EUROPEAN
COMMISSION

Brussels, 15.5.2017
SWD(2017) 159 final

COMMISSION STAFF WORKING DOCUMENT

Progress of implementation of Council Directive 2011/70/EURATOM

Accompanying the document

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

{COM(2017) 236 final}
{SWD(2017) 161 final}

TABLE OF CONTENTS

1. INTRODUCTION 4
2. STATUS OF IMPLEMENTATION 4
2.1. National policies and frameworks for the safe and responsible management of spent fuel and radioactive waste 4
2.1.1. National policies 4
2.1.2. National programmes, timeframes and key performance indicators 6
2.1.3. National legal and organisational frameworks 12
2.1.4. Regulatory framework and competent regulatory authorities 15
2.1.5. Shipments within EU and to third countries 23
2.1.6. Self-assessment and international peer reviews 24
2.1.7. Notification and reporting 27
2.2. Assuring the safety of spent fuel and radioactive waste management 27
2.2.1. Licence holder's responsibilities 27
2.2.2. Concepts and plans (including post closure) 28
2.2.3. Safety demonstration 35
2.2.4. Cost assessment, financing mechanisms and available resources 36
2.2.5. Expertise and skills 44
2.2.6. Research and development 44
2.2.7. Transparency 46
3. CONCLUSION 48

LIST OF ABBREVIATIONS AND ACCRONYMS

ARTEMIS	Integrated review service for radioactive waste and spent fuel management, decommissioning and remediation programmes
EIA	Enviornmental impact assessment
ENSREG	European Nuclear Safety Regulators Group
EU	European Union
KPI	Key performance indicators
HLW	High level waste
IAEA	International Atomic Energy Agency
ILW	Intermediate level waste
LLW	Low level waste
LTO	Lifetime extension
IRRS	International regulatory review service
MS	Member State
NORM	Naturally occuring radioactive material
NPP	Nuclear power plant
RAW	Radioactive waste
SEA	Strategic environmental impact assessment
SF	Spent fuel
URL	Underground research laboratory
VLLW	Very low level waste

1. INTRODUCTION

This Staff Working Document presents details on the outcome of the Commission's assessment of European Union (EU) Member States' notifications on the implementation of Council Directive 2011/70/EURATOM on responsible and safe management of spent fuel and radioactive waste (further "Directive")[1]. It is based on the information provided in Member States' national programmes[2] and national reports[3] on spent fuel and radioactive waste management, as notified to the Commission by 30 September 2016[4]. It provides background information related to the main findings, progress, challenges, and trends presented in the first Commission report COM(2017)236 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 future prospects.

On the basis of the notified legal measures transposing the Directive, 27 national programmes on spent fuel and radioactive waste management (5 of which under formal approval by Member States), and 28 national reports on implementation of the Directive, the Commission notes the commitment of Member States towards the safe and responsible management of spent fuel and radioactive waste. This is the first time that Member States report on the implementation of their national programmes for the management of spent fuel and radioactive waste under the Directive.

The Staff Working Document pays particular attention to national policies and principles, national frameworks, national programmes and their implementation, competent regulatory authorities, license holders responsibilities, concepts and plans, safety demonstration, financial resources, expertise and skills, research, and transparency.

In this first report, the Commission has taken into account information from the national programmes and national reports, relevant for implementation of the Directive in Member States in order to present a comprehensive overview to the Council and European Parliament on spent fuel and radioactive waste management in the EU.

2. STATUS OF IMPLEMENTATION

2.1. National policies and frameworks for the safe and responsible management of spent fuel and radioactive waste

2.1.1. National policies

Development of a national policy for management of spent fuel and radioactive waste is a key provision for long term and safe management of spent fuel and radioactive waste.

According to the Directive each Member State shall bear ultimate responsibility for the management of the spent fuel and radioactive waste generated in it. It is up to the Member States to take a decision whether they will build a single disposal facility for all radioactive waste or a number of facilities for different waste types.

Although the Directive requires that the radioactive waste be disposed of in the Member State in which it was generated, it introduces conditions under which the radioactive waste could be disposed of in another Member State or in a third country (Article 4(4) of the Directive). The export of radioactive waste for disposal in another Member State or in a third country is in practice considered by most Member States without a nuclear programme, or which have one or

---

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 Article 13(1) and Article 15(4) of the Directive.

3 Article 14(1) of the Directive.

4 The final programme of Hungary and revised programme of Slovenia have not been taken into account and are under assessment.

several research reactors and relatively small quantities of low level waste (LLW) and intermediate level waste (ILW).

Article 4 (3) of the Directive defines a number of principles national policies shall be based on:

- Keeping the generation of radioactive waste to the minimum;
- The interdependencies between all steps in spent fuel and radioactive waste management;
- Safe management of spent fuel and radioactive waste and passive safety features for long term safety;
- Graded approach in implementation of measures for spent fuel and radioactive waste management;
- The costs for the management of spent fuel and radioactive waste shall be borne by those who generated those materials;
- Evidence-based and documented decision making process to all stages of spent fuel and radioactive waste management.

The majority of Member States has developed national policies for management of spent fuel and radioactive waste, although not all Member States' policies cover all types of their radioactive waste or spent fuel (e.g. research facilities) or all states of their management, in particular long term management.

The majority of Member States has developed policies either in stand-alone documents, or reflected in their national frameworks and/or their national programmes. Almost half of the Member States are considering multiple options for disposal of their spent fuel and/or radioactive waste.

Operators from a few Member States are currently reprocessing their spent fuel in France, the United Kingdom and the Russian Federation. In the rest of the Member States spent fuel is intended to be disposed of in deep geological facilities without reprocessing. This is particularly valid for spent fuel from new build, and for current spent fuel in some Member States that used to reprocess it in the past.

The spent fuel from research reactors is intended for shipment to the supplier (USA or the Russian Federation) in most cases before 2020.

Three Member States (Finland, France and Sweden) have concrete plans for development of geological disposal facilities for ILW and high level waste (HLW) in the next 15 years. Based on the Member States' programmes to date, in total fifteen Member States plan to develop geological disposal facilities in the next 100 years in the EU. Thereby, shared disposal facilities remains an option[5] for many Member States.

The remaining Member States have either:

- Not defined their long-term policy for spent fuel, HLW and ILW disposal (e.g. national disposal facility, disposal in a third country or shared disposal facilities); or
- Considered two options (e.g. (i) national and shared disposal solutions or (ii) reprocessing and disposal),

and in those cases long term storage in the Member States is foreseen as an interim step.

About half of the Member States consider shared solutions in their programmes. Some define it as the primary option for disposal of HLW and spent fuel, other Member States take a dual track

[5] Recital 33 of the Directive 2011/70/Euratom. Luxembourg has recently concluded an agreement with Belgium for the management of its radioactive waste.

approach for a few decades until they will make a decision for a national or shared disposal facility, and a few Member States consider shared disposal as a last and not very realistic option.

Member States with small amounts of institutional waste[6] plan interim storage of radioactive waste, while a final solution is being decided: disposal on the territory of the said Member State, export for disposal abroad or a shared disposal solution.

The majority of Member States manage radioactive waste on their territory, while a number of Member States send radioactive waste for processing abroad. In the latter cases, as per Article 4(2) of the Directive, the Member State of origin remains responsible for the secondary waste as a by-product generated during the processing.

Most Member States established clearly in their laws and regulations the ultimate responsibility of the State for management of the spent fuel and radioactive waste generated on its territory, however in most cases no details on the practical implementation have been provided.

Almost all Member States policies address the principles stated in Article 4(3) of the Directive. In general, Member States require in their legislation that these principles are included in the policies. However, information on the practical implementation of the policy principles is not always presented in the national reports, especially in the reports of non-nuclear countries. Overall Member States' policies cover better the principles of (i) keeping the generation of radioactive waste to the minimum and (ii) safety demonstration, than the principles of application of the graded approach, passive safety features for long term safety and interdependencies between radioactive waste management steps.

In Member States with defined policies, a few Member States recognize the need for technical solutions for 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.

The majority of Member States with nuclear programmes focus on management of spent fuel and radioactive waste from large generators, such as nuclear power plants and therefore do not provide detailed information on management of institutional waste. In particular, for long-term management (e.g. strategy, technical solutions and cost estimates) of radioactive waste and spent fuel coming from the research activities (e.g. research reactors, universities).

2.1.2. National programmes, timeframes and key performance indicators

Member States are required to establish national programmes for spent fuel and radioactive waste management, which define the measures, timeframes and milestones for the national policy in practice. They were also required to notify these programmes to the Commission before 23 August 2015. All Member States except one have developed and submitted their national programmes to date, although the programmes of six Member States are expected to be finalised at the end of 2016 or in 2017, mainly due to ongoing Strategic Environmental Assessment (SEA) procedures. Overall the programmes of more than half of the Member States have been subject of SEA as presented in Table 1.

The majority of the programmes are recent and adopted in 2015-2016 period, however in two Member States the programmes date as of 2006 and in one as of 2013. Updated submissions of the programmes of two cases[7] (as per Article 13(1) of the Directive) are expected by the Commission.

---

[6] Radioactive waste generated outside of the nuclear fuel cycle facilities.

[7] The revised Slovenian programme was adopted in April 2016 and submitted to the Commission at the end of September 2016. France and Spain are working on the update of their existing programmes.

A few Member States have programmes that address most types of spent fuel and radioactive waste and the respective concrete plans from generation to disposal (including deep geological disposal and post-closure measures); although they recognize that there are exotic waste from research activities and remediation waste for which these Member States still need to take decisions.

Most Member States with nuclear power plants (NPPs) have developed and approved programmes that cover all stages from generation to disposal. A few Member States have not yet decided a long term solution for the management of their radioactive waste or spent fuel. As mentioned for the national policies, Member States with nuclear programmes provide very detailed information on the management of spent fuel and radioactive waste generated in the nuclear industry, and much less on the management of institutional radioactive waste. All Member States reflected the exclusions of the Directive as per Articles 2(2) and 2(3).

Member States without nuclear programmes and having research reactors address all types of radioactive waste and spent fuel generated from research reactor operation. The majority of the national frameworks of these Member States only cover activities up to interim storage and repatriation of spent fuel to the supplier, and have not yet defined policies or routes for the disposal of radioactive waste.

Except for one, Member States with no nuclear programmes communicated their national programmes. Most of these Member States cover all types of radioactive waste and have not yet defined a policy or a route for their disposal. Although a final solution has not been defined yet, some Member States have established decision-making milestones to progressively define more concretely the long term management and disposal of radioactive waste. Most of the Member States with no nuclear programmes aim at finding a shared disposal solution. Luxembourg has recently concluded an agreement with Belgium for the management of part of its radioactive waste.

Table 1. Member States' National Programmes under Directive 2011/70/EURATOM[8]

MS[9]	Organisation developing the programme	Organisation approving	SEA	Review and update
BE	National Committee created by law with Ministry of Economy, ONDRAF/NIRAS and Synatom	Federal Ministers of Energy and Economy	N	Regular update when a national policy is adopted or amended
BG	Ministry of Energy	Government	Y	2011 Strategy was revised in 2015.
CZ	Ministry of Industry and Trade	Government	Y	2002 Concept updated in 2014 is under review. Next review planned in 2025
DE	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety	Federal Cabinet	Y	Every 3 years
FI	Ministry on Employment and the Economy	Ministry on Employment and the Economy	N	Every 3 years

[8] The information in this table takes into account the data provided by Member States in ENSREG Working Group 2.

[9] Member States (MS) abbreviations in this report are as follows: Austria (AT), Belgium (BE), Bulgaria (BG), Czech Republic (CZ), Germany (DE), Finland (FI), France (FR), Hungary (HU), Italy (IT), Lithuania (LT), Latvia (LV), The Netherlands (NL), Slovenia (SI), Slovakia (SK), Spain (ES), Sweden (SE), Romania (RO) and the United Kingdom (UK).

