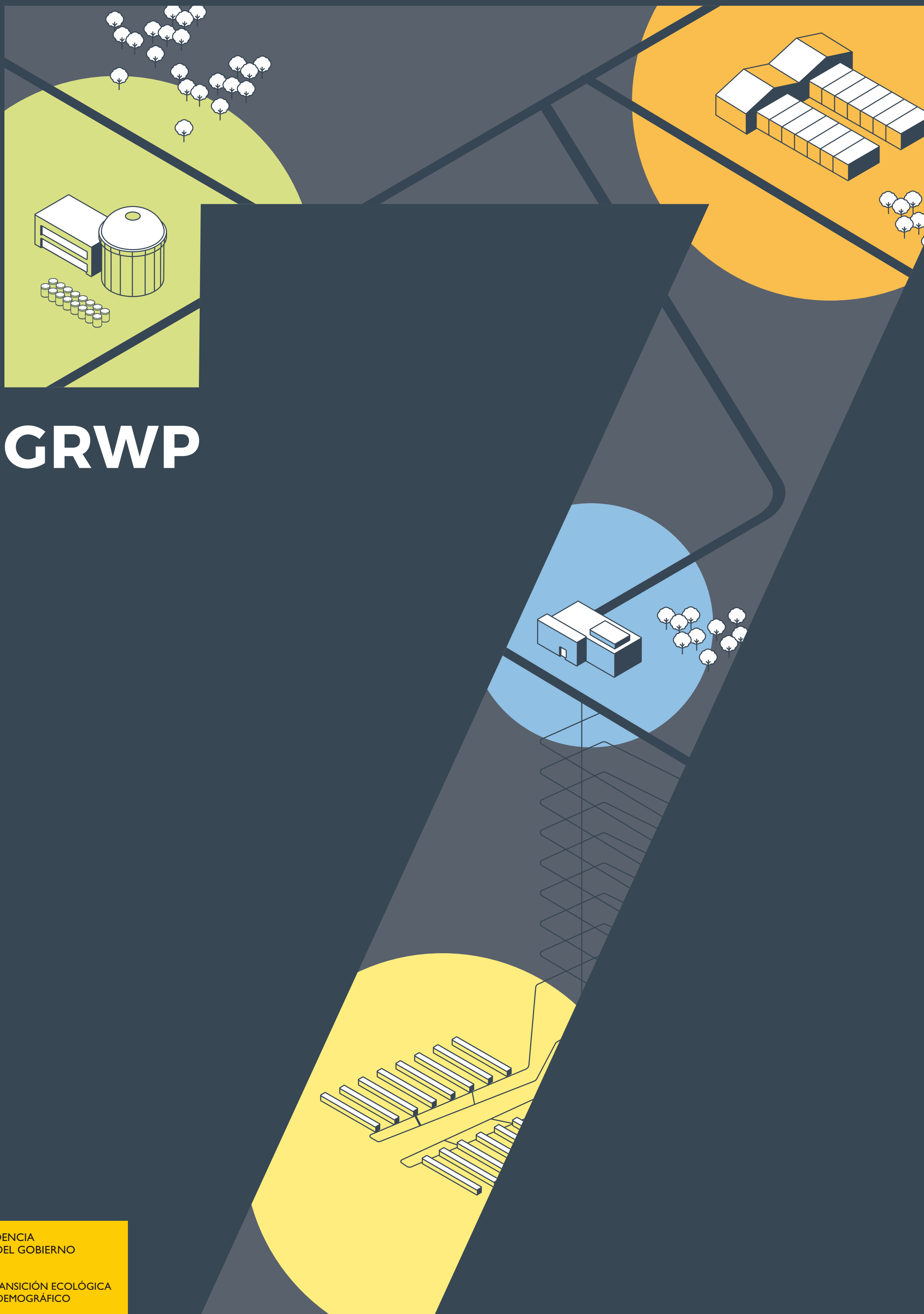
7th GENERAL RADIOACTIVE WASTE PLAN



GRWP

GOBIERNO DE ESPAÑA

VICEPRESIDENCIA
TERCERA DEL GOBIERNO

MINISTERIO
PARA LA TRANSICIÓN ECOLÓGICA
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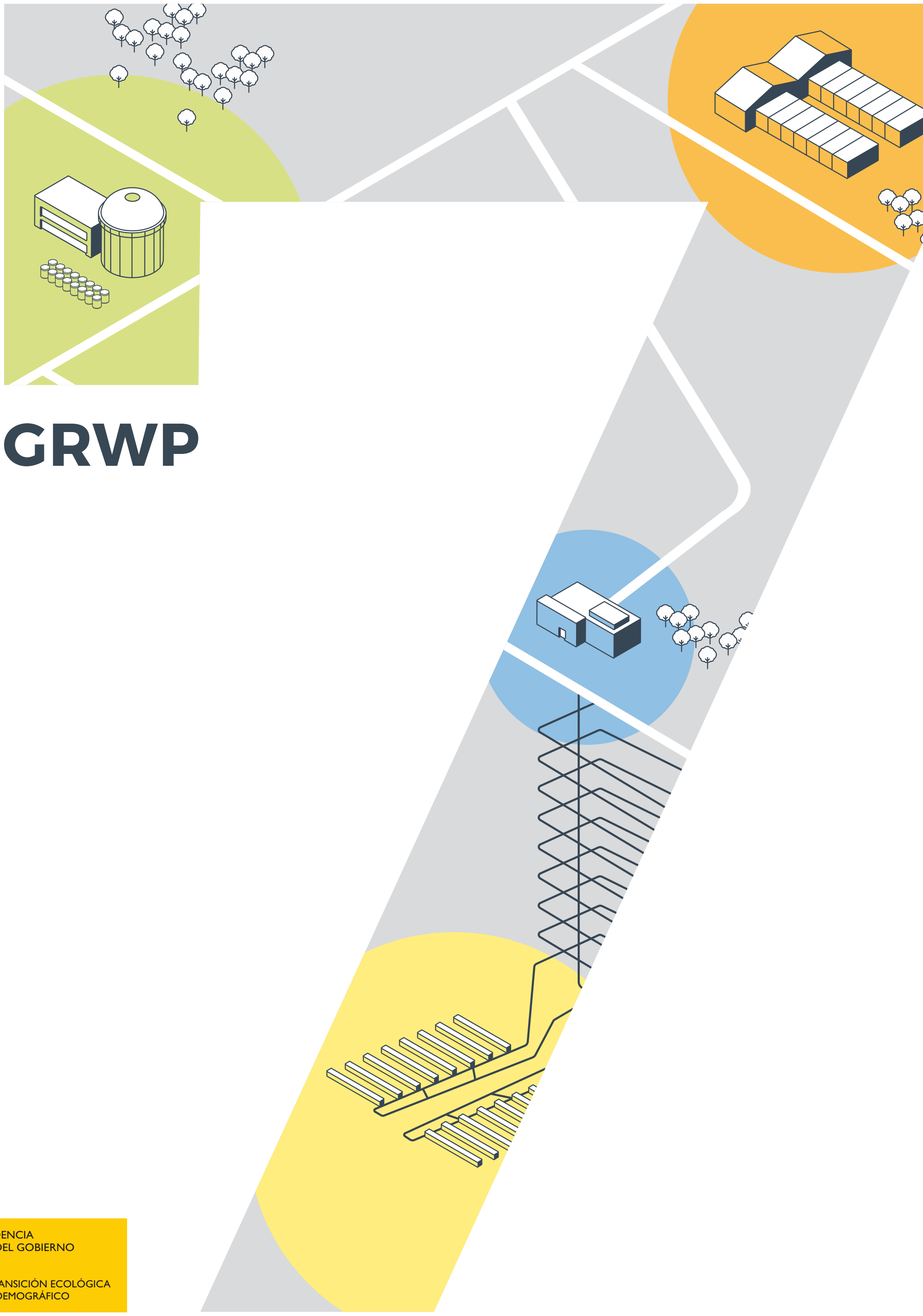

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Enresa website: https://www.enresa.es/esp/inicio/sobre-enresa/plan-general-de-residuos-radiactivos

Title: 7th General Radioactive Waste Plan
Edition: 2024

Author: Ministry for Ecological Transition and Demographic Challenge
Coordinator: Empresa Nacional de Residuos Radiactivos S.A., S.M.E. (ENRESA)

MINISTRY FOR ECOLOGICAL TRANSITION AND DEMOGRAPHIC CHALLENGE

NIPO (paper in Spanish): 665-24-008-2
NIPO (online in Spanish): 665-24-009-8
NIPO (online in English): 665-24-010-0
Statutory deposit: M-6146-2024

Layout: Komuso Comunicación Multimedia, Diseño y Soluciones Audiovisuales

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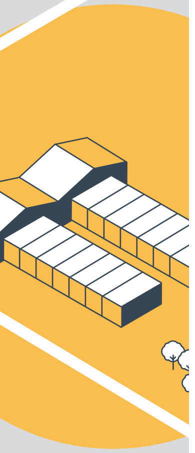

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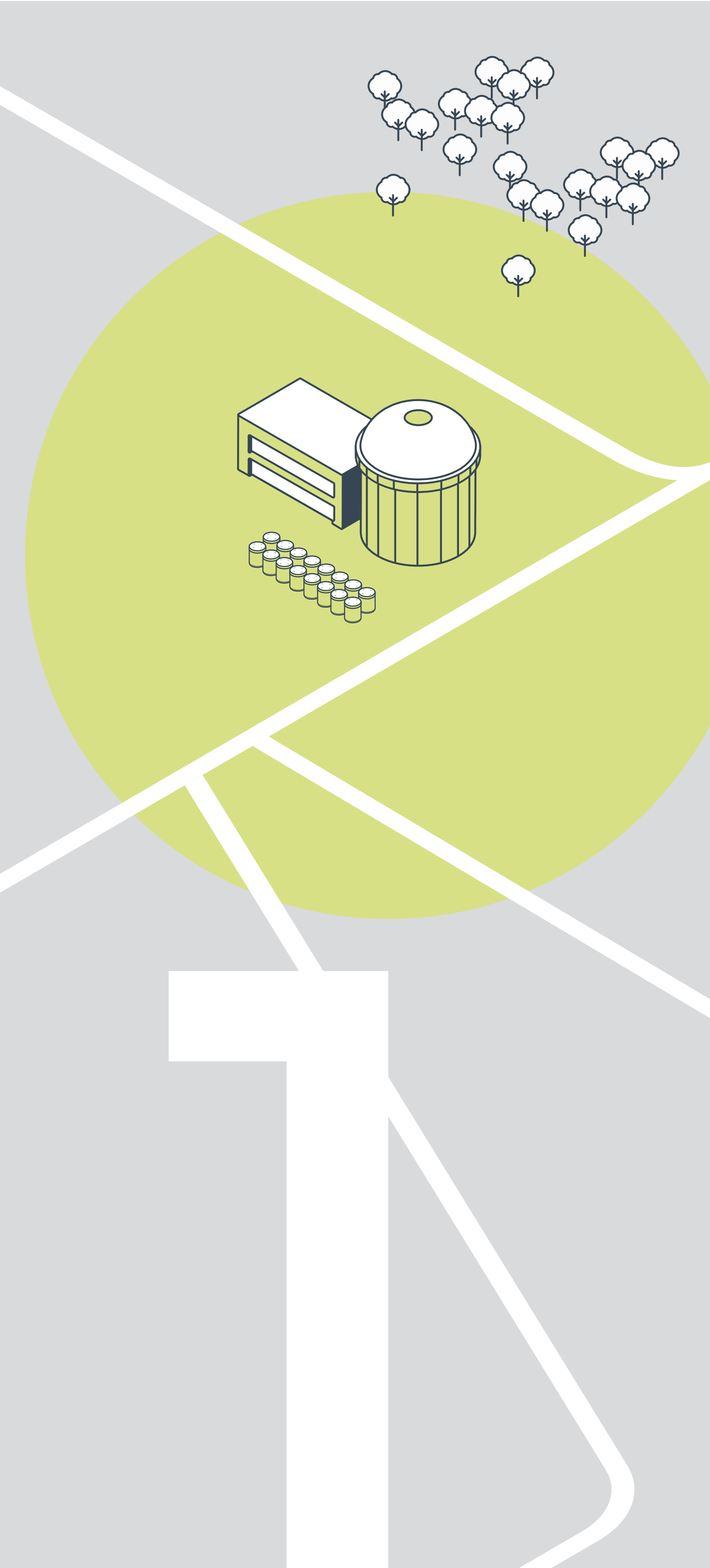

