important to ensure the safe management of such material from generation to disposal. This requires containment and isolation from humans and the living environment over a long period of time. By adopting and transposing the Directive, Member States have acknowledged their legal and ethical obligation to ensure a high level of safety when managing these materials and to avoid undue burdens on future generations.

Radioactive waste is radioactive material in gaseous, liquid or solid form for which no further use is foreseen or considered, and which has been classified as radioactive waste. Its generation is associated with the production of electricity in nuclear power plants or with non-power-related uses of radioactive materials for medical, research, industrial and agricultural purposes. Based on its radiological properties and potential hazards, radioactive waste is generally classified as 'very low level waste', 'low level waste', 'intermediate level waste' or 'high level waste'.² In the EU, almost 90 % of radioactive waste is classified as 'very low level waste' or 'low level waste'.

Spent fuel is nuclear fuel that has been permanently removed from a reactor core following irradiation that is no longer usable in its present form. It is generated by the operation of nuclear reactors for power generation, research, training and demonstration. In order to manage spent fuel, Member States can choose to either recover part of the material by reprocessing it – the remaining material being high level waste to be disposed – or to dispose the spent fuel directly, meaning it would be reclassified as high level waste. This explains why the management of this material should be addressed jointly with the management of radioactive waste.

Each Member State is free to define its own energy mix. At the time of Member States reporting, there were 129 nuclear power reactors in operation in 14 Member States,³ with a

¹ 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.

² Moreover, based on the half-life of the material (time required to reduce the radioactivity by half), it is also generally categorised as 'very-short lived' (about 100 days), 'short-lived' (less than 30 years) and 'long-lived' (more than 30 years).

³ Belgium, Bulgaria, the Czech Republic, Finland, France, Germany, Hungary, the Netherlands, Ro-

total capacity of about 120 GWe and an average operating time of 30 years. As estimated in the Nuclear Illustrative Programme (PINIC),⁴ more than 50 of the reactors currently in operation in the EU are to be shut down by 2025, while new build projects are envisaged in ten Member States, with four reactors under construction in Finland, France and Slovakia. This will lead to the generation of additional radioactive waste and spent fuel that will need to be safely and responsibly managed beyond this century.

The adoption of the Directive was a major step towards achieving a comprehensive and legally binding framework at EU level for the safe and responsible management of spent fuel and radioactive waste. The Directive's aim is to:

- ensure that workers and the general public are protected against dangers arising from ionising radiation now and in the future. This goes beyond national borders;
- implement the highest safety standards for radioactive waste and spent fuel management and avoid imposing undue burdens on future generations;
- achieve commitment from the Member States to implement sustainable and timely solutions for the management of spent fuel and radioactive waste, including in the long term with passive safety features;
- ensure translation of political decisions into clear actions (i.e. policies and programmes, specific projects and the construction of facilities) for the implementation of all steps of radioactive waste and spent fuel management;
- maintain continued improvement of the management system with priority to safety, based on step-by-step decision-taking, transparency and public involvement;
- ensure adequate and transparently managed financial resources, available when needed, in accordance with the principle that those who generate radioactive waste or spent fuel bear the costs of their management.

In order to achieve these objectives, the Directive requires Member States to put in place:

- **national policies**, which broadly describe the approach Member States are taking for all steps of radioactive waste and spent fuel management;
- **national programmes**, which translate the national policies into concrete plans of action, in order to ensure progress is made, and to enable monitoring thereof;

mania, Spain, Sweden, Slovenia, Slovakia, and the UK (Lithuania and Italy have shut down their reactors).

⁴ Communication from the Commission Nuclear Illustrative Programme presented under Article 40 of the Euratom Treaty – Final (after opinion of the European Economic and Social Committee) {COM(2017)237}.

- **national legislative, regulatory and organisational frameworks** (‘national frameworks’), that put in place the required framework to enable the implementation of the national policies and programmes decided upon and clearly attribute responsibilities.

Member States were required to transpose the Directive, including the national policies and national frameworks, by 23 August 2013. To enable specific planning, Member States were given two additional years to put in place the national programmes, with a deadline of 23 August 2015. By the same time, Member States were required to provide national reports on the overall implementation of the Directive, covering their national policies, frameworks and programmes for spent fuel and radioactive waste management.

This first report is based on all Member States’ national reports. It also takes into account the national policies, frameworks and programmes notified to the Commission to date,^{5,6} and the 2014 Joint Convention⁷ reports which were notified to the Commission.

It should be noted that, as provided by Article 13(2) of the Directive, the Commission has requested clarifications to Member States and may express its opinion on whether the content of the individual national programmes is in accordance with Article 12 of the Directive.