FR	Ministry of Ecology, Sustainable Development and Energy	Government, new 2016-2019 programme expected to be approved in 2016	Y	Every 3 years
HU	PURAM and the Ministry of National Development	Government after SEA completion	Y	Every 5 years
IT	Ministry of Environment and Protection of Land and Sea, Ministry of Economic Development, Ministry of Health	Ministry of Environment and Protection of Land and Sea, Ministry of Economic Development	Y	Every 3 years
LT	Ministry of Energy on the proposal of a Radioactive Waste Management Organization	Government	Y	Every 7 years at least
LV	Latvian authorities[10]	No available information	Planned	Concept of Radioactive Waste Storage, developed in 2003, National programme under development (incl. SEA)
NL	Ministry of Infrastructure and Environment	Parliament	N	At least every 10 years
SI	Agency for Radioactive Waste Management (ARAO) and Slovenian Nuclear Safety Administration (SNSA)[11]	National Assembly	N	2006 programme revised in 2016
ES	ENRESA[12]	Government upon proposal by Ministry of Industry, Energy and Tourism, being heard the CSN and relevant Autonomous Communities	Y	Periodic review, 2006 programme is being reviewed
SE	Swedish Radiation Safety Authority	Ministry of the Environment and Energy	N	Regular national and international reviews; Follow-up IRRS mission May in 2016
SK	The administrative board of the National Nuclear Fund for decommissioning nuclear installations and managing spent nuclear fuel and radioactive waste ('NNF')	Government	Y	Every 6 years
RO	Nuclear Agency and for Radioactive Waste (ANDR)	No available information	Y	Every 5 years
UK	Department of Energy and Climate Change	Department of Energy and Climate Change	N	Nuclear Decommissioning Authority strategy review every 5 years

[10] The Ministry of Environment issued the 2003 Concept of Radioactive Waste Storage after approval by the Cabinet.

[11] ARAO provides the technical basis for the revision of the Programme and based on this, SNSA prepares a draft National Programme which is adopted by National Assembly.

[12] The legal basis requires ENRESA to submit to the Ministry of Industry, Energy and Tourism every 4 years, or whenever so required by this Ministry, a draft update of the programme.

AT	Government of the Republic of Austria	Government	Y	Regular update
DK	Danish Radiation Protection Authority at the Danish Health and Medicines Authority (SST/SIS)	Ministry of Health	N	Not defined in the national programme
EL	Greek Atomic Energy Commission (EEAE)	Minister responsible for the EEAE, the Minister for Education, Research and Religious Affairs	No data	At least once every 3 years and updated by EEAE, upon agreement of the National Committee for Radioactive Waste Management (EEDRA)
PL	Ministry of Economy	Council of Ministers	Y	Every 4 years
PT	Regulatory Commission for the Safety of Nuclear Installations (COMRSIN)	Council of Ministers	Y	COMRSIN* Frequency not defined
HR	State Office for Radiological and Nuclear Safety (SORNS)	Ministry of Economy with the prior approval by the Croatian Parliament	Y	Krško programme every 5 years at least
CY	Radiation Inspection and Control Service (RICS), Department of Labour Inspection (DLI), Minister of Labour, Welfare and Social Insurance (MLWSI)	MLWSI	N	Every 10 years at least by RICS
EE	Ministry of the Environment, Environmental Board, Radiation Protection Bureau, Radiation Monitoring Bureau	Minister of the Environment	Y[13]	Regular update at least every 4 years
IE	Government Department of Environment, Community and Local Government (DECLG)	DECLG	N	Update and revision as necessary
LV	Minister for Environmental Protection and Regional Development*	Council of Ministers*	Y	2002 Concept, Programme in preparation
LU	Radioprotection Division (DRP) within the Department of HEalth	No available information	No data	Next review in 2018
MT	Radiation Protection Board	Radiation Protection Board	Under screening	As necessary

* Information from notifications to the Commission other than the national programme

A third of all EU Member States addressed waste with naturally occurring radioactive material (NORM) in their programmes, whereas the rest either explicitly exclude it from the scope of their national programmes, or do not mention it.

The overall timescale of Member States' programmes for spent fuel and radioactive waste management vary signifficantly due to the scope and scale of the current nuclear programmes in each Member State. The programmes include measures from a few years up to after 2300, which imposes challenges for the majority Member States (in particular the ones with nuclear programme) to ensure long term safety measures for several decades to centuries in the future.

[13] The programme states that SEA is available.

Clearly defined detailed milestones, timeframes and decision making points are defined by about a third of Member States (incl. shutdown and planned decommissioning of nuclear power plants that will also generate radioactive waste (see Table 2).

Table 2 Schedule for Decommissioning of Nuclear Power Plants in EU Member States[14]

MS	Reactors/Units	Operation	Shutdown	Decommission-ing	Comments
BG	Kozloduy unit 1	1974	2002	ongoing	Available data until 2030
	Kozloduy unit 2	1975	2002	ongoing	
	Kozloduy unit 3	1980	2006	ongoing	
	Kozloduy unit 4	1982	2006	ongoing	
	Kozloduy unit 5	1987	2017 (2030)		Planned LTO by 2030
	Kozloduy unit 6	1991	2021 (2030)		Planned LTO by 2030
CZ	Dukovany 1-4	1978-1987*	2038 - 2047		Planned LTO
	Temelin units 1-2	2000-2002*	2060-2062		60 years operation
	Dukovany unit 5	planned	no available data		60 years operation
	Temelin unit 3	planned	no available data		60 years operation
HU	Paks units 1-4	1982-1987	2032-2037		Considering 20 years LTO
	Paks units 5-6	2025-2026			Planned
SK	Bohunice V1 (units 1-2)	1978* 1980*	2006 2008	2025	
	Bohunice V2 (units 1-2)	1984* 1985*	2024 or 2044 2025 or 2045	2031-2048 (40 years operation) 2051-2068 (60 years operation)	Possible LTO to 60 years
	Bohunice A1	1972*	1979	2033	
	Bohunice unit 3	Planned (2029)	2089		
	Mochovce units 1-2	1998* 1999*	2028 or 2046 2029 or 2066	2046-2063 (40 years of operation) 2066-2083 (60 years of operation)	Possible LTO to 60 years
	Mochovce units 3-4	Under construction (2021)	2062 2082	2062-2079 (40 years of operation) 2082-2099 (60 years of operation)	Possible LTOto 60 years
FI	Olkiluoto unit 1	1979	2049*	2080-2090	
	Olkiluoto unit 2	1982	2042*	2080-2090	
	Olkiluoto unit 3	Under construction	2078*	2075 - 2085	
	Loviisa unit 1	1977	2027*	2030-2035	

[14] At the time of reporting to the Commission (2015).

	Loviisa unit 2	1981	2030*	2030-2035	
	Hanhikivi	Planned		2085-2100	
BE	Doel unit 1	1975	2025		End of operation dates by Phase-out Law of 31/01/2003 modified by the law of 28/06/2015.
	Doel unit 2	1975	2025		End of operation dates as established by the Phase-out Law of 31/01/2003 modified by the law of 28/06/2015.
	Doel unit 3	1982	2022		
	Doel unit 4	1985	2025		
	Thiange unit 1	1975	2025		
	Thiange unit 2	1983	2023		
	Thiange unit 3	1985	2025		
DE	8 reactors shutdown	1975-1984	2011-2015		
	9 reactors in operation	1984-1989	2015 - 2022		
FR	58 reactors and 9 shutdown reactors and EPR Flamanville	1977 – 1999 (operating fleet)	Between 2027 and 2078	After 2030	Operating lifetime of 50 years
IT	Caorso	1978	1990	Ongoing	
	Enrico Fermi	1964	1990	Ongoing	
	Garigliano	1964	1982	Ongoing	
	Latina	1963	1987	Ongoing	
NL	Dodewaard	1968*	1997*	After 2045	
	Borssele	1973*	2033		
SI	Krško	1983	2023	2023	
ES*	2 reactors undergoing decommissioning (José Cabrera and Vandellos I)	1969-1972	2006 and 1989		
	1 reactor shutdown (Santa María de Garoña)	1971	2012		
	7 operating reactors*	1981-1988	2021-2027		Assuming 40 years operation
SE	10 operating reactors 2 shutdown	1972-1985	2040 - 2045	After 2040 - 2050 2020 and 2023	Early shutdown of Forsmark 1-2, Ringhals 1-2 could be decided between 2018-2020

UK*	16 (14 AGR, 1 PWR and 1 MAGNOX)[15] reactors in operation	1976-1989	2023-2035 (or 2055)	2023-2083	Possible PWR LTO to 60 years
	29 reactors shutdown				
LT	Ignalina unit 1	1983	2004	Ongoing until 2038	
	Ignalina unit 2	1987	2009	Ongoing until 2038	
RO	Cernavoda unit 1	1996	2026	2063	Possible LTO to 2046
	Cernavoda unit 2	2007	2037	2055	Possible LTO to 2057
	Cernavoda units 3-4	Planned 2019-2020	planned	immediate dismantling	
PL	New build	2024	2084		

*Information from other sources to the Commission than the national programmes/reports

In a significant number of cases long term milestones or schedule have not been clearly presented for the whole national programme for spent fuel and radioactive waste management, decision making points are not defined or are postponed for the far future or the presented schedules are outdated. A number of Member States did not present schedules and timeframes for their national programmes or the one notified are very short term or not clearly fixed.

The commissioning of deep geological facilities is focused in two main periods – 2022-2030 and 2040-2065. Although part of Member States considers shared disposal solutions, there is no decision or site selected for demonstration that this option is feasible.

The majority of Member States have defined in their legal framework the responsibilities for review, update and implementation of the national programmes. A number of Member States still need to define or/present specific arrangements, deadlines and details that are not always detailed in the national programmes/reports (see Table 1).

Member States have to allocate responsibilities for the implementation of their national programmes and the key performance indicators to monitor progress towards implementation (see Article 12(1)g of the Directive). Most of Member States have reported the organisations responsible for implementation of the national programmes, as well as its monitoring and the main milestones to be followed. However, majority of Member States have not clearly defined in their programmes the key performance indicators that they apply.

2.1.3. National legal and organisational frameworks

Member States shall 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 were required to transpose the Directive by 23 August 2013. This section of the report presents the status of Member States' legal and organizational frameworks, while the regulatory framework is detailed in Section 2.1.4 below.

[15] At the time of reporting to the Commission, the Magnox reactor was planned for shutdown in 2015 and the Sizewell/B (PWR) - in 2055. Currently there are 15 operating nuclear power reactors in the UK. In addition, new reactors are planned to be built.

All Member States have communicated to the Commission their transposition measures and declared full transposition and the Commission is assessing the latest notified legal measures with the view to finalise the conformity assessment.

All Member States have presented their national framework with different levels of detail provided in the national reports. Member States have listed the legal arrangements and the provisions for the national framework, however only in some cases the national reports have provided details on how those legal provisions are implemented in practice.

The national frameworks in the Member States' national reports cover all types of radioactive waste and spent fuel in the scope of the respective national programmes, although only a few Member States provide details on ILW and HLW disposal and the post-closure stage. Also, a few Member States do not plan institutional control after closure of deep geological facilities.

Most Member States require the update and improvement of the national framework as per Article 5(2) of the Directive, and establish the responsibilities for that. About half of Member States have provided information on how in practice the development/review of the national framework takes into account operating experience, insights from the decision-making process, etc. The rest either refer to the requirements established by law or regulations, without providing additional details or do not provide such information.

All Member States have in place arrangements for safety and licensing systems with various level of complexity to ensure safety of spent fuel and radioactive waste that correspond to the existing and estimated inventories of spent fuel and radioactive waste in the country.

All Member States without nuclear programmes have implemented a national framework for the management of radioactive waste. The national framework contains legal and regulatory provisions mainly for predisposal waste management, which are commensurate with the type and amount of waste that they generate.