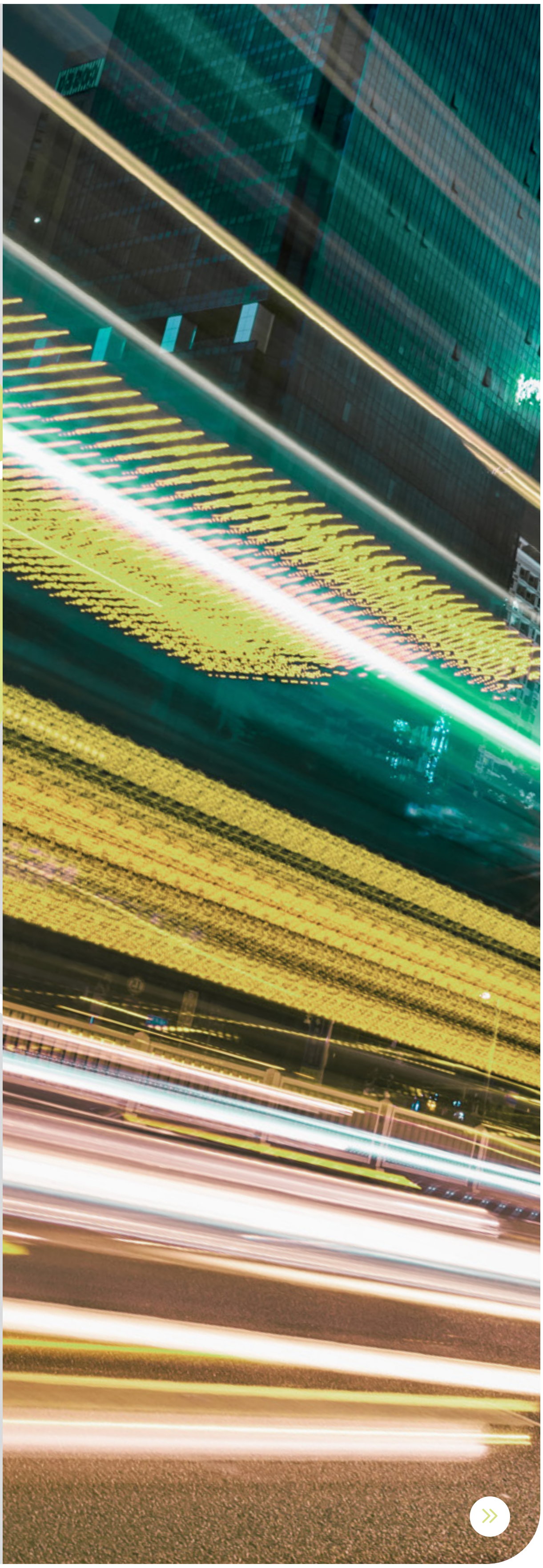

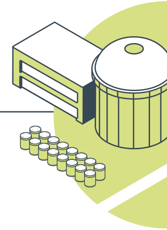

1. Introduction

1.1. Preliminary considerations

Radioactive waste (RW) is generated as a result of the use of nuclear energy in electricity production and the decommissioning of nuclear power plants (NPPs), as well as the use of radioactive material in medical, industrial, agricultural and research activities. It can also originate from activities performed in decontamination or intervention operations. Furthermore, significant volumes of sterile material from uranium mining and the production of concentrates, with low levels of naturally occurring radioactivity, have been generated in Spain.

Given their specific nature, particularly the fact that it contains materials emitting ionising radiation, the management of radioactive waste (RW) requires its long-term containment and isolation to protect both human health and the environment from ionising radiation. This involves adopting such measures as final storage in appropriate facilities.

Addressing this need is a matter of national interest, and decisions adopted must ensure maximum safety, transparency and public participation. This is an issue involving ethical considerations and intergenerational justice since those benefiting nowadays from activities that produce this radioactive waste (RW) must provide technical and economic resources to ensure its management without entailing risks for future generations.

For the safe management of spent fuel (SF) from nuclear reactors and radioactive waste (RW), Spain has a significant infrastructure from an administrative, technical and economic-financial perspective.

At an administrative level, Spain has an organisation, elaborated on later, based on a legislative and regulatory framework developed in line with the evolution of international regulatory requirements. In particular, at a European Union level, Council Directive 2011/70/Euratom, dated 19 July 2011, establishes an EU framework for the responsible and safe management of spent fuel (SF) and radioactive waste (RW), and at the level of the International Atomic Energy Agency, the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. These documents provide for the main responsibilities of the various parties involved in the process.

As regards the field of technical management, Spain has the Empresa Nacional de Residuos Radioactivos, S.A., S.M.E. (Enresa) - National Radioactive Waste Company - responsible for managing spent fuel (SF) and radioactive waste (RW), as well as the decommissioning of nuclear power plants (NPPs), equipped with the human, technical and financial resources to perform the tasks commissioned thereto.

In terms of economic-financial aspects, a system exists to guarantee funding for the costs of radioactive waste (RW) management, which, in the case of nuclear power plants (NPPs), relies on generating funds in advance over their operational life, collected through fees on gross electricity production.

For other radioactive waste (RW) producers, the financing system is based on economic consideration for services provided by Enresa, through the payment of the corresponding fees. Both for nuclear power plants (NPPs) and other radioactive waste (RW) producers, the fees may be revised by the Government.

1.2. Reference framework

Article 38 *bis* of the Nuclear Energy Act (NEA) 25/1964, of 29 April, states that the management of radioactive waste (RW) and spent fuel (SF), as well as the decommissioning and closure of nuclear power plants (NPPs), are essential public services reserved for the State, whereby Empresa Nacional de Residuos Radioactivos, S.A., S.M.E. (Enresa) is commissioned with the management of this public service, with Royal Decree 102/2014, of 21 February, on the responsible and safe management of spent fuel (SF) and radioactive waste (RW), establishing its activities and financing system. Furthermore, the Sixth Additional Provision of the Electricity Sector Act (ESA) 54/1997, of 27 November, extensively modified by Law 11/2009, of 26 October, regulating Listed Property Market Investment Companies and declared in force by the Electricity Sector Act 24/2013, of 26 December, establishes the financing system for this public service, consisting of a system of four fees[1] borne by radioactive waste (RW) producers.

The same Article 38 *bis* of the NEA states that the Government is responsible for establishing the policy on radioactive waste (RW) management, including spent fuel (SF), and the decommissioning and closure of nuclear power plants (NPPs), through the approval of the General Radioactive Waste Plan (GRWP). This Plan will be submitted by the Ministry for Ecological

1 These fees, pursuant to the Eleventh Final Provision of the Public Sector Contracts Act 9/2017, of 8 November, have acquired the legal nature of an untaxed public asset payment.

Transition and Demographic Challenge (MITECO), following a report from the Nuclear Safety Council (CSN), once the Autonomous Regions (ARs) have been consulted on territorial planning and the environment. The Government will subsequently inform Parliament.

Furthermore, Royal Decree 102/2014, of 21 February, on the responsible and safe management of spent fuel (SF) and radioactive waste (RW), establishes that public participation will be encouraged in the preparation of the Plan, as provided for in Act 27/2006, of 18 July, regulating the rights of access to information, public participation and access to justice in environmental matters, and in Act 21/2013, of 9 December, on environmental assessment.

In addition, Council Directive 2011/70/Euratom of 19 July 2011, establishing an EU framework for the responsible and safe management of spent fuel (SF) and radioactive waste (RW), transposed into Spanish law by Royal Decree 102/2014, of 21 February, states that Member States will establish a national programme for the implementation of the policy for the management of spent fuel (SF) and radioactive waste (RW).

This Directive also states that each Member State will guarantee the implementation of this national programme, covering all types of spent fuel (SF) and radioactive waste (RW) under its jurisdiction and all stages of the management of these materials, from generation to final disposal. The Member State will periodically review and update its national programme, taking into account scientific and technical progress, as appropriate, as well as the recommendations, lessons and best practices stemming from the peer review processes outlined in the Directive.

As regards the radioactive waste (RW) management system in Spain, the GRWP is the official document that outlines the strategies, necessary actions and technical solutions to be developed in the short-, medium- and long-term, aimed at the proper management of radioactive waste (RW), the decommissioning and closure of nuclear power plants (NPPs) and other activities related thereto, including economic and financial forecasts to implement the Plan.

Furthermore, the regulatory framework also provides that Enresa must submit to MITECO, during the first half of each year, an updated economic-financial study of the cost of the activities provided for in the GRWP, as well as the adequacy of the current financial mechanisms to that cost. In this way, the actions provided for in the GRWP and their costs undergo a continuous updating process, provided there are no substantial changes in policy and strategies in its different components.

The 6th GRWP, approved by the Government in June 2006, provided the following strategies for the different components of the Plan:

- Maintenance of the strategy and management capacity for low- and intermediate- level waste (LILW) and very low-level waste (VLLW), with its core element being their final disposal at the El Cabril Disposal Facility (El Cabril DC), located in the municipality of Hornachuelos (Cordoba).
- Maintenance of the strategy of unified temporary management of spent fuel (SF), high-level waste (HLW) and special waste (SW) in a single facility, with the most significant milestone being the start-up of the Centralised Temporary Storage (CTS).

- Provision of additional storage capacity for spent fuel (SF), high-level waste (HLW) and special waste (SW) in those nuclear power plants (NPPs) where operational or decommissioning needs require it, and as long as they cannot be covered by the operation of the CTS.
- Development of the technological capabilities and social acceptance necessary to guide and implement in the future the final disposal solution of spent fuel (SF), high-level waste (HLW) and special waste (SW) in a Deep Geological Repository (DGR).
- Maintenance of the strategy for the decommissioning and closure of nuclear power plants (NPPs) until the release of their sites in the shortest time possible, compatible with the criteria of dose minimisation and protection of health and the environment.

Although most of the strategies of the 6th GRWP are considered valid, it is necessary to approve a new Plan due to the age of the 6th GRWP, whose technical solutions and economic forecasts need updating, and the need to adapt it to the regulatory framework derived from Council Directive 2011/70/Euratom, of 19 July 2011. This Directive states that the Plan must undergo periodic review, taking into account scientific and technical progress, experience acquired as well as the recommendations, lessons and best practices stemming from international peer review processes outlined in the Directive. Furthermore, the Directive and Royal Decree 102/2014, of 21 February, which transposes it, include content for the GRWP that is not incorporated in the 6th GRWP.

The National Integrated Energy and Climate Plan 2021-2030 (PNIEC), of 16 March 2021, also provides for the orderly closure of Spanish nuclear power plants (NPPs) in the time horizon 2027-2035, which represents a modification of the scenario provided for in the 6th GRWP.

It should also be noted that Spain, in compliance with Article 14.3 of Council Directive 2011/70/Euratom, of 19 July 2011, conducted an international peer review (IRWS/ARTEMIS mission) in 2018 regarding the regulatory infrastructure and the country's radioactive waste (RW) and spent fuel (SF) management programme, respectively, addressing regulatory, technical and strategic aspects. The ARTEMIS mission made recommendations to update the GRWP, urging the Government to take immediate action to approve the updates to the GRWP.

In view of the above, on 16 March 2020, the processing of the draft 7th GRWP was initiated in accordance with the Nuclear Energy Act 25/1964, of 29 April, and the Environmental Assessment Act 21/2013, of 9 December. Based on the regulatory provisions, MITECO conducted prior consultations with the public authorities affected and interested parties and approved the scope document that served as the basis for the development of the Environmental Strategic Study of the Plan in October 2020.

From 11 April 2022 to 16 June 2022, the initial version of the 7th GRWP, along with the Environmental Strategic Study and the Non-Technical Summary, was subjected to a consultation and public information process.

Taking into consideration the submissions made, the Environmental Strategic Study was modified, and the revised version of the Plan was drawn up, which was submitted for the opinion of the CSN and the Autonomous Regions. Taking the CSN report into account, along with the Strategic Environmental Declaration dated 14 July 2023, the 7th GRWP was updated and prepared.

1.3. Definition, content and monitoring of the Plan

The GRWP is the document establishing, in accordance with Article 38 bis of the NEA, the policy on the management of radioactive waste (RW), including spent fuel (SF), and the decommissioning and closure of nuclear power plants (NPPs). It also constitutes the national programme for the implementation of this policy, as provided for in Council Directive 2011/70/Euratom, of 19 July 2011.

Accordingly, the GRWP outlines the strategies, necessary actions and technical solutions to be developed in the short-, medium- and long-term, aimed at the proper management of radioactive waste (RW), the decommissioning and closure of nuclear power plants (NPPs) and radioactive facilities, and other activities related to these, including economic and financial forecasts to implement them.

These activities are grouped into five main strategic lines, which are developed throughout the document:

- Management of LILW and VLLW.
- Management of SF, HLW and SW.
- Decommissioning and closure of facilities.
- Research and development.
- Other actions.

Furthermore, monitoring the activities that Enresa carries out to implement the current GRWP from time to time is substantiated in the preparation and submission to MITECO, as the responsible ministerial department, of the following documents[2]:

a. During the first half of each year:

    1. A report that includes the technical and economic aspects related to the activities during the previous year, and the level of compliance with the corresponding budget.

2 Article 10 of Royal Decree 102/2014, of 21 February for the responsible and safe management of spent fuel (SF) and radioactive waste (RW).

2. An updated economic and financial study of the cost of the activities provided for in the GRWP, as well as the adaptation of the existing financial mechanisms to this cost.

   This economic and financial study involves a three-stage analysis process:

   - Analysis of the current situation, assessing events that have occurred since the approval of the latest GRWP that impact the management and presentation of the inventory of radioactive waste (RW) produced by December of the previous year.

   - Establishment of the reference scenario and evaluation of total inventories of radioactive waste (RW) based on the latest available forecasts.

   - Analysis of future actions to achieve the targets set for the management of spent fuel (SF) and the closure of nuclear power plants (NPPs).

b. Before 30 November each year, a technical and economic justification of the annual budget for the following year, and its projection for the next four years, in accordance with the provisions of the updated economic and financial study of the cost of the activities outlined in the GRWP. In the event that, exceptionally, it is necessary to incur unforeseen costs not anticipated in the aforesaid economic and financial study, the corresponding justification must be submitted beforehan.

c. During the month following each quarter, a budget monitoring report for that quarter.