2. INVENTORY ESTIMATES AND FUTURE PERSPECTIVES

The Directive requires Member States to report to the Commission their inventory of all radioactive waste and spent fuel, clearly indicating the location and amount in accordance with an appropriate classification. Moreover, Member States’ reports should include estimates of future quantities, including those from decommissioning, and they should provide an update of their inventory and projections every three years. On the basis of the information provided by the Member States, the Commission is required to submit an inventory of radioactive waste and spent fuel present in the Community’s territory to the European Parliament and the Council. While the EU inventory is attached as a Staff Working Document to this report, a summary is also provided in Table 1 and Figure 1.

⁵ As all Member States have now declared full transposition, the Commission is in dialogue with them to clarify questions and finalise its assessment.

⁶ The report is based on the information available in all Member States reports, the final national programmes of 22 Member States that were notified as of 30 September 2016 (Belgium, Bulgaria, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Lithuania, Luxembourg, Malta, The Netherlands, Poland, Romania, Slovakia, Slovenia, Spain, Sweden, and the UK) and the draft national programmes of 5 Member States (Austria, Croatia, the Czech Republic, Italy, and Portugal).

⁷ Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (INFCIRC/546, 24 December 1997)

Waste category	Total amount (m ³)			
	2004	2007	2010	2013
VLLW	210 000	280 000	414 000	516 000
LLW	2 228 000	2 435 000	2 356 000	2 453 000
ILW	206 000	288 000	321 000	338 000
HLW	5 000	4 000	5 000	6 000

	Total amount (tHM)			
Spent Fuel	38 100	44 900	53 300	54 300

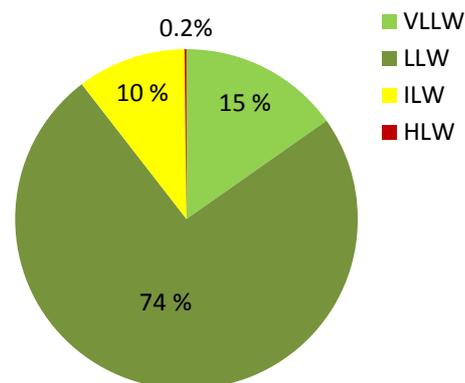


Table 1. Evolution of total volumes of radioactive waste and spent fuel in the period 2004-2013⁸

Figure 1. Radioactive waste category distribution (end of 2013)

The estimated total inventory of radioactive waste on the EU territory is 3 313 000 m³, of which about 70 % has been disposed of (2 316 000 m³) and about 30 % is in storage (997 000 m³). The main composition of the total volume of radioactive waste is 74 % low level waste (LLW), 15 % very low level waste (VLLW), 10 % intermediate level waste (ILW) and 0.2 % high level waste (HLW) (see Figure 1).⁹ ILW and HLW are generated and stored across the EU predominantly in the Member States with nuclear programmes.¹⁰

At the end of 2013¹¹ over 54 000 tHM of spent fuel was stored in the EU. Around 800 tHM of spent fuel — about 1.5 % of the total inventory — was stored in a third country pending reprocessing with the expected resulting material to be returned to the EU after 2017.

All spent fuel present in the EU is currently in storage, as no civil disposal facility for spent fuel is currently in operation worldwide. Although historical and current practice in certain Member States is to reprocess spent fuel, the majority of Member States operating nuclear power plants intend to dispose of their spent fuel in deep geological facilities without

⁸ The Commission estimates for 2004, 2007 and 2010 are based on the information from the 6th and 7th Situation reports (for details see SWD (2017)161 of Radioactive Waste and Spent Fuel Present in the Community's Territory and the Future Prospects). Figures in the table have been rounded up (e.g. to the nearest thousand).

⁹ The IAEA General Safety Guide GSG Classification system also defines exempted waste (waste with concentrations of radionuclides small enough to not require provisions of radiation protections) and very short lived waste (waste containing only very short half-life radionuclides allowing it to be stored until it has fallen beneath levels of clearance and managed as conventional waste). These do not require future long-term management or disposal as radioactive waste owing to their short lifetime and/or activity levels enabling exemption from regulatory control. Consequently, exempt waste and very short lived waste are in most cases not reported by Member States. Thus, these waste classes have not been used for data aggregation in this document.

¹⁰ For the purposes of this report, Member States with a nuclear programme are considered to be Belgium, Bulgaria, the Czech Republic, Finland, France, Germany, Hungary, the Netherlands, Romania, Spain, Sweden, Slovenia, Slovakia, and the UK. Lithuania and Italy are also considered to be part of this category as they have shut down the nuclear reactors on their territory and do manage spent fuel.