Most Member States have established dedicated radioactive waste management organisations that operate to date. All nuclear power Member States have such organisations. The majority of these organisations are public ones (see Table 3), while a few are established by the nuclear power plant operators. In both cases, funding of spent fuel and radioactive waste management activities is based on the principle that the generators of spent fuel and radioactive waste cover the costs associated with the management of this material. In addition to the responsibilities for spent fuel and radioactive waste management, in a number of cases, these organisations deal also with decommissioning. In some cases, it is foreseen that the responsibilities for the disposal facilities will be transferred from the radioactive waste management organisations to the State after disposal facility's closure.

Table 3. Radioactive waste management organisations in the EU

MS	Radioactive waste management organisation	Public/ private	Responsibilities
BE	Organisme national des déchets radioactifs et des matières fissiles enrichies/Nationale instelling voor radioactief afval en verrijkte splijtstoffen (ONDRAF/NIRAS)	Public	Managing radioactive waste from all sources, managing spent fuel when declared as radioactive waste, incl. disposal.
BG	State Enterprise Radioactive Waste (SE RAW)	Public	Radioactive waste and spent fuel management; and de-commissioning.
CZ	Radioactive Waste Repository Authority (SURAO)	Public	Operation of all low and intermediate level waste repositories; Monitoring of the now closed Hostim repository, Development of deep geological repository for disposal of HLW and spent fuel.
FI	POSIVA	Private[16]	Radioactive waste management facilities - site selection, design, construction, commissioning, operation, rehabilitation and reconstruction, decommissioning and closure/post closure.
FR	National agency for management of radioactive waste (ANDRA)	Public	Long-term management of radioactive waste.
DE	German Service Company for the Construction and Operation of Waste Repositories (DBE)	Public	Construction and operation of radioactive waste repositories.
HU	Public Limited Company for Radioactive Waste Management (PURAM)	Public	Management of all types of radioactive waste, decommissioning of nuclear facilities, as well as related to research and development.
IT	Company for management of nuclear power plants (SOGIN)	Public	Decommissioning of nuclear installations and radioactive waste management including waste produced by industrial, research and nuclear medicine activities; siting, design and construction of a national repository.
LT	State Enterprise Radioactive Waste Management Agency (RATA)	Public	Management and disposal of radioactive waste generated by the Ignalina nuclear power plant. Construction and operation of the repositories for radioactive waste.
NL	The Central Organisation For Radioactive Waste (COVRA)	Public	Implementing the Dutch policy with regard to radioactive waste in the Netherlands. Treatment and storage of all radioactive waste and spent fuel.
RO	Nuclear Agency for Radioactive Waste (ANDR)	Public	Promotion, development and monitoring of the nuclear activities. Coordination of the safe management of radioactive waste and spent nuclear fuel, including final disposal, at national level.
SK	Nuclear and Decommissioning Company (JAVYS)	Public	Management of spent nuclear fuel and radioactive waste. Decommissioning of the nuclear power plants.

[16] Owned by the NPP operators Teollisuuden Voima Oyj and Fortum Power & Heat Oy.

SI	Agency for Radioactive Waste (ARAO)	Public	Collecting, transporting, treating, storing and disposing of low and intermediate level waste and for the disposal of HLW. Management of the closed uranium mine.
ES	National radioactive waste complany (ENRESA)	Public[17]	Management of radioactive waste and spent fuel. Decommissioning nuclear plants.
SE	Swedish Nuclear Fuel and Waste Management (SKB)	Private[18]	Planning and construction of all facilities required for the management of spent nuclear fuel and radioactive wastes as well as for research and development programmes necessary for the provision of such facilities.
UK	Nuclear Decommissioning Authority (NDA)	Public	Implementing Government policy on the long-term management of nuclear waste, including the decommissioning and clean-up of the civil public sector nuclear sites.
HR	Radioactive Waste Management Centre	Public	Collecting, safeguarding and increasing the value of funds to finance the development, review and implementation of the Programme for the Decommissioning of the Krško NPP. Disposal of radioactive waste and spent fuel, as well as coordinating the preparation and drafting of the National Programme.
AT	Nuclear Engineering Seibersdorf GmbH (NES)	Public/ private	Collecting, processing, conditioning and storing radioactive waste, decontaminating installations and laboratories.
EL	National Center for Scientific Research (NCSR) "Demokritos"	Public	Interim storage facility of radioactive waste at the Institute of Nuclear and Radiological Sciences & Technology, Energy & Safety (INRSTES) of the National Center for Scientific Research "Demokritos"). A National Radioactive Waste Management Committee is planned to be established.
DK	Danish Decommissioning (DD)	Public	Decommissioning and receiving, handling and storage of radioactive waste. Also licensed operator for all radioactive waste.
PL	Radioactive Waste Management Plant (RWMP)	Public	Collection, segregation, and treatment, conditioning and interim storage/final disposal of all radioactive waste arising in the country. Operating the National Radioactive Waste Repository in Rozan.
PT	Higher Technical Institute (ITN)	Public	Collecting, segregating, conditioning and storing solid and liquid radioactive waste.
EE	A.L.A.R.A. AS	Public	Former Paldiski nuclear site and Tammiku radioactive waste repository management and decontamination.
LV	Latvian Environment, Geology and Meteorology Centre (LVGMC)	Public	Processing, reprocessing, storage for an extended period of time (long-term storage) and disposal of radioactive waste.

2.1.4. Regulatory framework and competent regulatory authorities

Member States are required to establish and maintain a competent regulatory authority in the field of safety of spent fuel and radioactive waste management. This authority shall be independent and be given the legal powers, as well as human and financial resources necessary to fulfil its obligations (Article 6 of the Directive).

To date all EU Member States have established national competent authorities with defined responsibilities and legal powers in the area of spent fuel and radioactive waste management (see Table 4). In general, the regulatory authorities also cover nuclear and radiation safety. The majority of Member States have only one competent authority, while in others; two or more

[17] State-owned company CIEMAT (80%) and SEPI (20%).

[18] Reactors licensees.

organisations have competence and regulatory functions in different aspects of spent fuel and radioactive waste management. In these cases, one of the authorities is competent for regulation and oversight of the management of spent fuel and radioactive waste originating from nuclear facilities, while another one is responsible for the safe management of institutional radioactive waste.

In other Member States, there are regional regulatory authorities (such is the case of the United Kingdom and Germany), along with federal or national ones. As a general trend, Member States with nuclear programmes have provided more information and details on the authority that regulates nuclear energy than on the ones responsible for the regulation of the institutional waste.

All Member States declare the independence of their regulatory authorities from any other organisation or body (i) promoting or using nuclear energy or (ii) managing spent fuel and radioactive waste. In most cases, functional or administrative independency is established in the relevant national law. The regulatory authority is in some cases embedded in a Ministry, and in others it is an autonomous body which reports to the national Parliament, the Council of Ministries, or the Government.

In general terms, regulatory authorities from countries without nuclear power programmes are usually small, corresponding to the radioactive waste inventories to be managed, and often form part of the administrative structure of the State. In one particular case, the national regulatory authority does not have staff, or budget, and carries out its regulatory function through staff of other governmental bodies. The regulatory authorities of two EU Member States (Italy and Portugal) are being reorganised with the objective of reinforcing their functional independence, while the regulatory body of the Netherlands has been reorganised recently.

In addition to the functional and administrative independence, technical and financial capacity are also necessary elements for an effectively independent regulatory authority capable of implementing its responsibilities within the licensing system put in place for the safety of radioactive waste and spent fuel. The national reports of most of the Member States have provided information on measures for ensuring technical and financial independency. Examples of such measures include, for instance, ensuring adequate human resources and sufficient funding by law, establishing fees to the licensees, negotiation of the budget, etc. Over half of the Member States have informed on the current status of staff and budget (see Table 4). A few Member States provided information on how the management of the regulatory authority is appointed or dismissed, to show that management is not subject to undue influence in its regulatory mission.

Member States (and in particular those without nuclear energy programmes) face challenges with respect to maintaining adequate human resources in the long term. A few Member States have clearly indicated the available limited budget and/or human resources to perform the regulatory functions of the national competent authorities.

A few Member States have reported that their regulatory authorities were responsible for storage of disused sources.

Table 4. National Competent Authorities for spent fuel and radioactive waste management[19]

MS	Competent authority	Responsibilities for spent fuel and radioactive waste	Reporting to	Staff (year)
AT	Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW)	BMLFUW is the licensing and regulatory authority for the construction and operation of radioactive waste management facilities.	Federal Government	Data not available
BE	Federal Agency for Nuclear Control (FANC)	With regard to the safety of disposal facilities, the competent regulatory authority, i.e. the AFCN/FANC, retains all of its prerogatives	Federal Minister of the Interior	Data not available
BG	Nuclear Regulatory Agency of the Republic of Bulgaria (BNRA)	BNRA has been assigned responsibility for all regulatory matters concerning radioactive waste and spent fuel management facilities	Council of Ministers	103 (2015)
HR	State Office for Radiological and Nuclear Safety (SORNS)	- Establishes the legislative framework in the area of radiological, nuclear and physical safety; - Coordinates the drafting of the Strategy; - Regulates spent fuel and radioactive waste management; - Coordinates the drafting of the National programme for implementation of the Strategy; - Participates in administrative procedures for obtaining permits and authorisations for management facilities included under the Strategy; - Reporting and public information on the management of radioactive waste and spent fuel	The Government of the Republic of Croatia	22 (2015)
CY	Radiation Inspection and Control Service – Department of Labour Inspection (RICS/DLI)	The MLWSI, acting through the RICS/DLI, is the regulatory authority for radiation protection and nuclear safety and has the responsibility for the administration of the relevant legislation and authorisation of all sources and practices involving risks of exposure to ionising radiation or release of radioactive materials in the environment.	Ministry of Labour, Welfare and Social Insurance (MLWSI)	5 (2015)
CZ	State Office for Nuclear Safety (SUJB)	State administration and supervision of the utilization of nuclear energy and ionizing radiation and in the field of radiation protection	Prime Minister	209 (2014)
DK	National Institute of Radiation Protection	As the radiation protection authority, performs duties relating to the use, etc. of radioactive substances, including the management and disposal of radioactive waste	Danish Health and Medicines Authority	No data
	Danish Emergency Management Agency	International cooperation in the area of nuclear safety	Nuclear Division of the Danish Emergency Management Agency	No data

[19] The data does not include staff of separate technical support organisations that exist in some Member States.

EE	Environmental Board	(i) Reviews the applications of the radiation practice licences and the qualified expert licences, provides services ensuring radiation safety; (ii) advises the Environmental Inspectorate, which carries out monitoring and (iii) coordinates and controls the use of the environment and natural resources by applying the coercive measures of the state in the cases determined by law.	Ministry of the Environment	17 (2014)
FI	Radiation and Nuclear Safety Authority (STUK)	STUK is responsible for controlling that the Radiation Act and other regulations based on the Act are followed. STUK grants safety licences for the use of radiation. The regulatory rights of STUK are described in the Radiation Act	Ministry of Employment and the Economy Ministry of Social Affairs and Health	342 (2014)
FR	The Parliament, the Government and Nuclear Safety Authority (ASN)	Regulates, authorises, controls and helps the public authorities to manage emergencies, participate in the public information	The ASN submits regular reports on its activities to Parliament and in particular to the Parliamentary Office for the Evaluation of Scientific and Technological Choices (OPECST) and parliamentary committees	470 (2013)
DE[20]	The Federal Office for Radiation Protection (BfS)	- Approval of interim storage facilities for nuclear fuels; - Planning, construction, operation and decommissioning of repositories; - Repository surveillance	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)	188 (2014[21])
	Federal Office for the Regulation of Nuclear Waste Management (BfE)	- Planning approval and licensing of repositories; - Granting of licences in accordance with mining law; - Mining supervision pursuant to Sections 69 to 74 of the Federal Mining Act; - Granting of permits in accordance with water legislation		planned
	BMUB, the Directorate-General Reactor Safety (RS)	- Competent authority for nuclear safety and radiation protection; - Legal and technical supervision of the Federal Office for Radiation Protection and of the Federal Office for the Regulation of Nuclear Waste Management; - Responsible for the obligations under		36 [22] (2014)

[20] Germany as a federal state, the "regulatory body" and consists of authorities of the Federation and the Länder – the regulatory structure comprised of BMUB, BfE, BfS and the Land Ministry. The Federal Office of Economics and Export Control (BAFA) is responsible for the import and export of radioactive materials.