In addition, during the first quarter of each year, Enresa must submit to the CSN information regarding the activities carried out in the previous year and forecasts for the current year in relation to the GRWP, to comply with the provisions of Article 12.2 of Royal Decree 102/2014, of 21 February.

Furthermore, every four years or as required by MITECO, Enresa will submit a review of the GRWP, in accordance with the indications contained in Articles 5.3 and 9.4 of Royal Decree 102/2014, of 21 February, taking into account scientific and technical progress, experience acquired, as well as recommendations, lessons and best practices stemming from peer review processes.

1.4. Current situation of radioactive waste management in Spain

Spain has the necessary infrastructure and resources, both administratively and in terms of technical and economic-financial aspects, for the management of radioactive waste (RW), spent fuel (SF) and the decommissioning and closure of nuclear power plants (NPPs).

From an administrative perspective, the legal and regulatory framework for the management of spent fuel (SF) and radioactive waste (RW) is integrated within the broader framework that regulates nuclear energy in Spain. This framework is extensive and developed in accordance with the evolution of international regulatory requirements. It establishes the responsibilities of different stakeholders and the distribution of functions among the various competent authorities.

The fundamental procedures within the regulatory framework for nuclear energy that specify the distribution of administrative functions among different competent authorities include:

- **Authorisation procedure**

  It is the responsibility of the Ministry for Ecological Transition and Demographic Challenge (MITECO) to grant the corresponding authorisations for NPPs and radioactive facilities, except for category 2 and 33[3] radioactive facilities, when this power has been transferred to the Autonomous Regions that have requested it.

  Any authorisation for a nuclear or radioactive facility must include a report from the CSN, the only competent body for nuclear safety and radiological protection that is independent of the Government. This report, besides being mandatory, is binding when it is negative or regarding the limits and conditions established for nuclear safety and radiological protection when it is positive.

  The approval of the Strategic Environmental Declaration and the Environmental Impact Statement for plans and projects of this nature is the responsibility of the MITECO.

- **Regulatory procedure**

  The Government is responsible for approving the regulatory implementation of laws passed by Parliament, and currently, MITECO is the ministerial department in charge of processing and submitting regulatory proposals in the field of nuclear energy. When the proposals relate to matters that may affect nuclear safety or radiological protection, the initiative falls to the CSN, which forwards the proposals to MITECO for processing before the Government.

  The CSN is empowered to issue its own regulations by approving Instructions, which are technical standards on nuclear safety and radiological protection integrated within

3 According to the classification established in the Regulation on Nuclear and Radioactive Facilities, approved by Royal Decree 1836/1999, of 3 December.

the domestic legal system, binding on the subjects affected once notified or published in the Official State Gazette, and non-compliance is legally classified as an administrative offence, subject to sanctions under the NEA penalty regime. It can also issue Complementary Technical Instructions, which are administrative acts binding on the subjects to which they are addressed and aim to ensure the maintenance of conditions and requirements for the safety of facilities and activities and better compliance with the requirements established in each authorisation. Finally, the CSN issues Circulars and Guides, which are technical documents for informational purposes and technical recommendations, respectively, that are not binding.

- Surveillance and control procedure

  The complete review and evaluation of nuclear safety and radiological protection of nuclear and radioactive facilities, as well as their inspection, are the exclusive responsibility of the CSN, as the sole competent authority for nuclear safety and radiological protection.

  As regards other matters such as physical safety, readiness for emergencies and environmental radiological impact, oversight and control are exercised in coordination with the bodies of other ministerial or regional departments that also have jurisdiction in the matter.

- Disciplinary procedure

  It is the responsibility of the Directorate-General of Energy Policy and Mines of MITECO to process disciplinary procedures for nuclear and radioactive facilities, except for category 2 and 3 facilities for which competence has been transferred to the Autonomous Regions, as well as to submit proposed sanctions to the authority determined by law according to the severity of the offence.

  When infringements relate to nuclear safety or radiological protection matters, the initiative corresponds to the CSN, which proposes initiating the corresponding proceedings to MITECO. As regards physical protection, the Ministry of Home Affairs and the CSN can propose the commencement of disciplinary proceedings for infringements of the nuclear energy regulatory framework.

  Furthermore, the CSN is legally empowered, under certain circumstances provided for in the NEA, to send warnings to the licensees, establishing corrective measures. If they do not respond to the warning, the CSN is authorised to impose coercive fines in accordance with the procedure legally established to this end.

Figure 1 shows the national system established for the management of radioactive waste (RW) and spent fuel (SF).

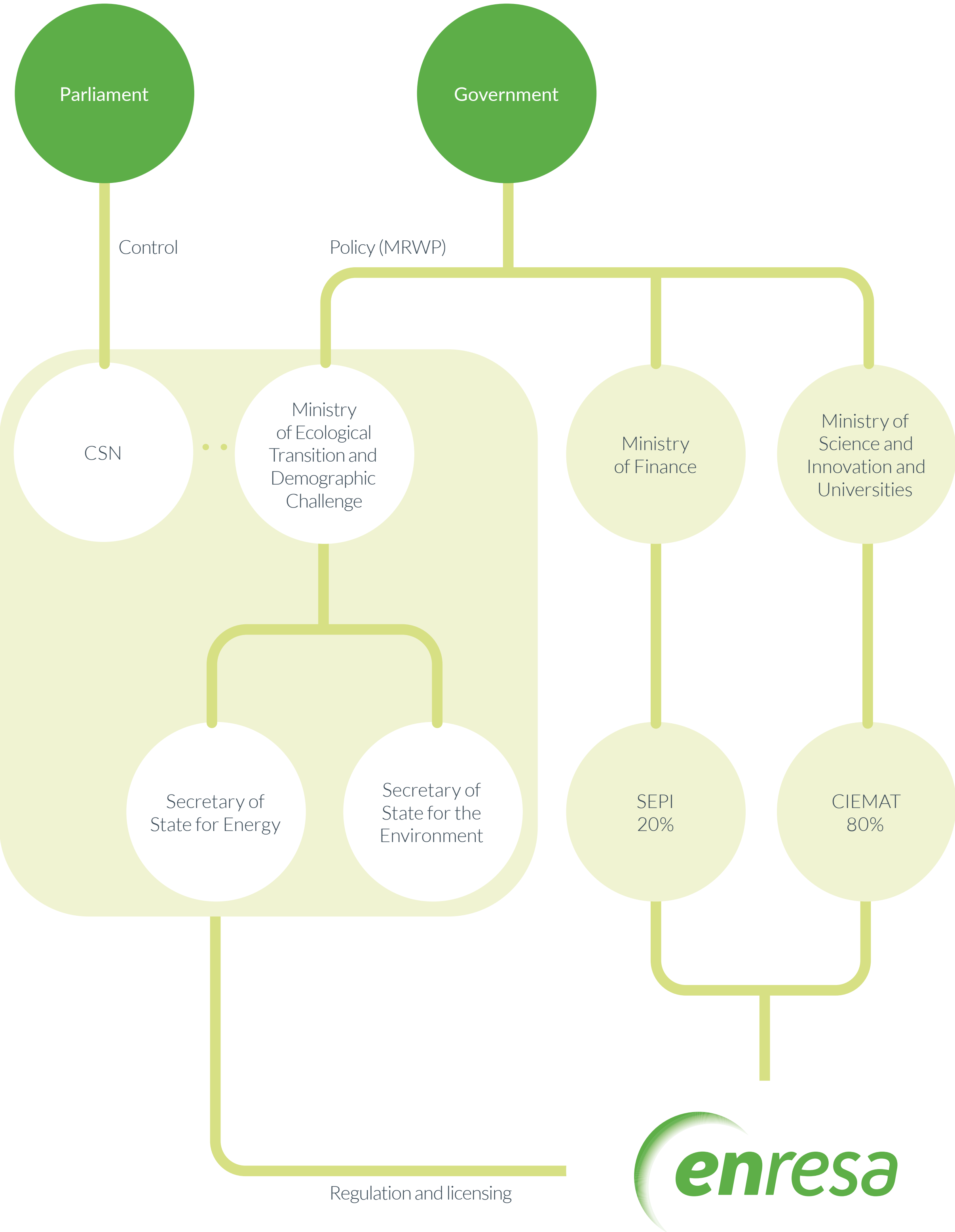

Figure 1. Institutional control organisational chart

As regards the technical and economic-financial infrastructure for the management of radioactive waste (RW) and spent fuel (SF) in Spain, Enresa has been responsible for its management since 1984. Enresa is an instrumental company through which this essential public service is provided. The current legal framework also states that the funding for this public service will be provided through a system of financial contributions borne by the producers of radioactive waste (RW).

In the field of low- and intermediate-level waste (LILW) and very low-level waste (VLLW), a consolidated, integrated management system is in place, with El Cabril Disposal Facility playing an essential part. This Centre serves as a centralised facility for the final storage of this type of radioactive waste (RW).

As regards spent fuel (SF), the capacity exists for its temporary storage in the storage pools at the nuclear power plants (NPPs) and in dry Individualised Temporary Storage (ITS) at the nuclear power plants (NPPs).

Furthermore, considerable experience has been acquired in the final management programme for spent fuel (SF)/high level waste as regards the knowledge of Spanish geology. The generic design of a deep geological storage facility has been studied in the three lithologies (granite, clay and salt) existing in the country. The corresponding performance and long-term safety assessments have incorporated the results of research and development conducted through various General Radioactive Waste Plans (GRWPs) since 1987.

As for the decommissioning and closure of nuclear power plants (NPPs) and radioactive facilities, there is currently an established system to carry out the necessary activities for the decommissioning and closure of regulated installations, with defined agents intervening in the process.

Over the years, significant experience has been acquired in this field through the decommissioning of uranium ore treatment facilities (former Andújar Uranium Mill Plant, La Haba and Saelices el Chico), as well as the restoration of mining operations, the partial decommissioning of the Vandellós I NPP, the closure of research reactors (Argos and Arbi) and the decommissioning of various Centres for Energy-Related, Environmental and Technological Research (CIEMAT) facilities under the Comprehensive Plan for the Improvement of CIEMAT Facilities. The José Cabrera NPP has been undergoing decommissioning since 2010.

The development and continuous improvement of this framework and of Enresa's actions require constant monitoring and active participation in radioactive waste (RW) management programmes of international organisations such as the European Union (EU), the International Atomic Energy Agency (IAEA), the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (NEA/OECD) and the International Nuclear Law Association (INLA). Furthermore, this may involve formalising bilateral or multilateral agreements with other organisations that have functions and programmes of interest to Enresa.

1.5. Reference scenario

The reference scenario outlined in the General Radioactive Waste Plan (GRWP) for planning and calculations can be summarised in the following points:

- Cessation of the operation of nuclear power plants (NPPs) in line with the Integrated National Energy and Climate Plan 2021-2030 (PNIEC), with the ongoing review of the PNIEC, and with the Protocol for the Orderly Cessation of the Operation of NPPs signed between Enresa and licensees in March 2019.

Nuclear Power Plant	Date of cessation of operations (month/year)
Almaraz I NPP	11/2027
Almaraz II NPP	10/2028
Ascó I NPP	10/2030
Cofrentes NPP	11/2030
Ascó II NPP	9/2032
Vandellós II NPP	2/2035
Trillo NPP	5/2035

- Open fuel cycle, meaning the option of reprocessing spent fuel (SF) is not considered.

- Maintenance of the operational capabilities of El Cabril Disposal Facility for LILW and VLLW from the operation and decommissioning of all nuclear facilities.

- Maintenance of the management capacity for spent fuel (SF), high-level waste (HLW) and special waste (SW) in nuclear power plants (NPPs), using ITS.

- Start-up of a Decentralised Temporary Storage (DTS) facility for spent fuel (SF), high-level waste (HLW) and special waste (SW) at each nuclear power plant (NPP) with spent fuel (SF) (Almaraz, Ascó, Cofrentes, Santa María de Garoña, José Cabrera, Trillo, and Vandellós II). Each plant's DTS will consist of one or more ITS, plus a new complementary facility or additional resources to perform maintenance and repair operations on its casks to ensure their recoverability function. The DTSs, including their complementary facilities, will be operational before starting the decommissioning of the fuel pool at the plant and will have all the safety and auxiliary systems in place to operate as an independent nuclear facility following the declaration of the closure of the plant. At the José Cabrera NPP, in the final phase of decommissioning, the measures outlined in the CSN's informative circular on cask recoverability will be implemented between 2024 and 2029. The DTSs will remain operational until the transfer of all spent fuel (SF), high-level waste (HLW) and special waste (SW) to the Deep Geological Repository (DGR).

- In 2031, one of the plant sites will have the means to ensure the recoverability function of the fuel assembly throughout the operational life of the DTSs until the transfer of spent fuel (SF), high-level waste (HLW) and special waste (SW) to the DGR. This facility will have a hot vault to handle spent fuel (SF) and radioactive waste (RW), storage capacity for casks to address potential contingencies at the DTSs throughout their operational life and a laboratory equipped with the necessary means to verify and inspect the condition of fuel and waste if necessary.

- Start-up of a interim storage facility at the Vandellós I NPP site in 2027 to accommodate waste from spent fuel (SF) reprocessing and, as the case may be, waste from the decommissioning of the plant. This will remain operational until the transfer of all waste to the DGR.

- Start-up of the DGR for spent fuel (SF), high-level waste (HLW) and special waste (SW) in 2073.