¹¹ The cut-off date for most data is end 2013 in order to reduce reporting burden on the Member States and facilitate joint reporting with the Joint Convention. A few Member States have provided more recent figures.

reprocessing in the future. This is expected to lead to an increase in the volume of high level waste for storage and disposal. Considering the planned shutdown of the reprocessing facilities in the United Kingdom by 2020 and the implications of Brexit, after 2020 France will be the only Member State with an industrial policy on reprocessing domestically, while some other Member States are reprocessing fuel abroad and are considering doing so in the future.

It should be noted that most Member States have historically developed their own classification systems while a few Member States with no nuclear programmes instead apply the International Atomic Energy Agency (IAEA) General Safety Guide GSG-1¹². In order to estimate the current EU inventory, the Commission chose to translate Member States' data into a common classification based on the IAEA standard.

In addition, as can be seen in the Staff Working Document on the EU Inventory (SWD(2017)161), projections of radioactive waste inventories in Member States differ in the level of detail and time frames provided and several Member States have not provided any or sufficiently detailed estimates of their future inventory of spent fuel and/or radioactive waste, particularly regarding new builds and decommissioning. Therefore, it was not possible for the Commission to forecast future total EU inventories.

Decommissioning of nuclear power plants will become an increasingly important activity for the European nuclear industry in the coming years due to the ageing of the reactor fleet, and investments are also needed to replace existing nuclear plants as was demonstrated in the PINC. This will have an important impact on the amounts of radioactive waste generated, especially very low level waste and low level waste, and should thus, need to be taken into account when planning disposal and storage facilities. For intermediate level waste and high level waste, safe and responsible management is challenging in terms of the availability of sufficient long-term storage capacity and the development of sustainable disposal solutions.

The development of a comprehensive and up-to-date Member State's inventory is the basis for national programming, cost estimation and related concepts and plans for the safe and responsible management of spent fuel and radioactive waste. Currently, the estimation and presentation of a reliable EU wide inventory is challenging as most Member States use their own classification systems and a harmonised approach is not addressed explicitly in the Directive. In addition, a number of Member States have not reported on all types of radioactive waste, particularly radioactive waste originating from decommissioning and new builds, future forecasts and institutional waste. Therefore, in the next reporting cycle (i.e. in 2018) under Article 14(1) of the Directive, the Commission intends to support the Member States in (i) further improving reporting of radioactive waste inventory data, providing e.g. a clear definition of the different sources of radioactive waste and their origins; and (ii) carrying out additional work on detailed and reliable projections.

¹² 'Classification of Radioactive Waste', General Safety Guide, IAEA, Vienna, 2009.

3. NATIONAL POLICIES AND PROGRAMMES: FROM POLITICAL DECISIONS TO CONCRETE ACTIONS

The development of a national policy is essential for the long-term safe management of spent fuel and radioactive waste. It should set out in broad terms the Member States' planned approach to managing their radioactive waste and spent fuel inventory from generation to disposal, and should be in line with the principles identified in Article 4 of the Directive. National policies should be translated into concrete plans of actions in the Member States' national programmes.

3.1 National policies

All but one Member State have reported to the Commission their national policies either in stand-alone documents or reflected in their national framework and/or their national programmes.

Most Member States have established clear **ultimate responsibility** of the State for spent fuel and radioactive waste management in line with Article 4(1) of the Directive. However, in most cases limited information on the practical implementation of this responsibility has been provided and about a third of Member States have not addressed this aspect in their reports.

Member States' policies are largely in line with the principles stated in Article 4(3) of the Directive. In general, Member States require in their legislation that these principles are adhered to in their policies. However, **only about a third of the Member States' policies are comprehensive** from the perspective of addressing all types of radioactive waste and spent fuel, as well as all stages of their management. Overall, the principles of waste minimisation and safety demonstration are better addressed than the principles of applying a graded approach, implementing passive safety features for long-term safety and taking account of interdependencies between spent fuel and radioactive waste management steps.

The majority of Member States acknowledge their **responsibility to dispose** of radioactive waste generated on their territory in line with Article 4 of the Directive, and no Member States have currently notified to the Commission agreements for the use of disposal facilities in third countries. The majority of Member States have legal requirements in place and, in line with Article 4(2) of the Directive, they report on shipments of radioactive waste for processing and/or spent fuel for reprocessing abroad. They recognise that responsibility for the disposal of the materials resulting from processing and reprocessing remains with the Member States from which the radioactive material was generated.¹³

The most important outstanding issue in a large number of Member States with regard to national policies is the decision on the long-term management of intermediate level waste, high level waste and spent fuel, and specifically their disposal.^{14,15} Moreover, half of Member

¹³ Storage in third countries is in line with the Directive, provided that the responsibility for disposal remains with the generating Member States and can only be transferred in line with Article 4(4) of the Directive.