[21] Department of Safety of Nuclear Waste Management and its six divisions. It is supported by 30 independent experts.

[22] Directorate RS III (Nuclear Fuel Cycle).

		the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management		
	16 Länder	Land Ministry is responsible for licensing and supervision of spent fuel treatment facilities	Federal government	270[23] (2014)
EL	Greek Atomic Energy Commission (EEAE)	Control, regulation and supervision in the fields of nuclear energy, nuclear technology, radiological, nuclear safety and radiation protection. According to its statutory role EEAE has the legal power to exercise the regulatory control of facilities and activities in the fields of radiation protection and radiation and nuclear safety. As described in detail in Article 43, par. 4 of the new Law 4310/2014 the competencies (legal powers) of EEAE include: - development of safety procedures, regulations and legislation; - licensing and inspection procedures; - environmental radioactivity monitoring; - radiological surveillance; - emergency preparedness; - research in the fields of its competence; - public information; - international cooperation and national representations; - education and training; - personal dosimetry and calibration services	Minister of Education, Research and Religious Affairs	74 (2014)*
HU	Hungarian Atomic Energy Authority (HAEA)	The supervisory and administrative regulatory competence relating to nuclear safety and physical protection regarding nuclear installations, radioactive waste disposal facilities as well as nuclear and radioactive materials lies with the HAEA in Hungary. The Atomic Energy Act authorises the HAEA to perform is supervisory activity.	The Minister appointed by the Prime Minister, currently by the Minister for National Development.	80 (2014)
	National Public Health and Medical Officer Service, Office of the Chief Medical Officer (NPHMOS-OCMO)	The national professional and regulatory body is the granting authority for regulations on radiation protection and the radiohygiene units of priority facilities, also participating in the nuclear safety licensing process as the competent authority for radiohygiene health issues.	Minister for Health	49 (2015)
IE	Environmental Protection Agency (EPA)	Regulates radioactive material including practices involving radioactive waste, and radiation sources through a licensing system	Department of Environment, Community and Local Government (DECLG)	34 in the Office for Radiological Protection (2015)

[23] About 120 staff working on radioactive waste management and 150 staff working on support the nuclear authorities of the Länder either at subordinate authorities or as authorised experts.

IT	National Inspectorate for Nuclear Safety and Radiation Protection (ISIN) – new competent regulatory authority established by the Legislative Decree n° 45/2014 Nuclear, Technological and Industrial Risk Department of Institute for Environmental Protection and Research (ISPRA) – until ISIN becomes operational	The assessment and the inspection activities on nuclear installations, as well as for approving detailed designs or activities related to the construction of nuclear facilities, which are part of the general construction licence granted by the Minister of Economic Development	Ministry of Economic Development	No available data
LV	Radiation Safety Centre of the State Environmental Service (SES RSC)	The SES RSC ensures national supervision and control in the area of radiation and nuclear safety, and also organises and coordinates training of the personnel whose work is related to radiation safety in order to increase the level of radiation safety in the country.	Ministry of Environmental Protection and Regional Development	No available data
LT	State Nuclear Power Safety Inspectorate (VATESI)	Regulation and supervision of nuclear safety, radiation safety of nuclear energy activities involving sources of ionizing radiation, physical security of nuclear installations, nuclear materials and/or nuclear fuel cycle materials and accountancy and control of nuclear materials as well as supervision of requirements arising from international nuclear weapon non-proliferation obligations of Republic of Lithuania.	The Cabinet of Government and the President	75 (2015)
	Radiation Protection Centre (RPC)	Regulation of radiation protection	Ministry of Health	59 (2015)
LU	Radiation Protection Division (RDP)	The RPD is in charge of a) preparing the technical aspects of draft laws, regulations and orders b) lays down the conditions for licences. It has also published several guidelines.	Minister for Health	9 (2015)
MT	Radiation Protection Board (RPB)	The functions of the RPB cover all waste activities (and the facilities when they are commissioned).	Ministry of Social Dialogue, Consumer Affairs and Civil Liberties (MSDC)	No available data
NL	Authority for Nuclear Safety and Radiation Protection (ANVS)	- preparing legislation and regulations and policy (including the national programme); - awarding licences and the accompanying review & assessment and evaluation tasks; - supervision and enforcement; informing interested parties and the public; participating in activities of international organisations; - maintaining relationships with comparable foreign authorities and	Ministry of Infrastructure and the Environment (I&M)	122 (2016)

		national and international organisations; - supporting national organisations with the provision of knowledge; - having research in support of the implementation of its tasks.		
PL	National Atomic Energy Agency (NAEA)	Tasks that involve ensuring national nuclear safety and radiological protection, in particular: - supervision over activities; - promulgation of technical and organisational recommendations concerning nuclear safety and radiological protection; - performing the tasks involving the assessment of national radiation situation in normal conditions and in radiation emergency situations, and the transmission of relevant information to appropriate authorities and to the general public; - performing the tasks resulting from the obligations of the Republic of Poland - activities involving public communication, education and popularisation; - cooperation with governmental and local administration authorities in matters involving nuclear safety and radiological protection; - preparing opinions; - cooperation with appropriate foreign national entities and international organisations; - developing the drafts of legal acts; - giving opinions on the draft legal acts developed by authorised bodies	Minister competent for environmental matters	No available data
PT	Regulatory Commission for the Safety of Nuclear Installations (COMRSIN)	- Licensing, evaluating, monitoring and inspecting facilities and activities relating to the management of spent fuel and radioactive waste (encompassing all phases, from initial choice of siting to decommissioning)	COMRSIN is governed by three Commissioners, appointed by the Prime Minister for five year renewable terms, chosen on the basis of academic, scientific and technical merit.	4 (2015)
RO	National Commission for Nuclear Activities Control (CNCAN)	Regulation, licensing, and control of nuclear activities	Prime Minister, through the General Secretariat of the Government	No available data
SK	Nuclear Regulatory Authority of the Slovak Republic (ÚJD SR)	State regulatory activities in the field of nuclear safety of nuclear installations, including management of radioactive waste, spent fuel and other parts of the fuel	The Government and subsequently to the National Council	108 (2014)

		cycle, as well as transport and management of nuclear materials including their control and record keeping system. It is responsible for the assessment of goals of nuclear energy programme and of quality of the classified equipment, as well as for commitments of the Slovak Republic under international agreements and treaties in the said field.		
SI	Slovenian Nuclear Safety Administration (SNSA)	Nuclear safety of facilities and the safety of industrial radiation sources	Ministry of Environment and Spatial Planning	41 (2014)
	Slovenian Radiation Protection Administration (SRPA)	Radiation protection in medicine and veterinary practice, medical surveillance of exposed workers, surveillance of workplaces, dosimetry and dose registers and education in the area of radiation protection	Ministry of Health	No data
ES	Nuclear Safety Council (CSN)	Reporting on nuclear safety and radiological protection and authorisations to nuclear and radioactive installations as well as carrying out inspection and control and issuing Instructions, which take the form of mandatory rules	Parliament	205 (2014)
SE	Swedish Radiation Safety Authority (SSM)	SSM supervises the Swedish Nuclear Fuel and Waste Management Co (SKB), the power plant operators and other licensees of nuclear activities in fulfilling their responsibilities for safe operation of facilities and transports as well as in planning for decommissioning and disposal.	Ministry of the Environment	321 (2015)
UK[24]	Office for Nuclear Regulation (ONR, UK)	Regulates: - nuclear safety; - nuclear site health and safety; - nuclear security; - nuclear safeguards; - transport	Government Department of Energy & Climate Change	330[25] (2014)
	Environment Agency (EA, England)	- Regulates the accumulation and disposal of radioactive waste from non- nuclear premises - Regulates nuclear and non-nuclear sites in England	Government Department of Environment, Food & Rural Affairs	No available data
	Natural Resources Wales (NRW)	- Enforces environmental protection legislation; - Regulates nuclear and non-nuclear sites in Wales	Welsh Government	
	Scottish Environment Protection Agency (SEPA)	- Enforces environmental protection legislation; - Regulates nuclear and non-nuclear sites in Scotland	Scottish Government	

[24] The environment agencies regulate the accumulation of radioactive substances and the disposal of radioactive wastes at all sites, with the exception of radioactive wastes at nuclear sites which are regulated by ONR.

[25] Nuclear safety specialists.

	Northern Ireland Environment Agency (NIEA)	Regulates non-nuclear sites in Northern Ireland	Northern Ireland Assembly	
	Health & Safety Executive (HSE)	- Regulate health and safety for England, Wales and Scotland; - Regulate the use of ionising radiation in the non-nuclear sector	Government Department of Work & Pensions	

*Other sources of information

2.1.5. Shipments within EU and to third countries

Radioactive waste shall be disposed of in the Member State in which it was generated, unless an agreement with another Member State or third country is in force and the conditions set out in Article 4(4) of the Directive are met. The Directive imposes conditions prior to the shipment of radioactive waste regarding safety arrangements in the destination country, and availability, operation and management of appropriate disposal facilities. This requirement is not applicable to: (i) the repatriation of disused sealed sources to a supplier or manufacturer, (ii) the shipment of spent fuel of research reactors to countries that supply or manufacture research reactor fuel (and according to international agreements), or (iii) Krško nuclear power plant spent fuel or radioactive waste shipped between Slovenia and Croatia.

Spent fuel and radioactive waste can be shipped to a Member State or third country for reprocessing and processing. In this case, the ultimate responsibility for the safe and responsible disposal of those materials, including any radioactive waste and by-products that could be generated shall remain with the Member State from which the spent fuel or radioactive waste originates (Article 4 of the Directive).

The majority of Member States have legal requirements in place for the spent fuel and radioactive waste sent for processing or reprocessing abroad, among which the allocation of the ultimate responsibility within the Member State originating the material. In most cases, the ultimate responsibility remains within the Member State or third country in which the spent fuel or radioactive waste was generated. A few Member States have provided the text of the agreements for (re)processing, while others have reported the main provisions of such agreements. In addition, a few Member States report that import of radioactive waste in their territory is excluded by law.

The majority of Member States with research reactors foresee the return of their spent fuel back to the supplier (USA and the Russian Federation) before 2020, without returning the possible arising radioactive waste back to the originating countries. A few Member States with research reactors have plans to ship the spent fuel for reprocessing, and a number of Member States with training and demonstration reactors have not yet defined the strategy for the long term management of spent fuel.

To date, eight Member States that have opted for spent fuel reprocessing will receive radioactive waste after reprocessing in the EU or outside the EU in the period 2017-2052 (see Table 5).