- Immediate total decommissioning of light water nuclear power plants (NPPs). Preparatory work will begin between three and preferably five years before the definitive cessation date, so that the transfer of ownership and the start of decommissioning works can be carried out within a maximum of three years after the definitive cessation. During these years, activities such as draining pools, preparatory decommissioning tasks and obtaining decommissioning and ownership transfer authorisation from Enresa will take place. Once this authorisation is obtained, decommissioning works will commence with an estimated duration of ten years. In the case of Vandellós I NPP, the last phase of its decommissioning will be executed as from 2030, with an estimated duration of 15 years. The surveillance period, after the completion of the works, is estimated to be a maximum of ten years prior to the declaration of closure.

Programme for operation and closure of Nuclear Power Plants (NPPS)

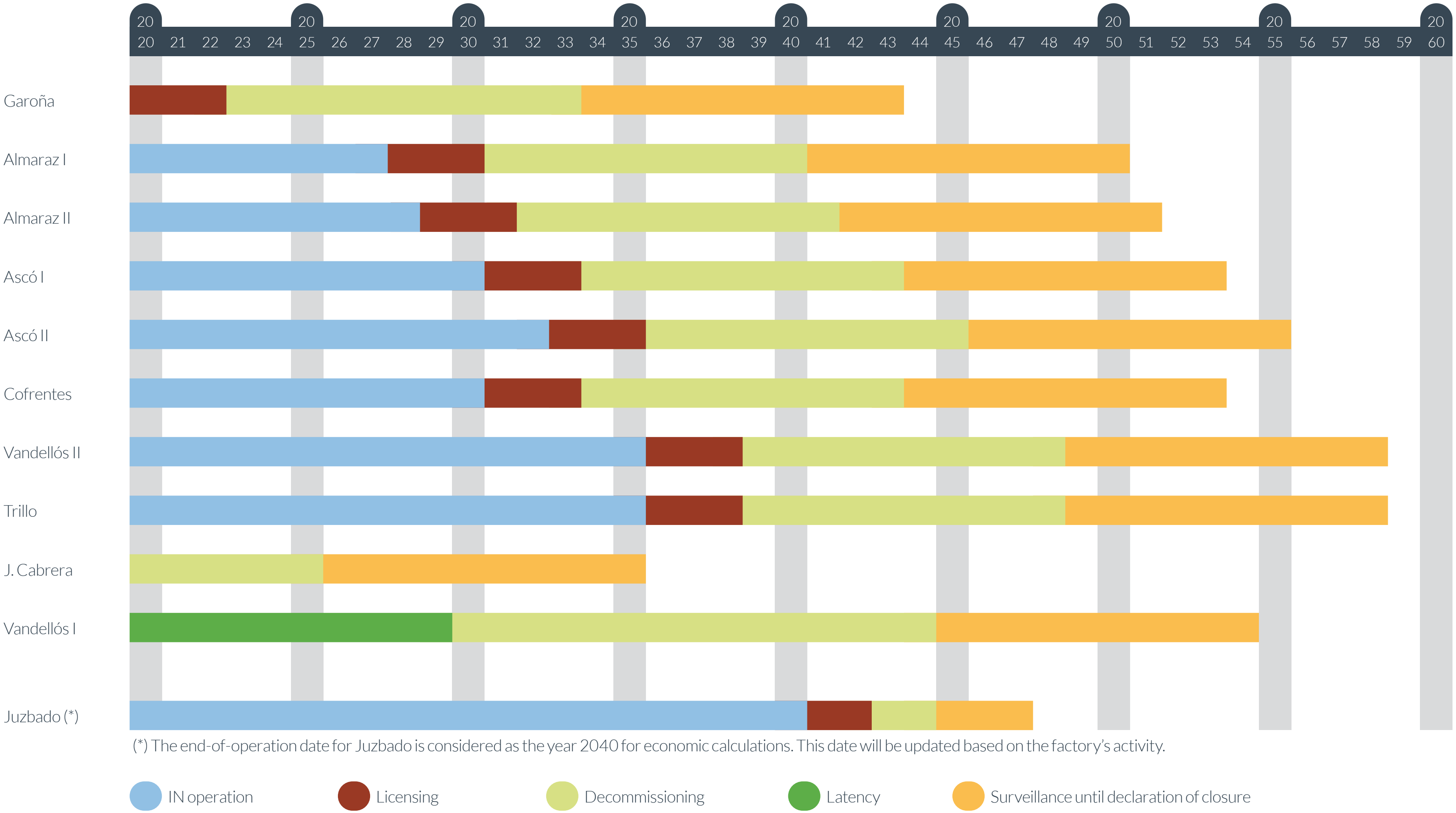

Figure 2. General programme for the management of radioactive waste (RW), spent fuel (SF) and decommissioning of nuclear power plants (NPPs)

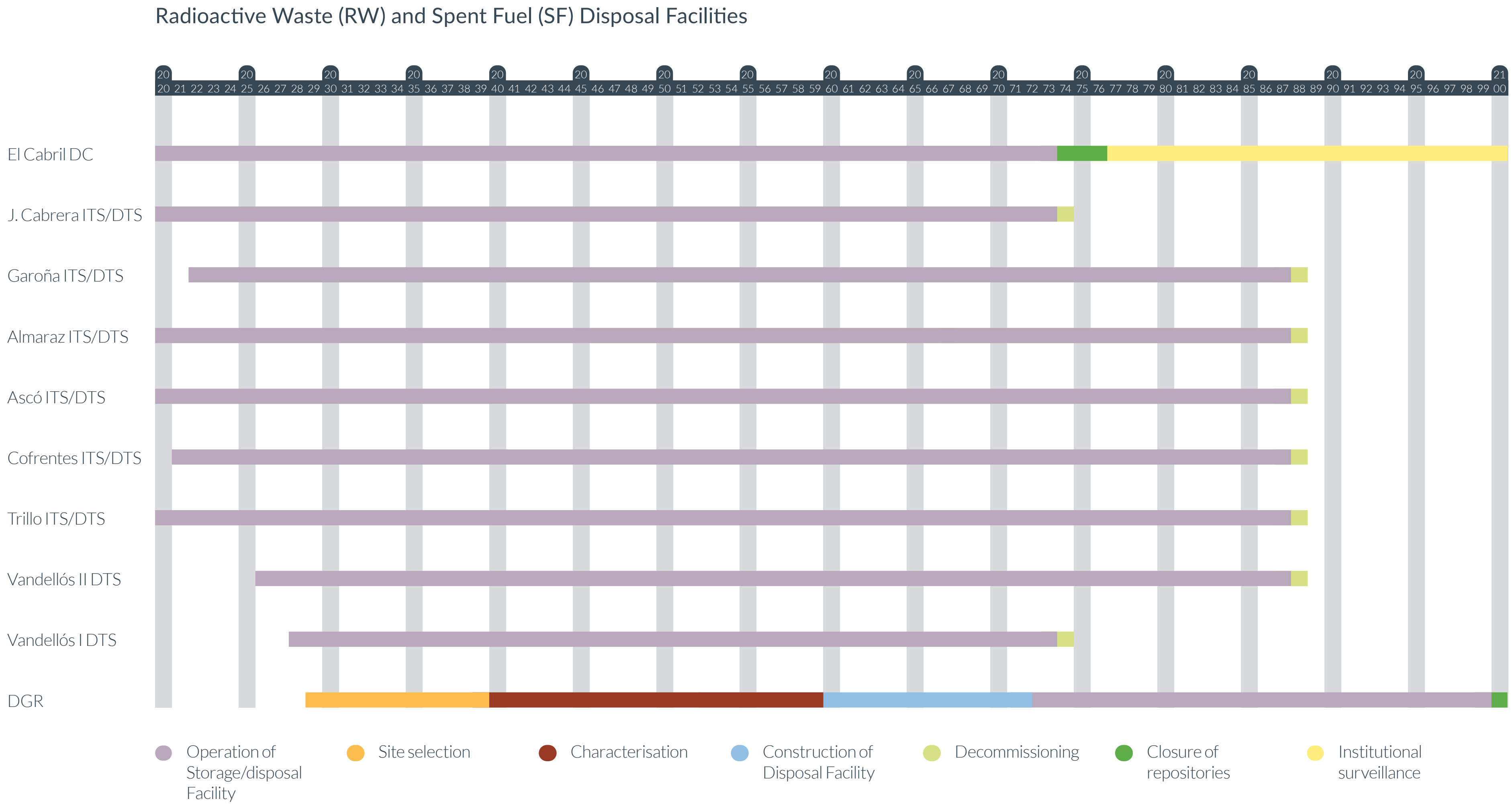

Figure 2. PGeneral programme for the management of radioactive waste (RW), spent fuel (SF) and decommissioning of nuclear power plants (NPPs)

1.6. Basic principles and general objectives of radioactive waste and spent fuel management

The basic principles underlying the key strategic lines of action for radioactive waste (RW) and spent fuel (SF) management provided for in this Plan are based on applicable regulations, particularly the Nuclear Energy Act (NEA) and Royal Decree 102/2014, of 21 February. Furthermore, they draw upon recommendations established in safety reviews by the International Atomic Energy Agency.

The following are noteworthy:

1. The generation of radioactive waste (RW) will be minimised as far as possible, both in terms of activity and volume, through the implementation of appropriately designed measures and proper operational and closure practices, including the recycling and reuse of materials.

2. Consideration of the interdependence between all stages of spent fuel (SF) and radioactive waste (RW) generation and management.

3. Implementation of measures for the safe management of spent fuel (SF) and radioactive waste (RW) will follow a graduated approach, with a proportional level of analysis, documentation and action to the magnitude of the risks involved, to the relative importance of safety, purpose and characteristics of the facility or activity, and any other relevant factors.

4. Application of a decision-making process based on empirical and documented evidence at all stages of management.

5. Without prejudice to safety conditions established in the Spanish legal framework, overseen by the Nuclear Safety Council, the management of radioactive waste (RW) and spent fuel (SF) will preferably employ passive safety systems. These are systems where safety is based on an intrinsically safe design, with components whose functionality is ensured by physical principles not dependent on external energy.

6. The cost of managing radioactive waste (RW) and spent fuel (SF) will be borne by those who have generated such materials. The financing system relies on contributions to the "Fund for the Financing of GRWP Activities" as provided for in the Sixth Additional Provision of the Electricity Sector Act 54/1997, of 27 November. This law establishes a financing system based on four types of contribution depending on the type of producers or services.

The general aims of this Plan are as follows:

1. Define the policy for radioactive waste (RW) management and the decommissioning and closure of nuclear power plants (NPPs) and radioactive facilities.

2. Establish the strategic lines of action in the different stages of management for the types of radioactive waste (RW) generated in the operation and decommissioning of nuclear power plants (NPPs) and radioactive facilities, including transportation.

3. Present the main actions scheduled that are required for the implementation of the proposed strategy.

4. Define the main lines of research to guide the formulation of R&D Plans related to radioactive waste (RW) management and the decommissioning of nuclear power plants (NPPs) and radioactive facilities.

5. Identify channels for the management of radioactive material from Naturally Occurring Radioactive Material (NORM) facilities, which are industrial facilities or work centres where radioactive material of natural origin are handled, generated and managed.

6. Evaluate the future costs of all actions outlined in the Plan.


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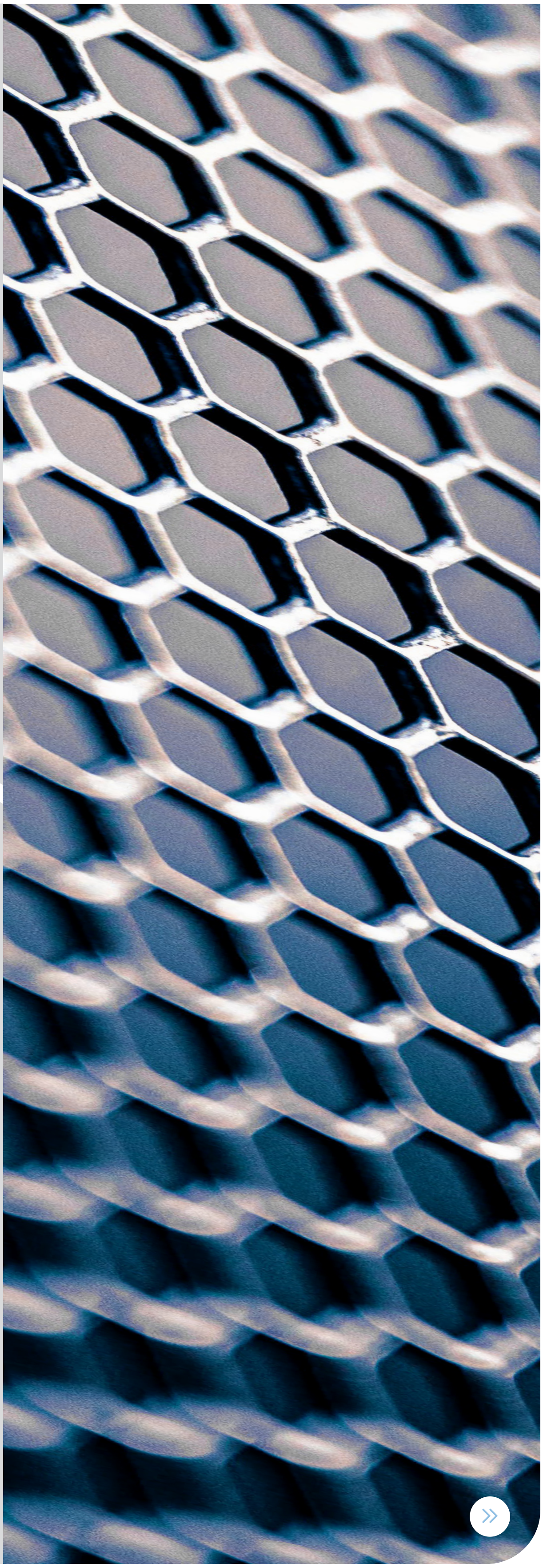


2. Inventory of radioactive waste and spent fuel to be managed in Spain

In Spain, radioactive waste (RW) is classified into very low-level waste (VLLW), low- and intermediate-level waste (LILW) - both of which are finally stored at the El Cabril Disposal Facility - and special waste (SW) and high-level waste (HLW), with the latter primarily including spent fuel (SF). This classification is performed depending on the management facilities, which are authorised for a specific volume, the radiological inventory and specific activity concentration limits according to the nature of different radionuclides present.