¹⁴ The majority of Member States with research reactors intend to return spent fuel to the supplier (USA or

States are considering the possibility of shared solutions for disposal either as a preferred or as an alternative option (the ‘dual track’ approach¹⁶). However, none of the Member States’ programmes or reports set out concrete milestones or measures towards the implementation of such a solution¹⁷.

While the Directive allows shared disposal solutions to be developed, a policy based only on this option, without a clear path towards implementation, cannot be regarded as being in line with the aims of the Directive. The **Commission sees important challenges in putting shared solutions into practice**. As is the case for the development of any disposal facility, engagement with all stakeholders and the public, and commitment at the highest political level are needed.¹⁸ As stated in the Directive and also acknowledged by the European Court of Auditors,¹⁹ the sharing of disposal facilities is a potentially beneficial, safe and cost-effective option. Therefore, the Commission will support the Member States in assessing the economic, legal and social impacts of shared repositories and launching a debate on the matter, in order to assess feasibility and Member States’ readiness to implement this disposal option.

3.2 National programmes

All Member States except one have submitted their **national programmes**, either in final or draft form, with the most recent submission in September 2016. The majority of Member States’ programmes are recent and were adopted in the 2015-2016 period, while two Member States’ programmes were adopted in 2006.²⁰

Overall, the Commission notes a varying degree of detail in the different national programmes. Only a few Member States have programmes that address all types of spent fuel and radioactive waste including detailed plans for all management steps (from generation to disposal) in line with Article 11(1) of the Directive, the main issue being again the disposal step.²¹

Russian Federation) before 2020, although for a number of training and research reactors a long-term management route for spent fuel (for example disposal) has not yet been defined.

¹⁵ A few Member States with defined policies recognise the need to find technical solutions for the long-term management of special radioactive waste (e.g. exotic waste from research). These Member States reported that they have ongoing or planned research activities to address this need.

¹⁶ In this case, Member States are continuing with the development and implementation of their own national programmes, while leaving open the option of a shared solution.

¹⁷ Luxembourg and Belgium have signed an agreement in 2016 for shipment to and disposal of relatively small amounts of radioactive waste in Belgium.

¹⁸ This is specifically relevant for selecting the host country and site, defining clear milestones towards implementation, determining specific responsibilities over the lifetime of the facility and for the associated liabilities.

¹⁹ Special report No 22/2016: EU nuclear decommissioning assistance programmes in Lithuania, Bulgaria and Slovakia: some progress made since 2011, but critical challenges ahead.

²⁰ Slovenia submitted an updated national programme on 30 September 2016 — Slovenia’s 2006 programme was used for the purposes of this report, as the analysis of the updated programme is still ongoing. Spain’s notification of its revised national programme is still pending.

²¹ It is recognised that this also includes the issue of certain types of exotic and remediation waste on which the Member States concerned are expected to make decisions soon.

Disposal of intermediate level waste, high level waste and spent fuel

For the **disposal of intermediate level waste, high level waste and spent fuel**, the concepts for disposal as per Article 12(1)d of the Directive (e.g. site selection, development of design) are not concrete in most of the Member States, often due to the need for policy decisions to be made or sites to be selected.²² Of the Member States that are planning to develop geological disposal facilities in the coming decades, only Finland, France and Sweden have so far selected sites, demonstrating the challenges of moving from the planning stage to practical implementation. Globally, Finland is the first country where the construction of a deep geological facility has begun and is expected to be in operation by 2022, with France and Sweden expected to start operation by 2030 (see Figure 2). Another 12 Member States have plans for a deep geological repository and are at different stages of implementation. The majority of Member States without nuclear programmes cover activities up to interim storage and repatriation of spent fuel (if relevant) to the supplier in their national programme and have not yet defined a policy or a route for the disposal of radioactive waste.

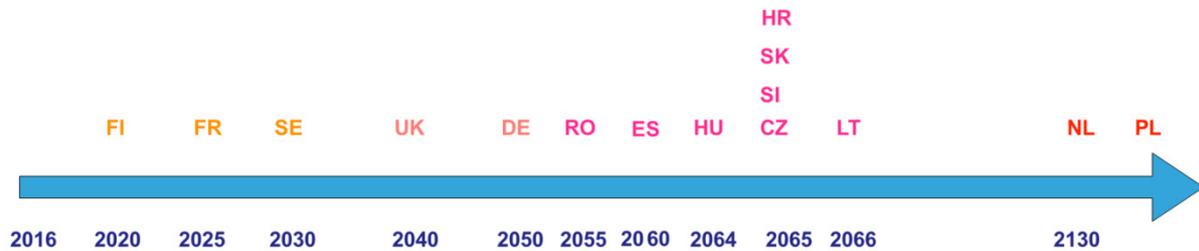


Figure 2. Planned start of operation of deep geological facilities

Concrete planning to develop long-term solutions for high level waste, intermediate level waste and spent fuel management, including research, development and demonstration activities should be put in place in all Member States as soon as possible to avoid placing an undue burden on future generations. Member States without such concrete plans in their programme at the moment should ensure sufficient available storage capacities remain in place in order to continue to safely manage their inventories. From this perspective, Member States' reporting does not always clearly demonstrate how the interdependencies between the generation of radioactive waste and spent fuel on the one hand, and their capacities for processing, storage and disposal (incl. for spent fuel and radioactive waste from new builds) on the other, are taken into account in practice. Member States should pay additional attention to this point in the review of their national programmes, and should report on it in the future.