Table 5. Return of By-products from Spent Fuel Reprocessing to EU Member States

MS	Type of material	Timeframe
BE	Around 16 % of the spent nuclear fuel from NPP has been reprocessed in the past at La Hague (France). Most has been returned and the remaining secondary waste will be returned in 2017	2017
BG	Return of HLW from Kozloduy NPP spent fuel reprocessing in Russia	After 2025
CZ	Return of residual waste from highly enriched Uranium (LRV-15 reactor) sent to Russia	2024-2026
DE	Radioactive waste from spent fuel reprocessing in the UK and France is expected to be returned to Germany. Vitrified fission products were already returned from France in the period 1996 - 2011	No information
HU	Planned return of material from spent fuel from planned Paks NPP units 5 and 6 reprocessing in Russia in case reprocessing is decided.	Decision not taken yet
IT	98% of NPP spent fuel is shipped to the UK and France. The remaining 2% will be shipped to France in 2016. The return of radioactive waste from the UK is scheduled between 2020 and 2025.	2020-2025
NL	Waste from spent fuel reprocessing in the UK returned. Part of vitrified HLW from France received and additional expected to be returned	latest in 2052
ES	Products from reprocessing that need to be returned to Spain are vitrified high level waste located in France (spent fuel from Vandellos I NPP) and recovered U and Pu in the UK (spent fuel from Santa Maria de Garoña NPP).	2021[26]

Member States are required to include in their national programmes any agreement(s) concluded with a Member State or a third country on management of spent fuel or radioactive waste, including on the use of disposal facilities (Article 12(1)k of the Directive). Only a few Member States submitted their agreement(s) with other Member States or a third country, while most Member States with no nuclear programmes did not notify having such agreements in place to date.

To date only two Member States have concluded an agreement for management of small amounts of institutional waste (Luxembourg and Belgium). In addition, two Member States (Slovenia and Croatia) are working towards common disposal solution for spent fuel and radioactive waste generated by the shared nuclear power plant (an agreement is expected by 2023).

2.1.6. Self-assessment and international peer reviews

At least every 10 years, Member States shall arrange for self-assessments of their national framework, competent regulatory authority, national programme and its implementation, and to

[26] When interim spent fuel /HLW storage facility is available.

invite international peer review of their national framework, competent regulatory authority and/or national programme. The aim is to ensure that high safety standards are achieved in the safe management of spent fuel and radioactive waste. It is Member State's decision to define the scope, timing and type of international peer reviews as long it complies with provision of Article 14(3) and is carried out by 2023. Member States are required to report the outcomes of these international peer reviews to the Commission and the other Member States, which may be made available to the public, unless there is conflict with security and proprietary information.

The majority of Member States address periodic self-assessments and international peer reviews in a general way in their national programmes and reports. Some Member States have clearly defined timeframes for review and update of the national programmes (which is assumed to cover the self-assessment requirement), however only about a third of the Member States provided information on self-assessment of the national framework for spent fuel and radioactive waste management (see Table 6).

In most Member States self-assessment of the competent authorities has been established and carried out through the IRRS missions of the IAEA. While the majority of Member States reported IRRS[27] missions, a few Member States provide details on the self-assessment outcomes related to spent fuel and radioactive waste management. Although the majority of IRRS missions' reports are publicly available, details on the Member States' follow up actions addressing the outcomes of theses reviews for achieving higher level of safety have been reported by a few Member States.

Therefore, the implementation of this Article requires specific attention in the future Member States reporting to the Commission. Since 2014 the Commission is supporting the IAEA in development of a self-assessment tool based on the IAEA safety standards and best practice to enable EU Member States to fulfil their obligations for periodic self-assessment (Article 14(3) of the Directive). The first reviews in Poland and France are scheduled for 2017.

About a third of the Member States report on the planned international peer reviews related to their spent fuel and waste management, however a few Member States present specific timeframes of planned international peer reviews in their national programmes and reports on spent fuel and radioactive waste management, and clearly explaining the mechanisms for taking into account lessons learned in the review of the national programme. The Commission is aware through ENSREG that eight Member States have specific plans to conduct ARTEMIS[28] peer review service and to host missions until 2023 (for details see Table 6).

[27] Integrated Regulatory Review Service of the International Atomic Energy Agency.

[28] Since 2014 the Commission is 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.

Table 6. Recent and planned international peer reviews as per Article 14(3) of the Directive[29]

MS	National programme and/or National framework	Competent regulatory authority
BE	No information	2013 (IRRS), 2016 (IRRS follow-up)
BG	No information	2016 (IRRS follow-up)
CZ	No information	2017 (IRRS)
FI	2009 (OSART[30] for the spent fuel disposal facility), 2023 (ARTEMIS)	2012 (IRRS), 2015 (IRRS follow-up), 2023 (IRRS full scope)
FR	1996 and 2005, IAEA Review of specific waste management projects 2017 (ARTEMIS)	2014 (IRRS)
DE	2019 (ARTEMIS)	2018 (IRRS full scope)
HU	No information	2012 (IRRS follow-up), 2015 (IRRS)
IT	No information	2016 (IRRS)
LT	2019 (ARTEMIS, self-assessment) 2021 (ARTEMIS)	2016 (IRRS full scope), 2018 (IRRS follow-up)
NL	2023 (ARTEMIS)	2014 (IRRS) and 2018 (IRRS follow-up), 2023 (IRRS full scope)
RO	No information	No information
SK	No information	2012 (IRRS follow –up)
SI	No information	2011 (IRRS) and 2014 (IRRS follow-up)
ES	2018 (ARTEMIS)	2008 (IRRS), 2011 (IRRS follow-up)
SE	2009 Plan review through IRRS (2012); SKB post-closure safety case NEA/OECD review (2012); WANO review of SKB SFR and Clab operation (2013)	2012 (IRRS), 2016 (IRRS follow-up)
UK	OSART for Sizewell B site planned.	2006, 2009, 2013 (IRRS) and 2014 (IRRS follow-up)
AT	No information	No information
DK	2019 – 2021 period (ARTEMIS)	2019 – 2021 period (IRRS)
EL	No information	2012 (IRRS)
LV	No information	No information
PL	2017 (ARTEMIS)[31]	2013 (IRRS)
PT	No information	No information
HR	No information	2015 (IRRS)
CY	No information	2017 (IRRS)
EE	No information	No information
IE	No information	2015 (IRRS)
MT	No information	Self-assessment in 2014 and 2015 (IRRS)
LU	After 2018	2018 (and expanded IRRS)

29 The information in grey is provided by Member State through the ENSREG Working Group 2 or other source (e.g. IAEA), however not included in the national programmes and reports of Member States.

30 IAEA Operational Safety Review Team for peer reviews of operational safety performance at a nuclear power plants.

31 Information to Commission after the notification of the Polish programme and report.

2.1.7. Notification and reporting

To date all Member States have submitted their first reports as required by Article 14(1) and a few Member States (Czech Republic, Germany and Estonia) have notified their Joint Convention[32] reports (dated 2014) for the 5th Joint Convention review meeting (held in May 2015) to the Commission as part of their national programme/reports required under Article 15(4) and Article 14 (1) of the Directive.

With exception of one (Latvia), all Member States submitted to the Commission their final (22 Member States) or draft programmes (5 Member States – Austria, Croatia, Czech Republic, Italy and Portugal) that currently undergo formal approval at a national level. Slovenia and Spain national programmes have been drawn-up in 2006 and therefore some of the information reported is out-dated but both of these countries have presented updated information on the spent fuel and radioactive waste management activities in their national reports, as well as an updated inventory of the spent fuel and radioactive waste. All this information has been used in the preparation of this report[33].

As the Member States' deadline for notification of their national programmes was 23 August 2015, the Commission opened 12 EU pilots for non-communication of the national programmes in October 2015. Three Member States submitted their final programmes in January 2016 and the Commission then proceeded with nine Letters of Formal Notice in April 2016. In response the Commission received three additional national programmes by August 2016. The majority of remaining Member States planned to notify their approved programmes by the end of 2016, although a few Member States foresee submission in 2017 due to the long approval process in the country.

2.2. Assuring the safety of spent fuel and radioactive waste management

2.2.1. Licence holder's responsibilities

Member States shall ensure that the prime responsibility for the safety of spent fuel and radioactive waste management facilities and/or activities rest with the licence holder; and that responsibility cannot be delegated (Article 7 of the Directive).

All Member States have reported that measures are in place to ensure that the primary responsibility for spent fuel and radioactive waste management is with the license holders. The provisions presented are mainly legal and focus on legal requirements, license conditions and enforcement actions in case of non-compliance. However, in some cases examples have provided with regard to their practical implementation of these legal provisions.

Licence holders shall establish and implement integrated management systems, which give due priority for overall management of spent fuel and radioactive waste to safety and are regularly verified by the competent regulatory authority. Overall the majority of Member States have reported their legal requirements for integrated management system or quality assurance for spent fuel and radioactive waste management that focus on safety. Limited information has been provided in the national reports on how these requirements are implemented in practice by all radioactive waste and spent fuel management license holders. The majority of Member States with nuclear facilities provided more details on integrated management and quality assurance systems within their national operators, bodies or organisations related with nuclear facilities (through examples in some cases), and less within organisations dealing with institutional waste. A few Member States have not addressed management system in their reports.

---

[32] Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Management.

[33] The updated national programme of Slovenia has not been taken into account, as it is currently under assessment.

Licence holders have to provide for and maintain adequate financial and human resources to fulfil their obligations for safe long term management of spent fuel and radioactive waste. Overall Member States have legally established requirements in this regard, such as, a license can be granted only in case the applicant does demonstrate sufficient human, technical and financial resources. The majority of Member States with nuclear programmes state that the financial and human resources are enough or adequate, without providing further details. In some cases, these countries establish in their national framework a generic requirement of adequate resources. A few Member States with nuclear facilities have provided very detailed information on human and financial resources currently available in the licensees.

2.2.2. Concepts and plans (including post closure)

National programmes shall include the concepts or plans and technical solutions for spent fuel and radioactive waste management from generation to disposal (incl. post-closure phase), in particular related to institutional control and preservation of knowledge in the longer term (see Article 12(1)d and Article 12(1)e of the Directive).

Overall the predisposal management of radioactive waste is a practice with long Member States' experience, and Member States either have capacities or plan to develop additional ones until disposal options remain available at national or international level. Concepts and/or plans and technical solutions for predisposal management of spent fuel and radioactive waste are defined in different level of detail by all Member States with present or past nuclear programmes.

Due to the long timeframes until geological disposal facilities become operational in most nuclear power plant Member States, the importance of spent fuel, HLW and ILW sufficient storage capacity is increasing. For example, some Member States already have plans for construction of mainly dry storage facilities for spent fuel, either new or expanding the existing capacities.

Contrary to this, disposal concepts for ILW, HLW and spent fuel are, instead, not as well developed and detailed in most of the countries. Regarding geological disposal, about over half of Member States have disposal plans spanning up to the next century, and one third of Member States plan to operate such facilities after 2040. A number of Member States with new build programmes have not considered the additional storage/disposal capacities in their national programmes.

The plans for spent fuel management in majority of the Member States with existing and planned nuclear programmes are to dispose this fuel without reprocessing, except for the few Member States which are reprocessing (France and the UK) or have ongoing reprocessing arrangements with France, the United Kingdom, and the Russian Federation.

There are plans of 15 Member States for geological disposal facilities, the majority planned to be operational after 2065 (the first three in Finland, France and Sweden by 2030, see Table 7). In order to facilitate the development of such complex projects five underground laboratories are in operation in four Member States. Three more laboratories are foreseen in Czech Republic, Poland and Romania as presented in Table 13. Some of the remaining countries consider as an option the disposal either in EU or in a third country (see Table 7). At the same time, a number of Member States presented their plans for finding solutions for disposal of exotic waste from research activities.

A few Member States with nuclear programmes did not address all types of radioactive wastes as their programmes mainly focused on nuclear power plant waste and spent fuel. Management solutions for some types of radioactive waste like orphan sources and institutional wastes (e.g. disused sealed sources categorised as radioactive waste) have not been addressed in detail in the national programmes.