- Low- and intermediate-level waste (LILW): this category includes waste with activities primarily due to the presence of beta or gamma-emitting radionuclides, with short or medium half-lives (less than 30 years), and very low and limited content of long-lived radionuclides. This group includes very low-level waste (VLLW), which forms a subset of low- and intermediate-level waste (LILW) and generally exhibits specific activities between 1 and 100 becquerels per gramme, potentially reaching several thousand in the case of certain radionuclides with low radiotoxicity or when dealing with small quantities.

- High-Level Waste (HLW): this category comprises waste containing long-lived alpha-emitting radionuclides, with half-lives exceeding 30 years, in appreciable concentrations, generating heat due to radioactive decay, given their high specific activity. Its primary component is the spent fuel (SF) discharged from nuclear reactors, which has been considered radioactive waste (RW) since the first GRWP. They are accounted for separately in the national inventory due to their quantitative importance (most of the high-level waste (HLW) is spent fuel (SF)) and management requirements.
- Special Waste (SW): this category includes additions for nuclear fuel, neutron sources, used in-core instrumentation and replaced components from the reactor vessel and internal reactor components, typically metallic. Due to their radiological characteristics, they cannot be managed at the El Cabril Disposal Facility. As long-lived radioactive waste (RW) with significant activity, their temporary and final management is approached similarly to that of high-level waste (HLW).

Table 1 establishes the correspondence between the classification of radioactive waste (RW) used in Spain, and consequently in this Plan, and that established in the 2015 IAEA Safety Guide GSG-1 "Classification of Radioactive Waste".

National System Classification		IAEA GSG-1 Classification
RBBA	Very Low-Level Waste	VLLW
RBMA	Low- and Intermediate-Level Waste	LLW
RE	Special Waste	ILW
RAA	High-Level Waste	HLW

Table 1. Classification of radioactive waste (RW)

2.1. Origin of radioactive waste and spent fuel generated in Spain

The main generators of radioactive waste (RW) in Spain are nuclear power plants (NPPs), resulting from both their operation and decommissioning. However, there are also nuclear facilities and radioactive facilities generating radioactive waste (RW), such as the nuclear fuel assembly factory in Juzbado, research centres, universities, hospitals, industries, etc. Figure 3 shows the locations of these waste-generating centres in Spain.

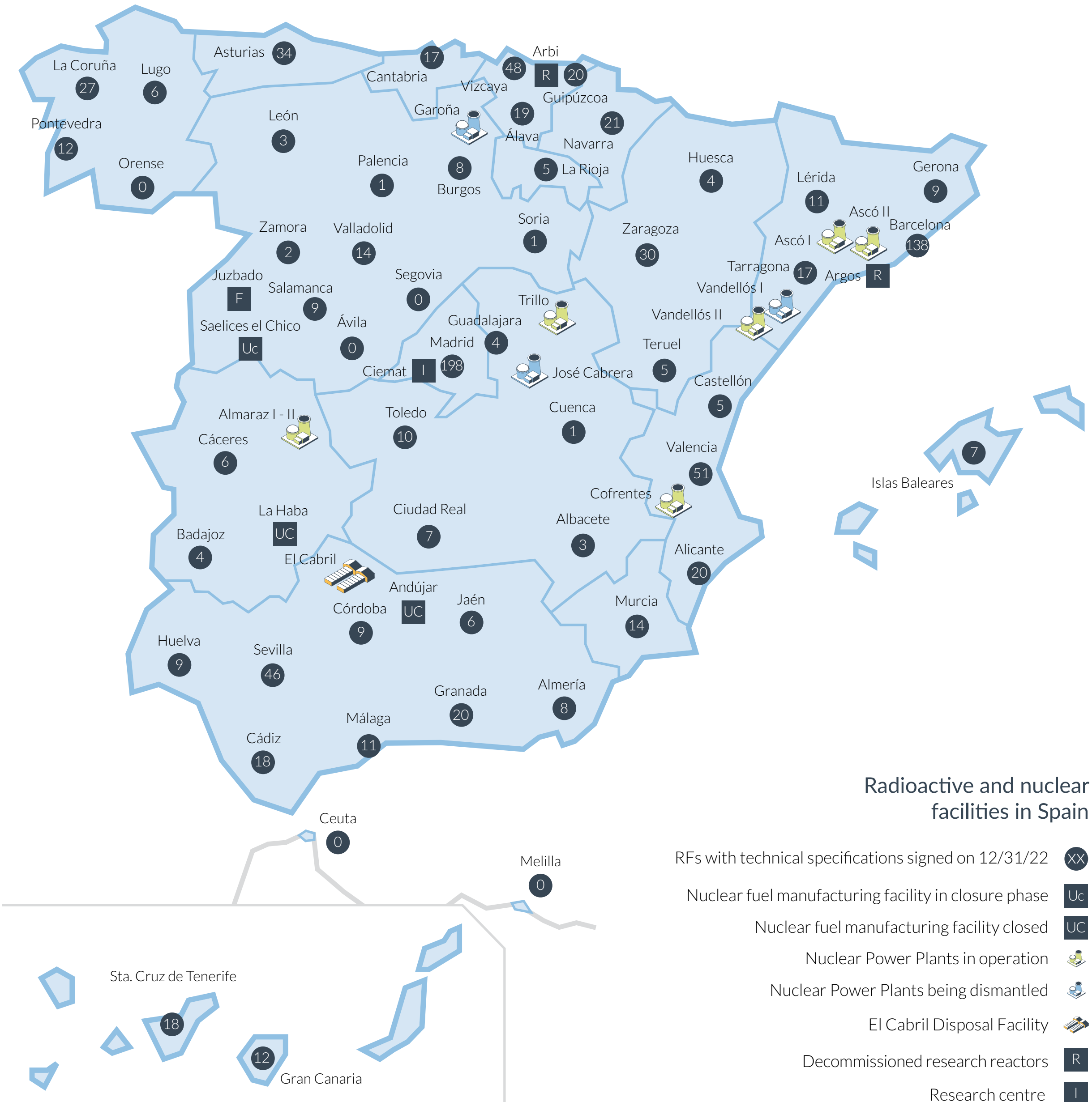


Figure 3. Map of radioactive waste-generating facilities at 31 December 2022

Spain has seven operating reactors at five sites. Vandellós I, José Cabrera and Santa María de Garoña NPPs are currently shut down and in different administrative situations. Vandellós I ceased operations in October 1989 and is currently in latency after partial decommissioning, awaiting total decommissioning. José Cabrera NPP shut down operations in April 2006 and is currently in the final phase of total decommissioning. Santa María de Garoña NPP is at the start of decommissioning Phase 1, following the authorisation for transfer of ownership and Phase 1 decommissioning granted by Ministerial Order TED/796/2023, dated 13 July 2023.

The Juzbado Nuclear Fuel Assembly Factory (Juzbado FAF) is located in the province of Salamanca and began operating in 1985, focusing on the production of uranium oxide fuel assemblies for PWR, BWR and VVER reactors.

The Centre for Energy-Related, Environmental and Technological Research (CIEMAT) in Madrid comprises a set of operational radioactive facilities and another set of permanently shut down nuclear facilities, which have been decommissioned under the PIMIC project.

Radioactive waste-generating facilities use radioactive isotopes and hence are subject to regulatory control. Enresa currently has a waste collection contract with 937 radioactive facilities for the management of their radioactive waste (RW).

In addition to the CIEMAT JEN-1 reactor, whose decommissioning is completed and its radioactive waste (RW) inventoried in the CIEMAT-PIMIC decommissioning project, there were two other reactors in Spain called Argos (1963-1977) and Arbi (1962-1972), located in Barcelona and Bilbao, respectively.

These reactors, both of the ARGONAUT type with a maximum power of 10 kW, are currently decommissioned, and their declarations of closure were issued in 2003 and 2005, respectively. The Argos reactor generated no radioactive waste (RW) during its decommissioning and the radioactive waste (RW) from Arbi was sent to El Cabril Disposal Facility.

In addition, Enresa manages orphan sources and radioactive waste (RW) from conventional facilities or companies, mainly in the steel and metal recovery industry, where radioactive materials are detected in the processed metallic scrap. Enresa also deals with radioactive waste (RW) resulting from incidents related to the presence of these materials.

El Cabril Disposal Facility generates radioactive waste (RW) in its operations, which is managed similarly to external waste received for the treatment, conditioning and storage of radioactive facilities and other producers.

To complete the national radioactive waste (RW) inventory, materials from the reprocessing of spent fuel (SF) that were sent abroad and are expected to return to Spain in the coming years, based on contractual clauses and the availability of facilities in Spain for their subsequent management, should be included. Currently, Spanish radioactive waste (RW) is only present at Orano (La Hague, France), generated from the reprocessing of spent fuel (SF) from Vandellós I NPP at the Marcoule facilities (France).

As regards spent fuel (SF), it is necessary to manage all the output produced by Spanish nuclear power plants (NPPs), both those in operation and those that have ceased operations, except for the spent fuel (SF) produced at Vandellós I NPP.

Lastly, residual materials from the first part of the nuclear fuel cycle (NFC), mining operations and uranium concentrate production should be considered. These residual materials require specific management, following international practice, based on in-situ stabilisation at the respective sites.

In the following table (Table 2), the quantities of mining waste and uranium concentrate production at 31 December 2022 from the specific facilities mentioned in Chapter 4, Section 4.1 (Current state of decommissioning and closure activities of mining and uranium concentrate production facilities) are provided.

Facilities	Mining waste ($x10^6$ t)	From threshing ($x10^6$ t)	From sludge ($x10^6$ t)	From classification ($x10^6$ t)
Andújar Uranium Mill Plant (FUA)			1.20	
19 former uranium mines (Extremadura and Andalusia)	0.30			
Lobo-G Plant (La Haba)	8.6		0.28	
Elefante Plant (Saelices el Chico)		7,2	0.43	
Saelices el Chico (mining operations)	68			
Quercus Plant (Saelices el Chico)		1,15	0.95	2.69
2 former uranium mines (Salamanca)	0.02			

Table 2. Mining waste and uranium concentrate production residuals at 31 December 2022, in tonnes (t)

2.2. Inventory at 31 December 2022

In this section, the inventory of radioactive waste (RW) and spent fuel (SF) at 31 December 2022 is specified, indicating their origin.

The data for radioactive waste (RW) whose intended destination is its final storage at El Cabril Disposal Facility is indicated in volume (m^3) of conditioned radioactive waste (RW) ready for acceptance. This radioactive waste (RW) is conditioned in storage units; in other words, in standardised casks (type CE-2a or equivalent). High-level waste (HLW) is indicated in the number of fuel assemblies, in tonnes of unirradiated uranium and volume (m^3) of fuel assemblies in standardised capsules (DGR).

At 31 December 2022, the occupancy rate in the vaults for LILW at El Cabril Disposal Facility is 82.11%, and for VLLW, the occupancy rate is 25.09% in vault 29 (Section I) and 24.81% in vault 30 (Section I).