With regard to Member States that do have concrete plans in their national programmes for the disposal of high level waste, intermediate level waste and spent fuel, the Commission sees the need for further discussion, as it is not always clear how these Member States demonstrate that they have taken reasonable steps to ensure progress and to avoid placing an undue burden on future generations. The Commission will pay particular attention to compliance with this

²² See Table 7 of the Commission Staff Working Document (2017)159 on Progress of Implementation of Council Directive 2011/70/Euratom.

principle in its opinions on the individual Member States' national programmes. It will focus on the proposed time frames for developing solutions as these appear in some cases to be unduly long for certain milestones, such as those for site selection. Site selection for disposal facilities is a demanding and long process, where public participation in the decision making process are essential to making progress. As such, all Member States should optimise planning, commit adequate resources, perform the necessary research and training activities and engage with the public and other stakeholders in order to accelerate implementation.

Disposal of very low level waste and low level waste

In relation to the **disposal of very low level waste and low level waste**, the Commission notes that most Member States with nuclear programmes have formulated solutions for handling their very low level waste and low level waste and they are progressing with the implementation of these solutions. However, this remains a challenge in several Member States. To date, over 30 disposal facilities have been developed in 12 Member States and about half of all Member States are planning to build new disposal facilities²³ in the next decade. The remaining Member States either do not have plans or are relying on shared solutions. In most of the Member States with research reactors or non-nuclear programmes, the disposal options for radioactive waste are only at a conceptual stage and the pertinent research and siting activities have been postponed – in some cases for several decades. A few Member States are also planning the remediation of existing disposal facilities and contaminated sites.

Monitor progress towards implementation

With regard to the overall national programmes, only about a third of the Member States have defined clear and detailed **milestones and time frames** for reaching their objectives, as required by Article 12(1)(b) of the Directive. In the remaining cases, long-term milestones or schedules have not been clearly presented for the whole programme, decision-making points have not been presented, decisions have been postponed to the future, or the schedules indicated were out-of-date. Although the overall timescales vary between national programmes, this can be explained in part by the scope and scale of the inventories and associated activities. The programmes include measures that span from now up to the 24th century (incl. post-closure periods).

Most Member States have not clearly defined **key performance indicators** for monitoring progress towards implementation of the national programmes as required by Article 12(1)(g) of the Directive. Moreover, the majority of Member States need to specify further how they plan to implement the results from monitoring their programme's implementation when reviewing and updating their programmes.

²³ See Table 8 of Commission Staff Working Document SWD(2017)159 Progress of Implementation of Council Directive 2011/70/Euratom.

Post-closure period of disposal facilities

According to Article 12(1)e of the Directive, Member States are to define the concepts or plans for the post-closure period of a disposal facility's lifetime, including the period during which appropriate controls are retained and the means to be employed to preserve knowledge of that facility in the longer term. Of the Member States with nuclear programmes, only a few have presented **detailed post-closure** plans mainly for near-surface disposal facilities while post-closure measures for deep geological facilities are either not foreseen or not addressed. Information on the Member States' approach towards preservation of knowledge after the closure of disposal facilities is limited in most of the national programmes. This is an area that Member States should develop further in their national programmes.

Research, development and demonstration activities

In line with Article 12(1)(f) of the Directive, Member States are to define the **research, development and demonstration activities** needed for the implementation of their national programmes. As such, there should be a clear link between the national research activities/time frames and the concept, plans, and milestones defined in the programmes. Overall, most Member States with nuclear programmes reported on their research activities needs. Four Member States operate five underground research laboratories for spent fuel, high level waste and intermediate level waste disposal and four more plan to develop such laboratories after 2020. The majority of research activities are undertaken by the licensee and/or dedicated research organisations. However, the link between the research activities presented in the national programmes and how they support in practical terms the implementation of these programmes was mostly not addressed in detail by the majority of Member States. Member States involved in European research initiatives (e.g. the Implementing Geological Disposal of Radioactive Waste Technology Platform²⁴) should explain how these projects support in practical terms the implementation of their national programmes. Member States with research reactors also addressed the research and development measures needed to implement their programmes, but clear roadmap/milestones for research on final disposal were often not in place. All other Member States did not report on the research activities needed for their nuclear programmes. Mostly, these programmes rely on shared disposal solutions.