Table 7. Planned Deep Geological Disposal Facilities[34] in EU Member States

MS	Siting	Commissioning	Operation (years)	Closure	Institutional Control	Cost (€[35])	Responsible organization	Comment
FI	Eurajoki (Olkiluoto) site	2022	90	2110	Not foreseen	3.5 bn (2012, 5 units)	POSIVA	Licence for construction (2015)
FR	Cigeo: sited in the Border of the Meuse and Haute-Marne	2025	more than 100	After 2125 [36]		16.5 bn (2012) [37]	ANDRA	100 year reversibility; concept for submission for authorization
SE	Forsmark site	2019-2030	45	2075-2076	Not foreseen		SKB	Licence application for construction under review
UK	2016	2040	until 2089	2120		9,5 bn £ (2014/2015) (undiscounted)	NDA	2016 is a formal process of working with communities for potential sites; start receiving ILW and LLW in around 2040 and HLW in 2075
DE	After 2031	2050				7.7 bn	Federal Office for Radiation Protection	The cost is for a new geological disposal facility
RO	2025	2055	100	2150		1.02 bn (2 units) to 2.04 bn (2006) USD (4 units)	ANDR	Siting not started yet

34 The terms near surface, intermediate depth and deep geological disposal are used in the meaning of IAEA Safety Guide GSG-1 "Classification of Radioactive Waste", 2009.

35 Otherwise specified.

36 Law on reversibility (100 years) passed in 2016.

37 http://cigeo.com/en/project-cost.

MS	Siting	Com-mis-sioning	Opera-tion (years)	Closure	Institu-tional Control	Cost (€[35])	Respon-sible organi-zation	Comment
HU	Site selection ongoing	2064	20[38]	2084[39]	Not yet establish ed	745 278.5 mill HUF (2015)	PURAM	Research activities are planned
SK	Site selection first stage (2013-2016) Sit selection in 2030	2065	40-60	2105-2115	Not foreseen	3.7-4.4 bn (2014)	JAVYS	3.7 bn for 40 years NPP operation and 4.4 bn for 60 years NPP operation
SI	Site to be selected (2045-2055)	2065	10	2075	No data	Not available	ARAO	Agreement with Croatia pending
HR	2043	2065						Possible agreement wih Slovenia by 2023
CZ	2018	2065				4.1 bn (2011) or 111.400 mill CZK	SÚRAO	Ongoing site selection; two sites to be selected
LT	2033	2066	6	2072		1.89 – 2.6 bn	Ignalina NPP/ RATA	
ES	2016-2050 (including knowledge update)	2050-2069	2069			3 bn (2005)[40]	ENRESA	
BG	Prefeasibi-lity study ongoing and 6 potential sites selected					Not available	SERAO	No con-cepts as yet for ILW / HLW other than interim storage
NL	Decision in 100 years	About 2130				1.5-2.5 (1996-2000)	COVRA	Costs for "final storage". Decision in 100 years

38 If Hungary opts for reprocessing of the spent fuel of the new-built, the operation of the deep geological disposal will be 50-60 years instead.

39 Could be 2114-2124.

40 Data from the 6th General Radioactive Waste Plan. In addition, the estimated total cost for spent fuel management is about 7 bn (2015) for a 40 years NPP operation scenario.

MS	Siting	Com-mis-sioning	Opera-tion (years)	Closure	Institu-tional Control	Cost (€[35])	Respon-sible organi-zation	Comment
BE	No date defined pending national policy	Not available	15 years after authorisation is given	at least 100 years after construction and operating license		3.2 bn (2012)	ONDRAF/NIRAS	The disposal cost is for waste category B and category C
PL	22nd century	22nd century	around 50 years	Mid-22nd century		Not available	RWMP	New build

In most of the Member States without nuclear programmes the disposal options for radioactive waste are only at a conceptual level and the pertinent research and siting activities have been postponed in some cases for several decades.

Radioactive waste predisposal activities in Member States without nuclear programmes are predominantly related to storage of disused radioactive sources, and return of disused sealed radioactive sources to the supplier.

To date over 30 dedicated disposal facilities for VLLW and LLW are in place in 12 Member States. Bulgaria, Latvia and Lithuania categorised their past disposal facilities of RADON type [41] as storage facilities. About half of Member States are planning to build new disposal facilities and capacities in the next decade (see Table 8).

The types of facilities range from landfills, trenches to vault type disposal facilities depending on the type and class of radioactive waste disposed. These facilities are mainly in the Member States with nuclear programmes and in a number of cases. In addition to Bulgaria and Lithuania, a few Member States also plan or consider remediation of existing disposal facilities and contaminated sites (e.g. Germany).

41 "RADON" type facilities for institutional waste built in the 1960s.

Table 8. Near surface and intermediate depth disposal facilities in EU

MSe	Existing/ planned	Siting	Commissioning	Operation (years)	Closure	Institutional Control (years)	Responsible organization	Comment
BE	Planned LLW (Category A waste)	Dessel site	4 y after construction/operation license	54 y after construction/operation license	104 y after construction/operation license	250	ONDRAF / NIRAS	Under licensing application review for construction
BG	Existing for LLW and ILW (institutional waste)	Novi han site	1964				SERAW	Used for storage. Planned decommissioning by 2025
	Planned near surface	Radiana	2021		2086		SERAW	
CZ	Dukovany (existing)	Duckovany NPP	1995		2050	300	SÚRAO	Capacity until 2050
	Hostim (existing)	Beroun	1959		1965	Ongoing	SÚRAO	Closed
	Bratrstvi (existing)	Jáchymov	1974		2020	100	SÚRAO	Capacity until 2020 for NORM waste
	Richard (existing)	Litoměřice	1974		2025	100	SÚRAO	Capacity until 2025; considered extension afterwards
EE	Planned	2018	2040		2050		A.L.A.R.A. AS	Concept for low and intermediate level waste disposal to be decided
FI	Lovisa NPP (existing)	Lovisa	1998		2060	Not required	TVO	
	Olkiloto NPP (existing)	Olkiloto	1992		2080 or 2100	Not required	FORTUM	
	Hanhikivi (planned)		After 2035		2120	Not required	FVO	
FR	Centre de L'Aube (existing)	Aube district	1992		Later than 2050	300	ANDRA	Low level waste and intermediate level waste-short lived

	Centre de La Manche (existing)	Manche district	1969		1994	300 (since 2003)	ANDRA	
	Cires (existing)	Morvilliers	2003		Saturation in 2025		ANDRA	VLLW disposal facility
DE[42]	Konrad	2007	2022		Several decades		Federal Office for Radiation Protection	Under construction
	Morsleben (existing)	Morsleben	1971	Until 1998	In progress		BfS	Closed under licensing
HU	Radioactive Waste Treatment and Disposal Facility (RWTDF, (existing)	Püspökszilágy	1976		2067	150	PURAM	Institutional waste
	National Radioactive Waste Repository (NRWR, existing)	Bataapati	2008		2084	50	PURAM	Waste nuclear power plants
IT	National repository (planned)	planned	2015 - 2018				SOGIN	Technology parc
LT	RADON (Existing)	Maišiagala	1964		1989			For institutional waste to be retrieved and facility remediated. Site release in 2023
	Industrial landfill for VLLW disposal (planned)	Ignalina NPP			Decision to retrieve or leave 2018 - 2025		RATA	Planned investigation for possible conversion of an existing industrial landfill to a VLLW disposal facility
	VLLW (planned)	Ignalina NPP	2018		2038	Active 30 Passive 70	RATA	
	LILW Ignalina (planned)	Ignalina NPP	2020		2021	Active 100 Passive 200	RATA	

[42] Asse II salt mine remediation is planned around 2033.

	Bituminised Ignalina (planned)	Ignalina NPP	Decision in 2022					
LV	Baldone (existing)	Baldone	1962				LEGMC	Also used for storage
PL	NRWR (existing)	ROZAN	1961		2024-2029	300	RWMP	Operating
	NNRWR (planned)	Selection in 2018	2018-2024		2144-2155	300	RWMP	Planned
RO	BaiTa-bihor (existing)		1986		2050-2055	100 active 200 passive	ANDR	
	DFDSMA (planned)	2017	2021		2090	100 active 200 passive	ANDR	
SI	LILW (Planned)	Site selected: Vrbina in 2009	2020		After 2061		ARAO	Pending agreement with HR
HR	Institutional radioactive waste disposal (planned)	Cerkezovav	2025	2062	After 2065			NPP waste disposal to be agreed with SI
ES	LLW and ILW (existing)	El Cabril	1992		2040	300 years	ENRESA	
	VLLW (existing)	El Cabril	2008		2040	60 years	ENRESA	
SK	Mochovce LLW (existing)	Mochovce	2001	After 2080	Extension to be decided in 2018	several decades active; and 200-300 passive	JAVYS	Existing; extension to be decided in 2018
	Mochovce VLLW (planned)	Mochovce	2018				JAVYS	
SE	SFR (low and intermediate level waste) (existing)	Forsmark	1983-1988		Extension requested in 2014	2070-2075	SKB AB	Expected extension in 2023
	SFL (long lived low and intermediate level waste) (existing)	License to be submitted in 2030	Planned 2045			2075	SKB AB	
	Forsmark NPP (VLLW) (existing)	Forsmark				30	Forsmarks Kraftgrup p AB	Operational
	Oskarshamm NPP (VLLW, existing)	Oskarshamm				30	OKG AB	Operational
	Ringhals NPP (VLLW, (existing)	Ringhals				30	Ringhals AB	Operational

UK	Studsvik (VLLW, (existing)	Studsvik			30	AB SVAFO	Operational
	Drigg VLLW/LLW (existing vaults and trenches)	Sellafield	1950	2050	100	Low Level Waste Repository Limited	Foreseen extension of capacity after 2050 for operation until 2129
	CLESA (existing)	Sellafield		2026			Decommissioning waste and site clearance waste
	Calder landfill VLLW	Sellafield					
	South landfill VVLW (existing)	Sellafield					
	Dounreay shaft (existing)	Dounreay		2005			closed
	Dounreay LLW (existing)	Dounreay 2014		2028		Dounreay Site Restoration Limited (DSRL)	
	Onsite pits and trenches (existing)	Harwell, Springfield, Sellafield, and Dounreay					

The national programmes should address post-closure measures for disposal facilities and measures for knowledge preservation (Article 12(1)e of the Directive).

The majority of countries cover the post-closure period only in very general terms or did not address the post closure measures for the disposal facilities in their notifications. Of the countries with a present or past nuclear programmes, only a few have presented detailed and defined plans for the post-closure period of the disposal facilities. Some of the countries present plans for the post-closure period only for the near-surface disposal facilities while the post-closure period of the deep geological facilities is either not detailed or not foreseen. The main reason provided in this case was either no availability of operational disposal facilities and/or that it is premature to consider this phase now, including the fact that a number of countries leave open the possibility for a regional solution to the disposal of spent fuel and high level wastes.

Information on the preservation of knowledge after the closure of the disposal facilities is in particular not available in most of the national programmes submitted.

2.2.3. Safety demonstration

The licensees shall regularly assess, verify and continuously improve, as far as is reasonably achievable, the safety of the radioactive waste and spent fuel management facility or activity in a systematic and verifiable manner, by applying the graded approach (see Article 7 of the Directive). The majority of Member States presented the legal basis and provisions for regular safety reviews, however a few concrete examples of how these provisions have been applied in

practice were available (e.g. stress test after Fukushima, safety assessment for spent fuel facilities).

Safety demonstration shall cover activities and facilities (i.e. development, operation and decommissioning), as well as the post-closure phase of disposal facilities (see Article 7(3) of the Directive). The majority of Member States have addressed safety demonstration in their reports mainly through presentation or reference to established legal requirements. About one third of Member States (mainly Member States with nuclear power plants) have addressed safety demonstration in their reports though concrete examples of safety assessments and safety cases mainly, for large nuclear facilities and producers of spent fuel and radioactive waste. Member States with research reactors and non-nuclear programmes provide little information on practical examples of safety demonstrations and their results, as well as implementation of emergency preparedness measures.