2.2.1. Very low-level waste, low- and intermediate-level waste

The inventory of VLLW and LILW at 31 December 2022 is shown in Tables 3, 4 and 5. The radioactive waste (RW) in the final disposal structures at El Cabril Disposal Facility is differentiated from waste pending final storage, either in the storage facilities there or in the production centre storage:

		Volume of VLLW (m^3)			
		Produced	Temporarily stored at the production centre	Temporarily stored at El Cabril Disposal Facility	Final disposal at El Cabril Disposal Facility
Almaraz NPP	In operation	1,447	981	3	463
Ascó NPP	In operation	1,022	677	14	331
Cofrentes NPP	In operation	1,857	863	1	993
Garoña NPP	In operation	782	152	14	616
José Cabrera NPP	In operation	412	0	0	412
	Decommissioning	10,905	3,001	9	7,895
	Total	**11,317**	**3,001**	**9**	**8,307**
Trillo NPP	In operation	244	71	19	154
Vandellós I NPP	Decommissioning	1,163	757	0	406
Vandellós II NPP	In operation	494	299	27	168
Juzbado FAF	In operation	634	220	47	367
CIEMAT	In operation	730	37	7	686
	Decommissioning	7,567	0	2	7,565
	Total	**8,297**	**37**	**9**	**8,251**
El Cabril DC/ radioactive facilities/incidents	In operation	4,062	0	743	3,319
Total		31,319	7,058	886	23,375

Table 3. VLLW generated at NPPs and other facilities

		Volume of LILW (m^3)			
		Produced	Temporarily stored at the production centre	Temporarily stored at El Cabril Disposal Facility	Final disposal at El Cabril Disposal Facility
Almaraz NPP	In operation	5,278	1,032	33	4,213
Ascó NPP	In operation	4,732	521	21	4,190
Cofrentes NPP	In operation	8,002	1,485	49	6,468
Garoña NPP	In operation	5,236	64	2	5,170
José Cabrera NPP	In operation	4,767	0	2	4,765
	Decommissioning	2,026	0	8	2,018
	Total	**6,793**	**0**	**10**	**6,783**
Trillo NPP	In operation	1,660	66	13	1,581
Vandellós I NPP	In operation	1,968	1,572	0	396
	Decommissioning	1,796	4	0	1,792
	Total	**3,764**	**1,576**	**0**	**2,188**
Vandellós II NPP	In operation	1,594	207	13	1,374
Juzbado FAF	In operation	122	73	7	42
CIEMAT	In operation	329	15	4	310
	Decommissioning	175	0	0	175
	Total	**504**	**15**	**4**	**485**
El Cabril DC/ radioactive facilities/incidents	In operation	3,431	0	93	3,338
Total		41,116	5,039	245	35,832

Table 4. LILW generated at NPPs and other facilities

Type of waste	Approximate volume (m^3)	%
VLLW	31,300	43
LILW	41,100	57
Total	72,400	100

Table 5. Summary Inventory of VLLW/LILW generated at NPPs and other facilities

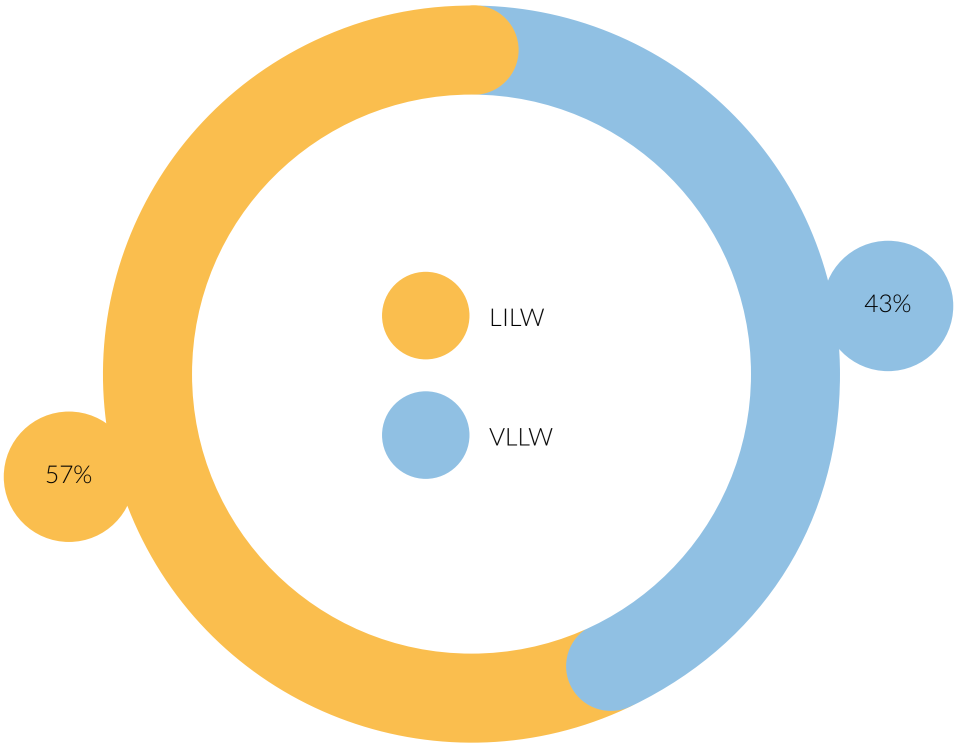


Figure 4. Structure by type of VLLW/LILW waste generated at 31 December 2022

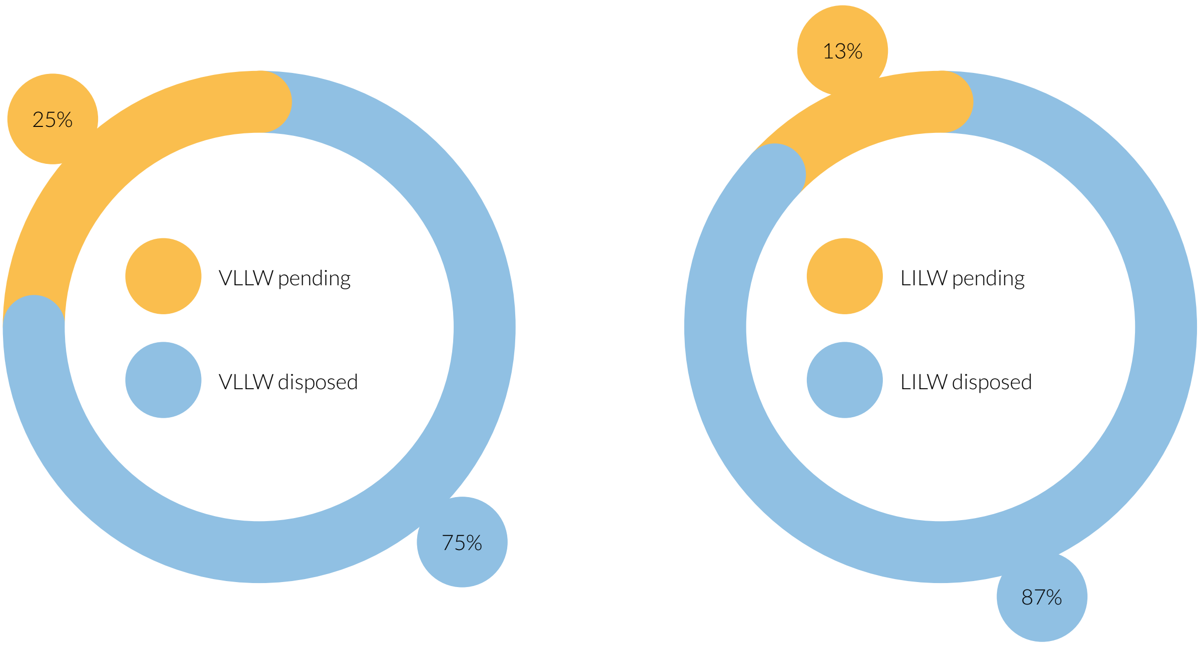


Figure 5. Percentage of waste disposed of in El Cabril cells at 31 December 2022

2.2.2. Special waste

For the inventory of special waste (SW) at 31 December 2022, the following types of radioactive waste (RW), conditioned in different types of casks, have been taken into account:

- Waste from the reprocessing of spent fuel (SF) from Vandellós I NPP, consisting of vitrified intermediate-level waste and super-compacted waste, which are conditioned in capsules and currently stored in France.
- Waste from the decommissioning of both José Cabrera NPP and Vandellós I NPP, classified as special waste (SW).
- Disused sources.

The special waste (SW) currently stored in the pools of the nuclear power plants (NPPs) are included in Table 9 of Section 2.3.

Type of waste		Approximate volume (m^3)	%
Reprocessing of SF from Vandellós I NPP		5	2.5
Decommissioning	José Cabrera NPP	31	15.5
	Vandellós I NPP	154	77
Disused sources		11	5
Total		201	100

Table 6. SW generated at 31 December 2022

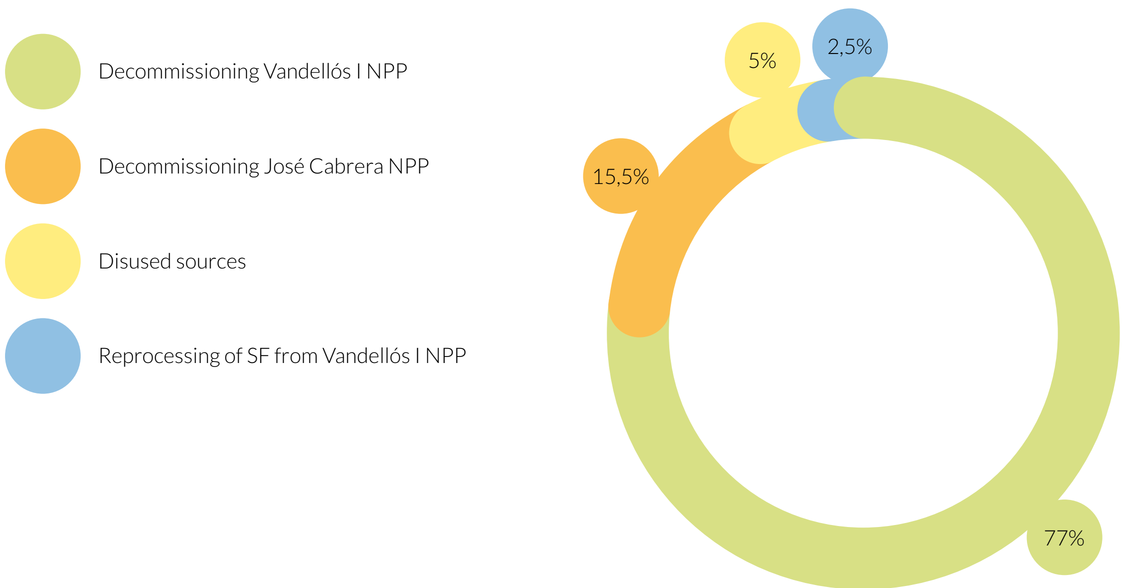


Figure 6. Structure by origin of HLW generated at 31 December 2022

2.2.3. Spent fuel and high-level waste

For the inventory of spent fuel (SF) and high-level waste (HLW) at 31 December 2022, the following radioactive waste (RW) has been taken into account:

- HLW: vitrified waste resulting from the reprocessing of spent fuel (SF) from Vandellós I NPP. Its conditioning is performed in standardised stainless-steel capsules, occupying an approximate total volume of 13 m^3. It is currently stored in France.

- SF: The inventory of spent fuel (SF) from Spanish nuclear power plants (NPPs) to be managed consists of two types of fuel assemblies (FA) based on the reactor type they come from: "Pressurised Water Reactor" (PWR) and "Boiling Water Reactor" (BWR).

  For BWR, there are currently four grid types: 8x8, 9x9, 10x10, and 11x11, which have been used interchangeably at Santa María de Garoña and Cofrentes NPPs. For each reactor, these types of fuel assemblies are dimensionally similar, with the main differences being the maximum length and weight (including uranium mass), which are greater at Cofrentes NPP.

  For PWR, there are three types in Spain: 14x14, 16x16, and 17x17, with significant dimensional differences between them (José Cabrera NPP: 14x14; Trillo NPP: 16x16; and the rest, Almaraz, Ascó, and Vandellós II NPPs: 17x17). Furthermore, for fuel with the same grid type, there are different models of fuel assemblies with design and material composition differences.

  Currently, the spent fuel (SF) assemblies are stored in the pools of nuclear power plants (NPPs), except for José Cabrera NPP, where they are all stored in an on-site ITS, and Trillo, Ascó, Almaraz, and Cofrentes NPPs, which, due to insufficient capacity in their pools, have an on-site ITS.

Table 7 summarises the number of fuel assemblies generated that are located in the pools of the nuclear power plants (NPPs) or in ITS at 31 December 2022, indicating the mass of non-irradiated uranium per plant. The total volume of this waste is approximately 8,900 m^3.

Nuclear Power Plant	Fuel assemblies			
	Stored			Tonnes of uranium
	Pool	Dry (ITS)	Total	
Almaraz I NPP	1,540	160	1,700	784
Almaraz II NPP	1,596	96	1,692	781
Ascó I NPP	1,096	512	1,608	752
Ascó II NPP	1,196	384	1,580	724
José Cabrera NPP	0	377	377	100
Trillo NPP	608	800	1,408	665
Vandellós II NPP	1,452	0	1,452	661
Cofrentes NPP	4,704	260	4,964	892
Garoña NPP	2,453	52	2,505	440
Total	14,645	2,641	17,286	5,799

Table 7. Inventory of spent fuel (SF) at 31 December 2022

2.3. Generation forecasts

The future generation forecasts are based on the reference scenario outlined in Section 1.5.