Agreements with other Member States or third countries

Finally, only a few Member States submitted their **agreement(s) with other Member States or third countries** in line with Article 12(1)(k) of the Directive. The Commission notes that in order to be consistent with the notifications on shipments of spent fuel and radioactive waste under Article 20 of the Directive 2006/117/Euratom²⁵ (e.g. for the 2012-2014 period), a number of Member States are still to notify their existing agreements to the Commission. The Commission is in dialogue with the Member States concerned to clarify this matter.

²⁴ <http://www.igdtp.eu/>

²⁵ Council Directive 2006/117/Euratom of 20 November 2006 on the supervision and control of shipments of radioactive waste and spent fuel.

4. NATIONAL FRAMEWORKS ASSURING SAFE SPENT FUEL AND RADIOACTIVE WASTE MANAGEMENT

Member States are required to establish and maintain a national legislative, regulatory and organisational framework ('national framework') for spent fuel and radioactive waste management that allocates responsibility and provides for coordination between relevant competent bodies (Article 5(1) of the Directive).

Member States have presented the legal arrangements for the national framework, however only in a few cases the national reports provide details on how those legal provisions are to be implemented in practice. The national frameworks generally cover all types of radioactive waste in the scope of the respective national programmes, and all stages of its management.

Overall, Member States have put in place arrangements for safety and licensing systems with various levels of complexity and have defined the organisations responsible for the implementation of the different radioactive waste management activities and for regulatory oversight in line with Article 5(1) of the Directive. The majority of Member States have also established a dedicated radioactive waste management organisation (in most cases State-owned).

For Member States without a nuclear programme the national framework contains legal and regulatory provisions mainly for predisposal management commensurate with the type and amount of waste that they generate.

Most of the Member States require that the national framework is continually updated and improved, as per Article 5(2) of the Directive, and have established the responsibilities for that. About half of Member States' national reports include details of how they intend to review the national framework, taking into account operating experience, insights from the decision-making process and the development of technology and research, in line with Article 5(2) of the Directive. The rest either refer to the requirements established by the law or regulations, without providing additional details, or do not provide such information.

4.1. Competent regulatory authorities

All Member States report having a competent regulatory authority, in line with Article 6(1) of the Directive. Some Member States have more than one organisation involved in the regulatory oversight of radioactive waste from nuclear and other facilities, such as medical or industrial activities. In a few cases, the interface and responsibilities of these regulatory bodies will need to be further clarified with the Member States.

All Member States have declared their regulatory authorities to be independent in line with Article 6(2) of the Directive. In a few cases, it was further reported how such independence was ensured in practice (for example by explaining how the management of the regulatory authority was appointed or dismissed). In a number of cases, the Commission needs to further clarify how the effective separation of supervisory functions from radioactive waste and spent fuel management activities is ensured.

Member States reported with varying levels of detail on the legal powers and financial and human resources available to the competent regulatory authority for carrying out their responsibilities in line with Article 6(3) of the Directive. Around a third of EU Member States chose to empower the competent authorities to carry out their own research programmes (including funding) that support the independent regulatory oversight of spent fuel and radioactive waste management. The Commission notes that a few Member States reported limitations in budget and/or human resources and challenges with respect to maintaining adequate human resources for the long timescales associated with radioactive waste and spent fuel management.

4.2. Licence holder's responsibilities, including safety demonstration and safety review

All Member States reported legal measures to ensure that the primary responsibility for spent fuel and radioactive waste management rests with the license holder, in line with Article 7(1) of the Directive.

The majority of Member States presented their legal basis and the provisions they have in place to require the license holder to perform a safety demonstration of radioactive waste and spent fuel management activities or facilities and regular safety reviews in line with Articles 7(2) and 7(3) of the Directive. However, only in some cases examples of how these provisions have been applied in practice were provided in their national reports. Therefore, Member States should provide further information on safety demonstrations of existing and planned facilities, on regular safety reviews and on how their findings are taken into account in subsequent reports.

The majority of Member States have reported legal requirements for integrated management systems or quality assurance for spent fuel and radioactive waste management that give due priority to safety. The Commission notes that a few Member States have not addressed management systems in their reports. This should be corrected in future reports.

Overall, Member States have established legal requirements on licence holders to provide for and maintain adequate financial and human resources to fulfil their obligations for the safe management of spent fuel and radioactive waste, in line with Article 7(5) of the Directive. The majority of Member States with nuclear programmes state that the resources currently available are adequate, whereas limited or no information has been provided by Member States without nuclear programmes. Therefore, further details on the licensees' financial and human resources should be presented in the next reporting cycle.