2.2.4. Cost assessment, financing mechanisms and available resources

Article 12(1)h of the Directive requires Member States to provide cost assessments for spent fuel and radioactive waste management in their national programmes, including assumptions used and profile over time. Over two-thirds of Member States included information about individual costs (e.g. disposal) or costs estimates for spent fuel and radioactive waste management in their national programmes.

The information on the cost assessments is mainly provided by Member States with nuclear programmes and research reactors, which represent the majority of spent fuel and waste inventory in the EU. While 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. Member States with only institutional waste have not provided cost estimation.

Based on the reported data, the estimated total cost for the management of spent fuel and radioactive waste in line with the Member States national programmes to date is about EUR 400 bn (see Table 9) which for some Member States includes also costs for decommissioning. A very significant part of the total cost is for 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. The data has not been verified by the Commission.

To put this figure in perspective and taking into account the total estimated production of electricity until the end of the NPP lifetime, the estimated cost for implementation of the Member States national programmes represents about 4 to 6% of the electricity generation cost from NPPs[43]. Some of the data differ from the PINC[44] as the national programmes in addition to NPPs cover also other facilities (e.g. research reactors) as well as costs of remediation of contaminated sites from past practices.

It can be noted that Member States with nuclear programmes applied two main approaches to cost assessment – different scenarios based on different hypotheses (e.g. including or not life time extension of nuclear power plants) and, variation of parameters for one base or reference scenario.

About half of Member States provide information on the assumptions and other data explaining the basis for the estimation, however with different level of detail. The scope of assessments also

[43] Assuming average cost of 20 to 30 cents per kWh.

[44] Communication from the Commission Nuclear Illustrative Programme presented under Article 40 of the Euratom Treaty for the opinion of the European Economic and Social Committee {COM(2017)237}.

differs, as some Member States presented only waste disposal costs, other included decommissioning cost (including management of decommissioning waste) as well. In some cases, the cost for management of research reactor spent fuel (i.e. storage in EU and repatriation to the state of origin) was not reported. The cost of management of institutional waste is not often clearly presented in the Member States' programmes. In some cases, the cost presented does not include all facilities, and in other cases, the costs are estimated for a fraction of the programme (for instance only until the next revision of the national programme). Most Member States with large nuclear facilities have established mechanisms for the periodic update and review of the cost estimation.

Member States are also required to have adequate financing mechanisms (Article 12(1)i, Article 5(1)h and Article 9 of the Directive). So, all Member States have presented their mechanisms in place for the funding of their national programmes, with diverse levels of details. Member States with nuclear facilities have opted for different arrangements. A few Member States have internal funds (e.g. within the companies generating spent fuel and radioactive waste) established by large electricity producers. Member States with institutional waste declare that the cost of waste management will be covered by the fees that the waste management organisation charges to the radioactive waste/spent fuel generators.

Financial mechanisms provide in most cases for regular and independent assessment, and stringent legal constraints to ensure that the funds are in effect spent for the purposes for which they were created.

More than half of Member States provided information about the status of the funds for spent fuel and/or radioactive waste management at different level of detail as presented in Table 10. Lithuania and Estonia have indicated their reliance on EU funds for radioactive waste and spent fuel management, while a number of Member States declared insufficiency of funds to date.

Table 9. Estimated total cost of spent fuel and radioactive waste management based on EU Member States' programmes

Member State	Estimated total costs, bill€ (year)	Timeframes	Assumptions	Generated capacity (TWh, total estimated for the lifetime)[30]
BE	4.6 (2012)[45]		Category A and B disposal costs of: 1.38bill€ for near surface disposal facilities and 3.2bill€ for geological disposal	1748
BG	2.0-4.5 (2015)	2030	Decommissioning, spent fuel processing and. storage for Kozloduy NPP units 1-4 and 5-6. The range of costs depends on the extension or not for units 5 and 6.	807
CZ	4.2 (2011)	geological disposal after 2160	Low and intermediate level waste disposal up to 2050 3,250 CZK mill (2013) = 0,11 bill Eur; and 0.037 CZK/€; includes also decommissioning	1334
FI	6.5 (2012)	2110	Not including future NPPs' 100 mill € for near surface disposal and 3,5 bill € for geological disposal	1041
FR	89 (2011 prices)	2135	Including institutional control; 35 bill€ for legacy sites recovery; 38 bill € decommissioning; 16 bill € for geological disposal (although now reassessed to 25 bill€)	21076
DE	66.9 (2012)	2080	34 bill € for NPP waste, Asse - 5 bill€; Morsleben – 2.4-4.7 bn€; Konrad – 7.5 bn € and new geological disposal facility – 7.7 bn €; public radioactive waste management - 6 bn €; Gorleben site - 2 bn € (40 mill€/year for 50 years until 2065) all at 2012 prices	5234
HU	5.3 (2015)	2064	1 650 402 mill HUF (2015) for: - Decommissioning of 4 NPP Units in operation; - Decommissioning of spent fuel interim storage facility (ISFS); - Radioactive waste disposal facilities; - HLW disposal facility; - PURAM operating costs, supervision fees, fund management and support to local governments.	624
IT	18.1	2030 (excluding geological disposal)	1,5 bill € for siting and construction of the Technological Park	143
LT	2.5 (2005-2014)	2038 (but before geological	RAW management and disposal & SF management: 560.2 mill €	311

[45] Based on data provided by the Belgian Ministry of Economy the cost for radioactive waste management in Belgium is €9.2 bn and for decommissioning – 4.6 bn €, in total €13.8 bn (see footnote 132 of PINC SWD(2017)158).

		disposal)	(decommissioning plan 2014) Close Maišiagala repository: 4.2 (specific programme 2013) Other activities: 47.7 (present cost 2014); SF disposal: 1889.0 (feasibility study 2005)	
NL	1.5-2.5 (1996-2000)	No data	Cost for "final storage"	202
RO	1.8 to 3.5	Geological repository development should start from 2040	Average of 1.8 and 3.5bill€. 3,5bn € (includes 2 new reactors) and 1.8bn€ without new build	448
SI	0.31 (2005)	2006-2065	Total costs for 2005-2065 extrapolated from 2006-2015 costs	138
SK	8 (2014)	2060		707
ES	20 (2015)	2085	Total cost incurred until the end of 2014-5.2 bn; and future costs (2015) - €14.7 bn	3126
SE	10 (2013)	From 2015 onward	January 2013 price level	3386
UK	147.5 (2014)	NDA costs till 2130	The NDA, having considered a number of scenarios, continues to estimate the undiscounted cost within a potential range from £95 bn (€118 bn) to £218 bn (€272 bn)	3445
HR	0.9 (2015)	After 2043	Immediate decommissioning of the Krško NPP after shut-down in 2043, The cost includes, waste management, spent fuel and decommissioning	138
AT	No data	No data		-
DK	No data	No data		-
EL	4.6×10^{-3}	Next 5 years	Costs cover for collection and storage of disused radioactive sealed source	-
PL	99×10^{-3}	2025	The cost excludes future NPP and geological repository	-
PT	2.5×10^{-3}		Cost for the spent fuel transfer to USA remaining fuel & decommis-sioning	-
CY	0.5×10^{-3} (2016)		Cost of repatriation or disposal, and operational costs of the storage included in Nicosia General Hospital	-
EE	4.6×10^{-3}			-
IE	No data	No data		-
LV	1.08		2002 costs for construction radioactive waste management, Im-proving safety, compensation to Baldone municipality for radioactive waste storage facility	-

LU	No data	No data	Costs for shipment to Belgium. The government states it is capable of covering any cost	-
MT	No data	No data		-

Table 10. Financial mechanisms and accumulated funds by Member State

MS	Financial mechanisms (organisation)	Gradual	Internal (I)/ External (E)	Funds accumu lated (bn €)	Total accumu lated (date)	Preliminary estimate of available funds[46] (%)	Comments
BG	Radioactive waste management fund (SE RAO)	Annual fees	E	0.845 (2003)	0.845b€ (2003)	19 to 20 (the latter assuming 6 units and LTO)	EU funds for Kozloduy NPP units 1 to 4 are taken into account. Recognised insuffiency of fund to date.
	Decommission ing fund (SE RAO)	Annual fees	E	1.4 (2015)			
CZ	Nuclear Account for SF & RAW (Ministry of Finance)	Annual fees	E	1.4 (2014)	1.4 (2014)	33	37.4b CZK, 2014 (0.037 CZK/€)
HU	Central Nuclear Financial Fund	Annual fees	E	0.8 (2015)	0.8 (2015)	15	Fund to cover the costs for management of waste, spent fuel and decommissioning; 246,386 mill HUF, 2015 (0.0032HUF/€)
SK	National Nuclear Fund	Annual fees	E	1.2 (2015)	1.2 (2015)	18	
FI	The State Nuclear Waste Management Fund	Annual fees	E	2.5 (2016)	2.5 (2016)	38	Does not include new build
BE	Long-Term Fund (NIRAS/OND RAF)		I	No information	-	-	
DE	Private generators		I	36 (2015) reported for	36 (2015)	54	Based on the total cost 66.9 bn€ (as

[47] The costs notified by Member States have not been verified by the Commission. The figure in the column is indicative and is based on the available financial resources vs total costs in the national programme and report reported by a Member State.

	(NPPs) make provisions[47]			NPPs			at 2012) until 2080 and 2103
FR	Licensees create a portfolio of dedicated assets.		I	43 (2011)		48	As dedicated internal funds & assets
IT	State pays for state owned facilities. SOGIN manages the funds for waste management	Annual fee		No information	-	-	The national programme cost is until 2030 and exclude geological disposal. Private generators shall pay to a fund (no details on the fund available)
LT	Decommissioning Fund for Ignalina Nuclear Power Plant, State Budget, Ignalina Programme, INPP, Other funds			No information	No information	-	The national report states that the funds are sufficient SF and RAW management until 2020. Reliance on EU funds after 2020. Decommissioning continues until 2038
NL	Contributions to COVRA		E	183 mill (2014)[48]	-	8	Temporary surface storage for at least 100 years. Operation of geological disposal in 2130.
RO	Waste Disposal Fund (ANDR)	Annual fees	E	102 million (2014)	0.15 (2014)	4 - 8	4% for new build scenario and 8% without new build. Financing mechanism under revision to address the insufficiency of funds

[47] For public generators of spent fuel/radioactive waste, resources are entered in the respective current budget for the decommissioning and dismantling costs.

[48] Ministry report states that "final storage" reserves at the end 2014 € 68 mill, "long term storage" reserves € 102 mill, and additional costs of € 13 mill. The long-term reserves are made increased yearly by 4.3 % (2.3% real+ 2% inflation).

	Decommissioning Fund (ANDR)	Annual fees	E	47 million (2014)			209 million Lei (€47 million)
ES	Fund for the financing of activities included in the General Radioactive Waste Plan	Annual fees	E	19.96 (from 2015 onward)	5.2	35[49]	costs to 2085; future costs considered only
SI	Fund for Financing the Decommissioning and Management of Radioactive Waste from the Krško NPP	Annual fees	E	0.04	0.04	13	Estimates only made for period 2006-2015. financing the decommissioning of the NPP and for the disposal of NPP radioactive waste
SE	Nuclear Waste Fund	Annual fees	E	SEK 56 bn. and 19 bn SEK guarantees	76.3 bn SEK (2015)	75	Total of 76.3 bn SEK. Only remaining costs considered. 56% coverage if guarantees are excluded
	Studsvik Legacy Fund		I	1.3 bn SEK (2013)			
	Non-nuclear waste management of orphan sources		E	127 mill SEK			
UK	NDA Fund	State funds		83.8 (2015)		30-70 depending on the scenarios	67 bn £ = (0.8P/€) (activities until 2130, and total NDA cost between 95-218 bn £)
	Nuclear Liabilities Fund	Annual fee	E	8.3 (2015)			8.3 bn £ (2015)
HR	Fund for Financing the Decommissioning of the Krško Nuclear Power Plant and the Disposal of NPP RAW and SF	Annual fees	E	0.2 (2013)		22	0.16 bn € as at 2013, if reactor extension is up to 2043 then estimated to 0.54bill €

[49] Future costs (€14.7 bn) considered only.