2.3.1. Very low- and low- and intermediate-level waste

The generation forecasts for very low-level waste (VLLW) and low- and intermediate-level waste (LILW) from 1 January 2023 are set out below:

		Volume of VLLW (m^3)	Volume of LILW (m^3)
Almaraz NPP	Operations	1,700	1,000
	Decommissioning	13,600	6,500
	Total	15,300	7,500
Ascó NPP	Operations	1,900	1,200
	Decommissioning	13,600	6,500
	Total	15,500	7,700
Cofrentes NPP	Operations	800	3,000
	Decommissioning	11,000	9,200
	Total	11,800	12,200
Garoña NPP	Operations	0	120
	Decommissioning	7,500	5,900
	Total	7,500	6,020
José Cabrera NPP	Decommissioning	2,500	0
	Total	2,500	0
Trillo NPP	Operations	290	900
	Decommissioning	7,700	3,300
	Total	7,990	4,200
Vandellós I NPP	Decommissioning	15,400	8,000
	Total	15,400	8,000
Vandellós II NPP	Operations	700	800
	Decommissioning	7,700	3,300
	Total	8,400	4,100
Juzbado FAF	Operations	340	30
	Decommissioning	20	0
	Total	360	30
CIEMAT	Operations	170	6
	Decommissioning	130	0
	Total	300	6
Other (includes El Cabril DC)	Operations	8,600	3,310
	Decommissioning	60	0
	Total	8,660	3,310
Total		≈93,700	≈53,100

Table 8. Forecast of VLLW and LILW generation from NPPs and other facilities

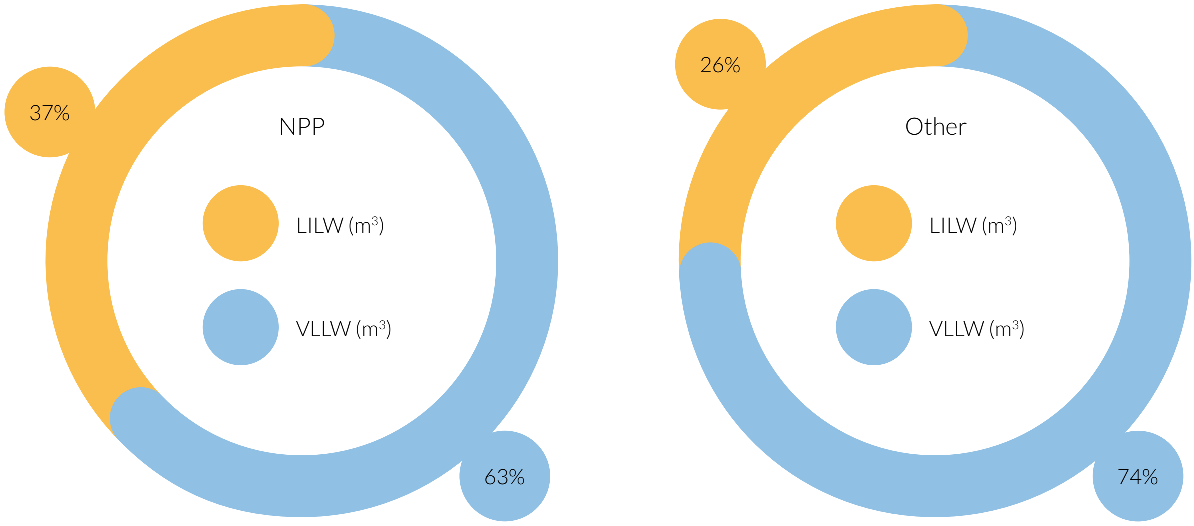


Figure 7. Generation forecast by type of VLLW/LILW

2.3.2. Special waste

The following is a medium-term forecast for the generation of special waste (SW), including out-of-service radioactive sources both from operations and decommissioning, broken down by origin.

Nuclear facility	Total volume (m^3)
Almaraz I NPP	88
Almaraz II NPP	88
Ascó I NPP	77
Ascó II NPP	77
Cofrentes NPP	71
Garoña NPP	28
Trillo NPP	77
Vandellós I NPP	99
Vandellós II NPP	88
Others	3,000
Total	≈3,700

Table 9. Forecast of special waste (SW) generation from NPPs and other facilities

2.3.3. Spent fuel (SF) and high-level waste

The following is a forecast of the average generation of high-level waste (HLW) and spent fuel (SF) in fuel assemblies and estimated after conditioning in storage canisters for DGR (final stage of its management).

Nuclear Power Plant	Fuel assemblies	Total volume (m^3)
Almaraz I NPP	349	244
Almaraz II NPP	353	244
Ascó I NPP	482	348
Ascó II NPP	548	396
Cofrentes NPP	1,492	359
Trillo NPP	637	460
Vandellós II NPP	609	460
Total	≈4,500	≈2,500

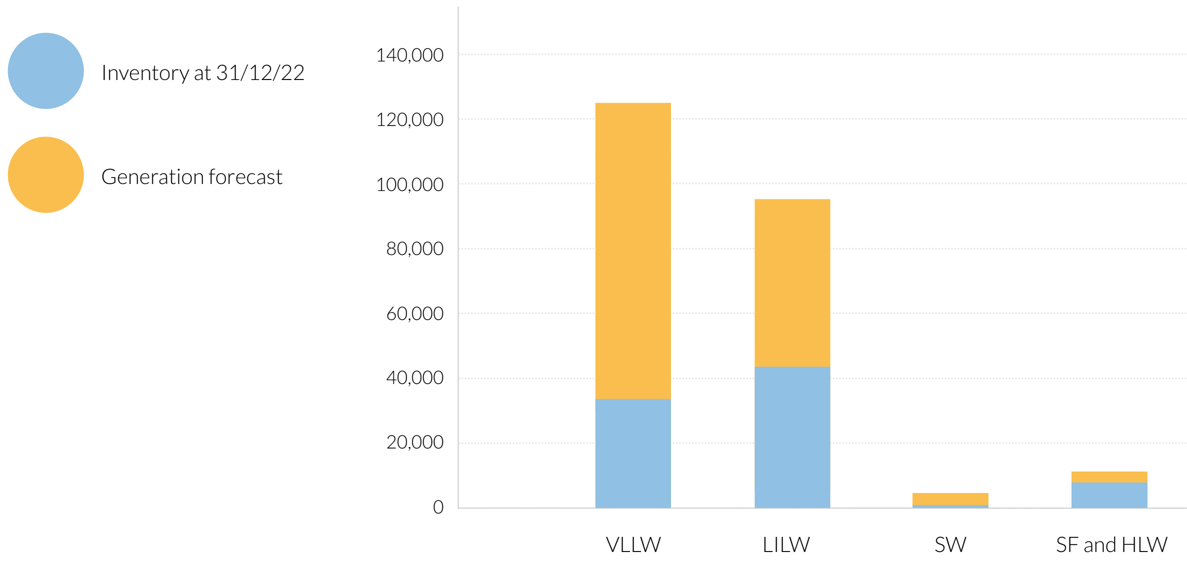
Table 10. Forecast of SF and HLW generation from NPPs

2.4. National Inventory

The following is a summary of the volumes included in this section, both for the radioactive waste (RW) generated at 31 December 2022 and for the future generation forecasts in order to obtain the total inventory.

Type of waste	Approximate volume (m^3)			%
	Inventory at 31-12-22	Forecast generation	Total inventory	
VLLW	31,300	93,700	**125,000**	**53**
LILW	41,100	53,100	**94,200**	**40**
SW	200	3,700	**3,900**	**2**
SF AND HLW	8,900	2,500	**11,400**	**5**
Total	81,500	153,000	234,500	100

Table 11. Summary of the National Inventory



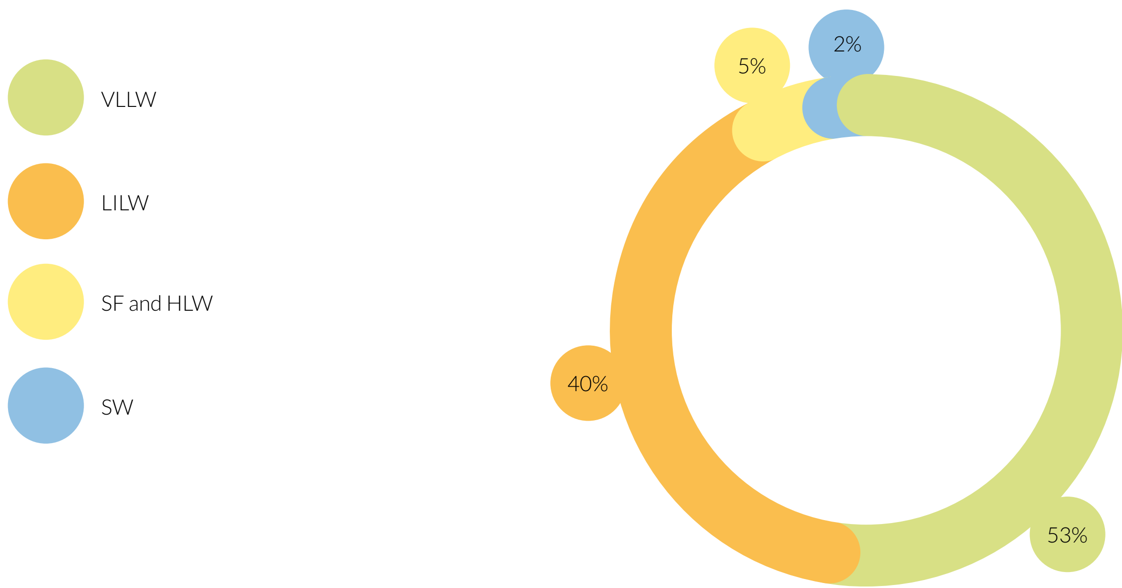
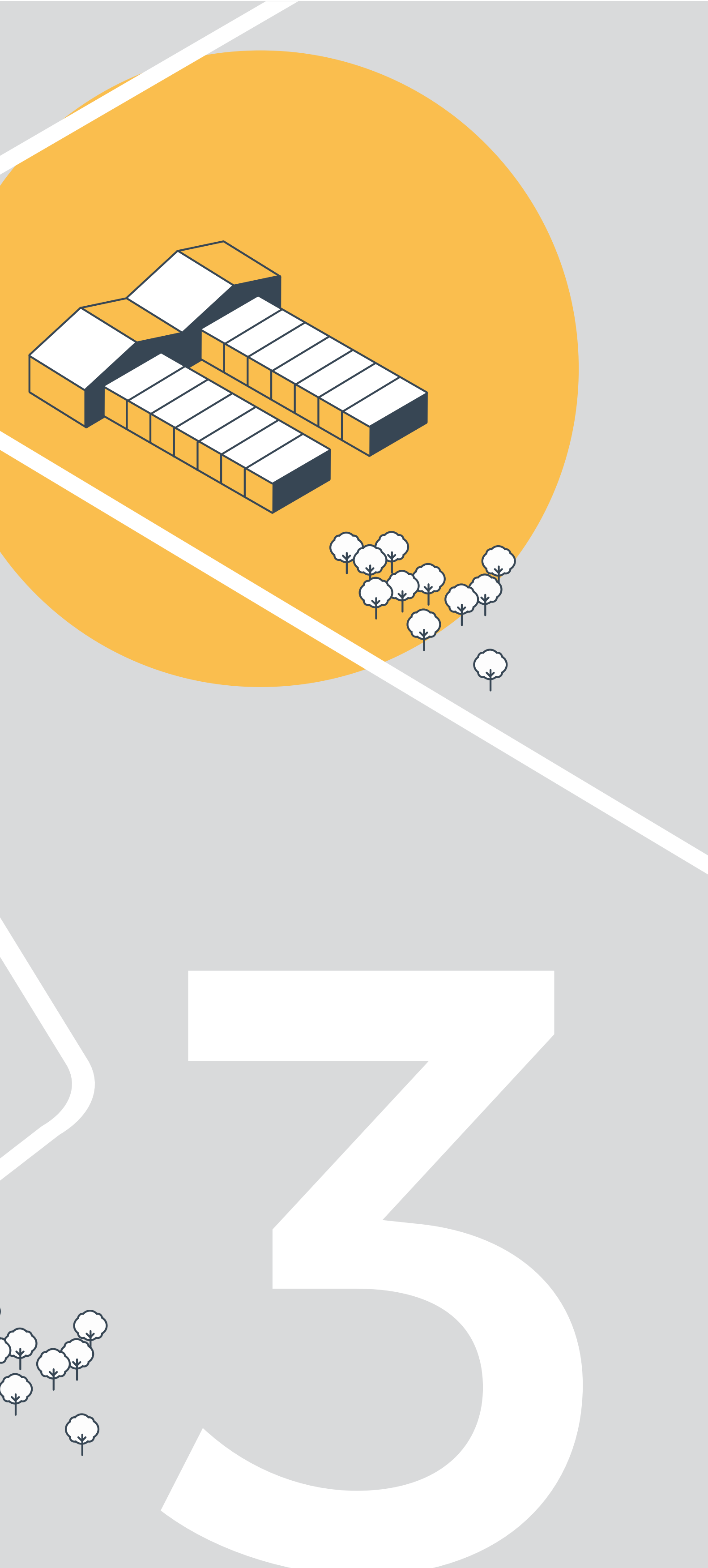


Figure 8. National Inventory by type of radioactive waste (RW)



3

3. Technical solutions for the management of radioactive waste and spent fuel

This section sets out the details of technical solutions for strategic lines related to the management of low- and intermediate-level waste (LILW) and very low-level waste (VLLW), on the one hand, and the management of high-level waste (HLW), spent fuel (SF) and special waste (SW), both on a temporary and final basis, on the other. Each of them describes the current situation, the lines of action, the scheduled activities and includes international references on the subject.

3.1. Management of very low- and low- and intermediate-level waste

The management of this radioactive waste (RW) includes a broad set of activities such as the handling, pre-treatment, treatment, conditioning, temporary storage and final storage.

3.1.1. Current situation

Spanish legislation demands the transfer of such materials from their producer or holder to Enresa, regardless of the form and characteristics of these materials, with the possibility of seizure by means of the corresponding State intervention, if necessary.

With the administrative procedures implemented, it can be asserted that Spain has globally resolved the management of this type of radioactive waste (RW), with a management system in place equipped with the necessary technological capabilities, which is configured based on the actions of a well-identified set of agents operating in a structured manner.

Enresa provides radioactive waste (RW) management services to operators of nuclear facilities and radioactive facilities governed by technical-administrative acceptance specifications (previous specimen contracts approved by resolution of the Directorate-General of Energy Policy and Mines). These contracts establish acceptance criteria for subsequent conditioning and storage.

Regulated facility licensees generating radioactive waste (RW) must have the capacity for waste management, which can be implemented following the technical specifications established by Enresa.