4.3. Expertise and skills

The majority of Member States have legal requirements in place to ensure the training and education of staff of all parties involved in spent fuel and radioactive waste management, in line with Article 8 of the Directive. About half of Member States (mainly those with nuclear programmes) have presented specific measures for maintaining the skills and competences of generators of spent fuel and radioactive waste, operators of radioactive waste and spent fuel management facilities and competent regulatory authorities, although the emphasis was mostly on competent regulatory authorities. International exchange of experience through peer reviews, workshops, conferences and visits has been recognised as a useful tool.

Overall, in future reports Member States should present more detailed and comprehensive information on the practical arrangements for ensuring the necessary expertise and skills of staff of all parties involved in spent fuel and radioactive waste management. Specific attention should be paid to how these take into account the long timescales associated with the national programmes so as to ensure the retention of knowledge and the availability of adequately trained and competent staff (regulators, licensees, etc.) for the effective implementation of the national programmes.

4.4. Cost assessment, financing mechanisms and available resources

The Commission, through the PINC and the Member States' programmes and reports on implementation of this Directive, aimed to compile for the first time a comprehensive EU-wide overview of the total costs of radioactive waste and spent fuel management as estimated by Member States. It also aimed to better understand how Member States ensure that these activities are financed according to the principle that those who generate radioactive waste or spent fuel are to bear the costs of their management (see Article 4(3) of the Directive).

Article 12(1)(h) of the Directive requires Member States to present an assessment of the national programme costs, basis and profile over time. Although most Member States have estimated the global costs of the actions that are included in their national programmes, in the majority of cases this information is not sufficient to conclude on the completeness and accuracy of the figures reported. Some Member States need to demonstrate ownership of the cost assessments of their national programmes, as they appear currently to rely mostly on the spent fuel and radioactive waste generators' cost assessments.

Based on the reported data, the estimated total cost of the management of spent fuel and radioactive waste in line with the Member States' national programmes to date is about EUR 400 bn.^{26,27} A significant part of this figure stems from the national programmes of the United Kingdom, France and Germany as these Member States have the largest nuclear programmes and inventories of spent fuel and radioactive waste in the EU.

In order to be able to conclude that the reported figures are accurate and complete, the national programmes should be revised to include for example, assumptions for the predisposal and disposal of radioactive waste and spent fuel, including the unit costs per type of radioactive waste/spent fuel, the cost of the existing and planned facilities, transportation and research costs and a sensitivity analysis linked to different possible operational lifetimes of the existing/planned nuclear facilities and other uncertainties in the national programmes, as applicable.

In line with Articles 12(1)(i), 9 and 5(1)(h) of the Directive, Member States are required to put

²⁶ Compared to the estimates released under PINC, this estimate takes into account investments that will be made beyond 2050 and covers a broader range of installations (other than nuclear power plants) and additional activities included in the national programs (such as remediation of contaminated sites).

²⁷ See detail per Member State in the Staff Working Document (2017)159 on Progress of Implementation of Council Directive 2011/70/Euratom. The data have not been verified by the Commission.

in place financing mechanisms that ensure adequate financial resources are available when needed for the implementation of their national programme. Although most Member States referred to their financing mechanisms, the information provided is in most cases insufficient to draw conclusions on their compliance with the relevant provisions of the Directive.

Member States' national programmes should provide analysis of the planned income from and disbursement of funding over the life time of the programme, at a minimum assessing whether expected incomes are sufficient. Such analysis has only been provided in the national programmes of a few Member States. A few Member States reported that the mechanisms they have in place will not be adequate in order to ensure that funds are available when needed, and/or declared dependence on possible future EU funding.

The Commission has reviewed the measures implemented to ensure that the available resources are secured. This includes ensuring the funds are used only for their intended purpose, managing a secure risk profile in the investment of the assets and requiring regular independent verification of the costs assessment and funding mechanisms. The Commission notes that there are significant differences between Member States in this regard, and that future reports should address this issue in more detail.

The Commission therefore considers that further information and analysis is required, and is in the process of clarifying these specific issues with the Member States in line with Article 13 of the Directive.

4.5. Transparency

The majority of Member States have mechanisms in place to ensure public information and opportunities for public consultation in line with Article 10 of the Directive (e.g. in the framework of strategic environmental assessment and environmental impact assessment procedures). Almost all Member States have clearly indicated that the national competent regulatory authority is responsible for providing information to the public in the field of its competence in spent fuel and radioactive waste management.

However, about half of the Member States have not reported on the mechanisms in place to ensure public participation in the decision-making process beyond public consultation, such as working groups, advisory bodies or national commissions. Member States should in the future present or explain further the extent of public involvement in the decision-making process for spent fuel and radioactive waste management.