AT	Final disposal fees paid to the Government	Fees for treatment and dis-posal	No information	-	-	
EL	Fund yet to be established		No information	-	-	4.6 mill€ costs over 5 years for collection & storage of disused radioactive sealed sources.
DK	No information		No information	-	-	
PT	Disposal revenue; General state budget and IST budget	Fees from producers	No information	-	-	US transfer of remaining fuel to be covered by the State; increase of fees foreseen in 2015
PL	RWMP collects fees	Fees for disposal, decon-tamina-tion, and transport	No information	-	-	Decommissioning fund for the new build to be established
CY	Fund planned	Currently genera-tors' fees and State budget	No information	-	-	The fund costs will cover waste management (incl. disposal), decommissioning, R&D, etc.
EE		Estonian environm ental fees E EU funds Fees from waste producers	No information	-	-	Reliance on EU funds for historical liabilities
IE		Currently gene-rators' fees and State budget	No information	-	-	The state cost cover orphan sources. The regulators income in 2012 was 5.2 mill € but not specifically for radioactive waste
LV		Currently gene-rators' fees and State budget	No information	-	-	Provisions for Salaspils research reactor assumed by the State

MT		Currently gene-rators' fees	No information	-	-	State to cover the cost of orphan sources
LU	Government will provide necessary resources	Currently gene-rators' fees	No information	-	-	Statement for all necessary resource available

Limited information has been reported on the funds' investments and management to ensure availability of funds when needed in the future.

2.2.5. Expertise and skills

All parties in Member States have to make arrangements for education and training for their staff, as well as research and development activities to cover the needs of the national programme for spent fuel and radioactive waste management in order to obtain, maintain and to further develop necessary expertise and skills (Article 8 of the Directive).

The majority of Member States have legal requirements for training and education of staff involved in spent fuel and radioactive waste management. About half of Member States has presented specific measures in place for maintaining skills and competence of generators, operators and competent authorities, although the emphasis was more on training and competence of regulatory body's staff and less on research and development.

Overall Member States with nuclear power plants have presented more developed practical arrangements for training and education than the remaining Member States. Some Member States presented very detailed training programmes and information on the costs/investments for training and skills development

Member States use national schemes and arrangements that can be summarised as follows:

- Post-graduate courses at universities;
- Training centres (basic and specialized, some of which at nuclear power plants);
- Training programmes or plans (i.e. at national, facility, or organizational entity level);
- Regular self-assessments of staff and needs analysis;
- Specialised, regular training for different levels of staff (e.g. or on-the job training with experienced staff);
- Specialized courses (e.g. for newcomers or experienced staff).

International exchange of experience through peer reviews, workshops, conferences, visits, etc. has been recognized by Member States as useful tool in particular for non-nuclear Member States.

2.2.6. Research and development

Each Member State programme shall include the research, development and demonstration activities needed in order to implement solutions for safe long term management of spent fuel and radioactive waste (see Article 12(1) f of the Directive).

To date the research programmes in the EU are at different level stage of implementation depending on the status of implementation of their national programmes. Member States have long experience in national and international projects (including EC research framework programmes) that cover various aspects of predisposal and disposal.

They are mainly developed by the Member States with nuclear programmes, where four Member States currently operate five underground research laboratories for spent fuel, HLW and ILW disposal and four more Member States plan to develop such laboratories after 2020-2030 period to support the national geological disposal projects (see Table 11).

Table 11. Underground research laboratories (URL) for Disposal of HLW/Spent Fuel in EU[50]

MS	URL	Site	Status	Purpose	Responsible organization for facility development
BE	HADES	SCK•CEN site at Mol	In operation	Methodological and non-site-specific URL in Boom clay (poorly-indurated) at ~ 230 m depth on; has been extended as part of ongoing PRACLAY project.	EURIDICE (cooperation of ONDRAF/NIRAS & SCK CEN)
CZ	Planned	To be selected	2030	Long term site investigations	SURAO
DE	Gorleben	Gorleben	Exploration started in 1986. Discontinued in 2013	Salt formation	BfS/DBE
FI	ONKALO	Eurajoki	In operation	Waste characterization, 420 m depth, planned to be incorporated into disposal facility with first disposal about 2025	POSIVA
FR	Bure	Meuse/Haute Marne	In operation since 2006	Callovo-Oxfordian clay (hard) at ~ 450 - 500 m depth	ANDRA
	Tournemire	Southern Aveyron	In operation since 1990	methodological laboratory (former train tunnel) in sediments (hard clay), 250m depth	IRSN
HU	Planned	Western Mecsek	Planned from 2020 to 2055	Preparation for implementation of the geological disposal programme	PURAM
	BCF	Western Mecsek	Discontinued in 1998		
PL	PURL	Planned	Planned	Research for the DGR	Minister of Economy, Polish Geological Institute – National Research Institute and other interested institutes[51]

[50] Several Member States carry out experimental work in the Grimsel Test Site (Switzerland), which is in operation since 1984. The facilities in grey are not in operation any longer.

[51] The minister responsible for the economy, the Polish Geological Institute – National Research Institute (PIG-PIB) and other interested institutions to sign an agreement for supporting the concept of deep disposal of radioactive waste and the construction of an URL and initiating integrated research in these areas.

RO[52]	Planned	On the selected site	2030	Confirm the suitability of the underground conditions	
SE	Äspö HRL	North of Oskarshamn	In operation since 1995	Granite, 200 - 500 m depth; Used for research activities on performance of barriers for spent fuel disposal.	SKB
	Stripa mine		Closed in 1991	Granite, former iron ore mine at 360 - 410 m research from 1977 - 1991	SKB

Member States with nuclear programmes have presented in different level of detail their research programmes, towards development of disposal solutions for spent fuel and radioactive waste. France, Finland and Sweden have advanced research plans and detailed milestones for their deep geological disposal of spent fuel with the aim to start the geological facilities operation by 2030. In light of the longer timescales for the other nuclear power plant countries (see Table 7) they presented in more general terms the research and development activities and timeframes concerning final disposal of ILW, HLW and spent fuel. A few Member States recognize the need for research in management of exotic waste/fuel, while the institutional waste is usually not mentioned separately.

The majority of research activities in Member States' with nuclear programmes are undertaken by the licensee and/or dedicated research organisations. In some Member States (less than a third) the competent authorities have their own research programmes (including funding) that support the independent regulatory oversight.

Member States with research reactors address the research and development measures in the reports, however in most cases without clear roadmap/milestones for final disposal. Member States using radioactive sources only do not have their own research programmes as most of them rely on shared disposal solutions, and participate or plant to take part in international programmes or projects (e.g. the International Atomic Energy Agency, European Commission) in line with their radioactive waste management needs.

2.2.7. Transparency

Member States' programmes shall include the national policy/process for transparency required by Article 10 of the Directive. They shall ensure that necessary information on the management of spent fuel and radioactive waste is made available to workers and the public (including the one from the competent regulatory authority) and that the public is given the necessary opportunities to participate effectively in the decision-making process in accordance with national legislation and international obligations.

Overall the majority of Member States have reported on the policy frameworks they have put in place in order to ensure transparency. This information covered the relevant legislation, mechanisms for public information, consultation and public participation.

According to Member States' notifications transparency is required at the national level by the constitution, general laws, environmental laws, nuclear laws, radioactive waste management, radiation protection or energy laws.

Member States apply the transparency requirements via different mechanisms adopted to allow information and involvement of the public, local communities and other stakeholders in spent fuel and radioactive waste management presented in Table 12 below.

[52] The National Agency for Radioactive Waste is responsible for the research and development.

Table 12. Overview of main information and involvement mechanisms

1. Information	*2. Consultation*	*3. Participation*
a. Internet	a. Public meetings and workshops	a. Working groups
b. Printed information	b. Surveys and opinion polls	b. Voluntary arrangements
c. Public events	c. Public consultations/hearings	c. National commissions
d. Media relations	d. Other tools	d. Advisory bodies
e. Other tools		

In general, the Member States' national programmes and reports contain a details on how Member States allow and provide information and ensure opportunities for public consultation (e.g. in the framework of SEA and environmental impact assessment (EIA) procedures). The Commission noted that in some case, information on the transparency policy and its implementation in practice has not been included in the national programme as required by Article 12(1)j of the Directive but rather in the Member State's report, or vice versa.

Almost all Member States have clearly indicated the responsibility of the national regulator to provide information to the public about the safety and security of nuclear energy decisions and activities, including spent fuel and radioactive waste management. In some cases, Member States specify that the public can access the regulator's acts on the basis of the right of public access to official records if such acts are not covered by secrecy. Some Member States have reported that documents about the licensing procedure of nuclear and radioactive waste management facilities are made public and easily accessible on the authorities' websites as requested by national laws. National laws also assign a legal obligation of information to the licence holders (i.e. operator of nuclear facilities or implementer for radioactive waste management facilities): e.g. licence holders have a duty to inform the general public and the affected local community. Finally, other bodies (usually at ministerial level) may also be responsible for the provision of information.

Information to the public and other stakeholder is provided by Member States through several mechanisms that can be summarized as follows:

a) Internet – mostly reported tool, mainly in the form of corporate websites;

b) Printed information – e.g. newsletters (or e-newsletter), leaflets, brochures and publications; studies and reports (e.g., annual reports, progress reports and technical reports;

c) Public events – e.g. exhibitions, public conferences and presentations;

d) Media relations – e.g. press releases, press conferences, TV programmes, newspaper article or insert, etc. Official journals are also used for information, for instance about new legislation and regulation;

e) Other tools - social media and blogs as their channel of communication with the public; information centres (for instance those located in a given facility's site) and open days (such as site visits).

Most Member States' national programmes are public documents that have been used as an instrument for informing the general public about national policy and plans for spent fuel and radioactive waste management. Although the techniques for information are similar both in

Member States with nuclear power plants and without nuclear power plants, these techniques and their use are explained more in detail by Member States with nuclear power plants.

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).

However, about half of the Member States have not reported on 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 for spent fuel and radioactive waste management.

In general institutions exist at the local level (e.g., municipalities) and regional level (e.g., counties) to ensure representation of local interests in the national policy-making. In addition, mechanisms for participation have been reported aiming to enhance participation of citizens in the decisions about radioactive waste management, particularly in the case of those localities that are directly involved in the storage and disposal of radioactive waste. These mechanisms of participation of stakeholders are:

- Working groups - involving (in a formal way) representatives from a broad range of interests, from state authorities, regulators and implementers to associations from the civil society and non-governmental organisations; focus on a specific project (e.g., deep geological disposal) or can be used for the preparation of strategic documents. Bodies for local information (called "commissions", "committees", etc.) are also established in several Member States on specific nuclear power plant or radioactive waste management sites, as well as associations of local governments created with the purpose of information and social monitoring of given Radioactive Waste management facilities.
- Voluntary arrangements – allowing local communities to express their support or dissent about radioactive waste management projects.
- National commissions - promoting public participation in radioactive waste management.
- Advisory bodies - involving state and non-state actors (often at the national level).

With regard to the principle of public information and participation in international law, less than half of Member States refer explicitly to the application of the Aarhus and Espoo Conventions in their programmes and reports, although all EU Member States are parties to these international legal instruments.

3. CONCLUSION

The Commission has reviewed the notified national reports of all Member States and the national programmes of 27 Member States submitted until September 2016. Having reviewed these notifications, the Commission prepared its first report to the Council and the European Parliament on implementation of this Directive. It identified progress, trends and challenges in the spent fuel and radioactive waste management.

The next Member States reports to be submitted to the Commission are due by 23 August 2018.