4.6. Self-assessment and international peer reviews

Most Member States have provided information on self-assessments and international peer reviews of the regulatory authorities (IAEA IRRS missions),²⁸ but only a few of these Member States reported details of outcomes and follow-up actions as required by Article 14(3) of the Directive.

²⁸ Integrated Regulatory Review Service of the International Atomic Energy Agency.

For self-assessments and peer reviews of the national programmes and national frameworks, only a third of the Member States and less than half of the Member States with nuclear programme have reported concrete plans for such international peer reviews (i.e. ARTEMIS²⁹ or similar). Taking into account the obligation to conduct these reviews at the latest by August 2023, Member States should put necessary measures in place for a timely implementation.

5. MOVING FORWARD

The Commission recognises Member States' efforts in implementing the Directive and encourages Member States to continue these efforts in the future. Having reviewed the national reports, as well as the national policies, frameworks and programmes submitted to date, the Commission concludes that there is, in general, a good level of compliance with the Directive in terms of the legal and regulatory framework. However, additional effort is needed in a number of areas, in particular with respect to policies, concepts, plans, research and site selection for intermediate level waste and high level waste (including spent fuel) disposal, projections of inventories for spent fuel and radioactive waste, cost assessments and financing mechanisms. Deciding on the development of geological disposal facilities, and specifically on their location, is a complex, long-term process in which continuous efforts towards transparency and public participation play an essential role. Member States should engage in this process without delay.

The Commission notes that Member States were at different stages of implementation of their spent fuel and radioactive waste management activities when the Directive came into force. While this can explain the differences between Member States in terms of the stage of implementation they are at, planning should not be delayed and implementation must move forward.

The Commission has requested clarifications to Member States and may express its opinion on whether the content of the individual national programmes is in accordance with Article 12 of the Directive, focusing, among other things, on the following:

- Whether policies, concepts and plans for the disposal of radioactive waste (in particular intermediate level waste and high level waste) and spent fuel are in place, accompanied by milestones, time frames and key performance indicators to monitor progress towards the implementation.
- Whether policies for shared disposal solutions are accompanied by a demonstration of their feasibility, including site-specific matters.
- Whether cost assessments are reliable, complete and reviewed periodically.

²⁹ Since 2014, the Commission has been supporting the development of a self-assessment tool by the IAEA for the ARTEMIS review service to assist those Member States that decide to use this international peer review service.

- The independence and resource sufficiency of the competent authorities.
- Information on safety demonstrations for existing facilities and frequency of safety reviews.
- Suitability of measures for post-closure and for the retention of knowledge to ensure long-term safety, as well as for the availability of properly trained and competent staff.

6. CONCLUSIONS

The EU nuclear legal framework has undergone significant changes in the last decade with the adoption of legislation on nuclear safety, radioactive waste and spent fuel management and radiation protection. Through the implementation of Directive 2011/70/Euratom, Member States are required to demonstrate that they have taken reasonable steps to ensure that no undue burden is passed to future generations and that radioactive waste and spent fuel is managed safely.

The Commission will continue supporting Member States in addressing the relevant challenges as follows:

- Discussion on options for radioactive waste and spent fuel disposal, including shared solutions and the role of public participation in the decision-making process. The Commission stands ready to support the Member States in assessing the economic, legal and social impacts of shared repositories, given that the sharing of facilities for spent fuel and radioactive waste management, including disposal facilities, may be a potentially beneficial, safe and cost-effective option.
- The Commission will carry out additional work with the aim of compiling a comprehensive overview of the total costs for spent fuel and waste management and how Member States ensure that these are financed according to the principle that all generators are to cover the costs of the management of spent fuel and radioactive waste (from generation to disposal). This work will be performed in collaboration with the Decommissioning Funding Group and build on the recommendations already made by the Commission in 2006.³⁰
- The Commission will further analyse Member States' approaches to the development of national inventories and specifically the classification system used therein. In addition, the Commission, in consultation with Member States and the European Nuclear Safety Regulators Group, will continue working together with international organisations (e.g. the IAEA and the OECD Nuclear Energy Agency) on exploring the possibilities for harmonising and facilitating reporting requirements for Member

³⁰

Commission Recommendation 2006/851/Euratom of 24 October 2006 on the management of financial resources for the decommissioning of nuclear installations, spent fuel and radioactive waste.

States' inventories for spent fuel and radioactive waste.

The Commission acknowledges that there is still important work ahead to ensure the long-term safe and responsible management of radioactive waste and spent fuel. In this regard, the periodic international peer reviews of the national programmes, frameworks and competent regulatory authorities are of high importance in building stakeholders' trust and confidence in the management of these materials in the EU. The Commission will continue to promote an open and transparent dialogue and facilitate the exchange of good practices and knowledge.