Within this system, nuclear facilities have waste treatment capabilities, prepared to condition waste in accordance with Enresa's acceptance specifications for disposal at El Cabril Disposal Facility. In other cases (radioactive facilities), producers deliver their waste to Enresa in an agreed form, and it is Enresa that performs the necessary treatment and conditioning tasks prior to storage at El Cabril.

El Cabril Disposal Facility (Figure 9), as an essential part of the national system, is the facility where the final storage of this type of solid radioactive waste (RW) takes place.

Figure 9. Aerial view of El Cabril facility

This facility has various technological capabilities, including installations for the treatment and conditioning of radioactive waste (RW). Treatment is carried out at the centre on waste from radioactive facilities, as well as radioactive waste (RW) from interventions at facilities not subject to nuclear regulation. Furthermore, some complementary treatments are performed on radioactive waste (RW) from nuclear facilities.

El Cabril Disposal Facility also has laboratories (Figure 10) to verify the quality and characterisation of waste, which form the basis for the acceptance of different types of radioactive waste (RW) and to verify their characteristics. Lastly, the centre has temporary storage capacities, workshops, laboratories and the auxiliary systems required for its operation.

Figure 10. Laboratory at El Cabril Disposal Facility

For the final disposal of low- and intermediate-level waste (LILW), there is a disposal capacity for conditioned waste of some 50,000 m^3. 28 disposal vaults have been built, of which 22 have been completed (Figure 11) at 31 December 2022.

Figure 11. LILW storage cell

As regards very low-level waste (VLLW), the complementary facility for its disposal (Figure 12) is authorised for four cells with a combined capacity of some 130,000 m^3, which are being built according to needs. Currently, section 1 of cell 29 has been completed, and section 1 of the second authorised cell - cell 30 - and section 2 of cell 29 are in operation.

Figure 12. Complementary facility for VLLW storage

3.1.2. Lines of action

The experience acquired in Spain in managing low- and intermediate-level waste (LILW) and very low-level waste (VLLW) has led to the identification of areas for improvement and the definition of suitable actions to optimise their management. This involves addressing elements of the system that are most necessary at present.

Based on estimates of low- and intermediate-level waste (LILW) and very low-level waste (VLLW) generation, considering the uncertainties inherent in the methodology used, the following key action areas for improving the management of this waste can be identified:

- Coordination with waste generators to minimise waste generation and volume, both during operations and in the decommissioning of nuclear facilities, thus making it advisable to undertake joint projects to reduce volume.

- Continuous analysis of the evolution of radioactive waste (RW) generation and the adaptation of El Cabril Disposal Facility to potential future needs, optimising vault occupancy, considering types of radioactive waste (RW) and new types of casks and vaults.

- Monitoring and participating in projects to optimise the management, treatment and conditioning of graphite radioactive waste (RW) for its final disposal.

- Evaluation of the design of new low- and intermediate-level cells, as outlined in the 6th General Radioactive Waste Management Plan, taking into account the results of decommissioning operations and preparing supporting documentation for their construction.

- Exploration of the possibility of implementing treatment and volume reduction systems at El Cabril Disposal Facility.

- Evaluation of cover layer trials for subsequent sealing of disposal areas.

- Continuous improvement in knowledge of radioactive waste (RW) and methods/techniques for understanding the conduct of disposal systems (engineering barriers) and safety evaluation.

- Enhancement of technological capabilities available to optimise previous processes and prepare for future situations, both anticipated and unforeseen.

- Improvement of the methodology for classifying waste areas, defining management routes for radioactive and conventional waste generated, such that:

    - Waste from conventional waste areas will be managed through conventional routes, boosting reuse, recycling and recovery.

- Waste generated in radioactive waste (RW) areas will be managed through specific routes, taking into account its potential radioactive content. Its management will involve suitable radiological checks, and in the case of radioactive content, the evaluation of radiological impact, within specific procedures or authorisations (e.g. declassification).

3.1.3. Scheduled actions

Low- and intermediate-level waste (LILW) and very low-level waste (VLLW) management systems will continue to operate normally, ready to address and provide the appropriate response to the management needs of this type of radioactive waste (RW) generated by nuclear facilities and radioactive facilities or as a result of other activities at Naturally Occurring Radioactive Material (NORM) facilities.

In this regard, the operational capabilities of El Cabril Disposal Facility and its support capacities will be maintained, complying with the conditions of the facility's operating authorisation.

Efforts will focus on maintaining and optimising the acquired capacities, stressing the optimisation of radioactive waste (RW) volume and activity, along with techniques to classify low- and intermediate-level waste (LILW) and very low-level waste (VLLW), taking into account existing availabilities and the lowest cost solution for very low-level waste (VLLW).

The storage capacity for all very low-level waste (VLLW) is presumed to be sufficient with the four authorised cells, with cell 29 and cell 30 currently in operation since October 2008 and July 2016, respectively. As becomes necessary, the construction of section 2 of cell 30 and the other two authorised cell - cell 31 and cell 32 - is planned for the same purposes.

For the disposal of all low- and intermediate-level waste (LILW), the construction of new cells is required, as set out in the 6th GRWP, necessary in any operating scenario of nuclear power plants (NPPs). Accordingly, the optimisation of managing this type of waste is considered strategic.

Furthermore, estimates must also consider that the final disposal capacity would also be impacted by the radioactive waste (RW) that could be generated in future specific incidents that may initially be unforeseen, resulting from the inadvertent presence of radioactive sources in recycled metallic materials, along with other waste generated outside the regulated system when its management is required by a resolution of the Ministry for Ecological Transition and Demographic Challenge (MITECO).

Accordingly, the analysis of the capacity of the existing 28 low- and intermediate-level waste (LILW) cells concludes with the need for new cells by 2028 to avoid affecting the operation and decommissioning plans of nuclear power plants (NPPs) and to continue normal disposal of this waste.

The construction of new cells will be undertaken in phases, with the first phase involving the construction of 12 cells and subsequently, additional cells (initially 15), constructed as needed, according to the decommissioning of nuclear power plants (NPPs).

In accordance with one of the principles established in this Plan, minimising radioactive waste (RW) generation and volume, with a view to optimal cell occupancy, is an ongoing line of action. In this regard, the collaboration policy between Enresa and major radioactive waste (RW) producers will continue and be reinforced. This involves participating in joint working groups, developing and using treatment, decontamination and characterisation equipment at different nuclear power plants (NPPs) and jointly undertaking projects to apply volume reduction, declassification and decontamination technologies to optimise their management.

Among the lines to promote volume reductions, based on the volumes indicated in Section 2, their origin and type, worthy of mention are drying out, waste decontamination, treatment through the melting of large equipment and components and declassification projects of residual materials.

As regards activities related to final disposal, radioactive waste (RW) characterisation, methods and techniques for understanding the conduct of disposal systems and safety evaluation, the following lines of action are noteworthy:

- Analysis of projected inventories and available capacities.
- Improvements in characterisation techniques and the measurement of radioactive waste (RW) packages.
- Definition of management routes for radioactive waste (RW) currently pending acceptance for disposal at El Cabril Disposal Facility.
- Acquisition of information and development of methodological and instrumental improvements to optimise the safety assessment of these facilities.
- Continuation of studies on the durability of engineering barriers in the disposal system.
- Continued data collection and analysis in the cover layer trials conducted to support the detailed design of the final disposal cover.
- Study of new configurations of disposal units for managing large equipment and components of nuclear power plants (NPPs) or other needs.
- Design and testing of new transport packaging that better suits the new needs of decommissioning operations.
- Continuation of work on the radiological disposal capacity of low- and intermediate-level waste (LILW).
- Preservation of memory records and knowledge transfer at El Cabril Disposal Facility in all its processes.

As regards the adaptation and improvement functionalities and the availability of means for future situations at El Cabril Disposal Facility, the main actions to be undertaken include:

- Provision of new handling resources to increase the operational disposal capacity of very low-level waste (VLLW) and low- and intermediate-level waste (LILW).
- Evaluation of the design of new cells for low- and intermediate-level waste (LILW), taking into account the results of decommissioning operations.
- Continuation of actions to support radioactive facilities to optimise the "in situ" management of the waste they generate.

The implementation of the actions described in these sections will require, where applicable, the corresponding authorisation.

3.1.4. Plans for the period after the operational life of El Cabril Disposal Facility

After the completion of the decommissioning of the last nuclear plant, with its waste adequately conditioned and disposed of, and with a Deep Geological Repository (DGR) for spent fuel (SF), high-level waste (HLW) and special waste (SW), Enresa will finalise the covering of all the storage structures at El Cabril Disposal Facility with a definitive cover consisting of several alternating layers of drainage and waterproofing materials. Finally, the entire structure will be covered with topsoil and integrated into the landscape through the planting of native species. The final cover project must receive approval from the CSN before its execution.

For the decommissioning and closure of El Cabril Disposal Facility, Enresa must request the necessary authorisation. As provided for in the Regulation on Nuclear and Radioactive Facilities, approved by Royal Decree 1836/1999, of 3 December, the Regulation empowers the licensee to initiate final engineering and other necessary works to ensure the long-term safety of the storage system. This includes the activities of decommissioning auxiliary facilities as determined, ultimately allowing the delimitation of areas that should be subject to control and radiological or other types of oversight for a specified period. The process of decommissioning and closure will conclude with a declaration of closure issued by the MITECO, following a report from the CSN.

In accordance with Article 38 bis 4 of the Nuclear Energy Act (NEA), the State will assume ownership of the radioactive waste (RW) once final storage has been completed. Furthermore, Article 4.4 of Royal Decree 102/2014, of 21 February, establishes, for the responsible and safe management of spent fuel (SF) and radioactive waste (RW), that the State will take over the oversight of final storage facilities after their closure.

To preserve knowledge of the facility in the long term, the corresponding records will be developed to document the development and characteristics of the facility, as well as the inventory of stored waste.

In line with the analyses for the safety evaluation and performance of these facilities, the activities planned for the period after the closure of the disposal, encompassed under the generic concept of "institutional surveillance" (a set of actions that allow the evolution of environmental and radiological parameters of a site during the period established by competent authorities to be monitored once the facility is closed), including such aspects as radiological and environmental surveillance, control of meteorological and hydrogeological data, knowledge transfer, maintenance of information on available mediums, maintenance of the terrain and physical security control.

3.1.5. International situation

At an international level, the definitive management of low and intermediate-level waste is considered a process resolved at an industrial scale, with numerous examples of functioning management systems for several decades. Many countries already have disposal facilities or plan to build them. While disposal of low- and intermediate-level waste (LILW) in surface or near-surface facilities is the typical strategy, other countries (such as Sweden, Finland, South Korea, Hungary, Germany, Switzerland and Canada) have chosen or are considering the option of disposal in facilities at a depth of 50 to 100 metres. El Cabril Disposal Facility represents the first type, with engineering barriers for low- and intermediate-level waste (LILW) and trench-type facilities for very low-level waste (VLLW).

El Cabril Disposal Facility, which began operating in 1992, initially benefited from experience acquired in foreign facilities with similar characteristics used as reference models. Currently, El Cabril Disposal Facility is internationally considered as a benchmark of how to resolve the final storage of low- and intermediate-level waste (LILW) and very low-level waste (VLLW). This has sparked the interest of numerous foreign delegations, leading them to visit the facility, and its concept is being adopted in the design and construction of facilities in other countries.

In the medium term, it is foreseeable that the international situation for this type of solution for low- and intermediate-level waste (LILW) will not undergo significant changes. Although some specific cases in Germany, Belgium and Switzerland remain unresolved, where the implementation of their repositories has been delayed due to public acceptance issues, it appears that in the coming years, the number of these facilities in operation will increase. Existing facilities will evolve and adapt to the operational needs of low and intermediate-level waste management, optimising technical and economic capacities. In terms of references, this affects the development and construction of new disposal cells in France, China and Japan, the expansion of capacity for the disposal of decommissioning radioactive waste (RW) in silo-disposal in Sweden, and the design and construction of specific facilities for the disposal of decommissioning low- and intermediate-level waste (LILW) and very low-level waste (VLLW) in Lithuania, Bulgaria and Slovakia.

Furthermore, developments in the management of low and intermediate-level waste continue to be the subject of discussion and exchange of experiences by the main international organisations (NEA/OECD and IAEA). Spain is present in all these bodies and benefits from the knowledge acquired in these areas.

Country	Type	Facility	Situation
Germany	Mine	Konrad	Under construction
Belgium	Surface	Dessel	Licensing phase
Bulgaria	Surface	Radiana	Under construction
Canada	Cavern	Kincardine	Licensing phase
South Korea	Cavern	Wolseong	Operational
Slovakia	Surface	Mohovce	Operational
United States	Surface Surface Surface Surface	Richland (WA) Barnwell (SC) Andrews (TX) Clive (UT)	Operational Operational Operational Operational
Finland	Cavern Cavern	Olkiluoto Loviisa	Operational Operational
France	Surface Surface	La Manche L´Aube	Closed Operational
	Surface	Morvilliers	Operational
Hungary	Surface Cavern	Püspökszilágy Bátaapáti	Operational Operational
Japan	Surface	Rokkasho Mura	Operational
Lithuania	Surface	Visaginas	Under construction
Czech Republic	Surface Mine Mine	Dukovany Richard Bratrstvi	Operational Operational Closed
United Kingdom	Surface Surface	Drigg Dounreay	Operational Operational
Sweden	Cavern	Forsmark	Operational

Table 12. Final disposal facilities for LILW in different countries

3.2. Spent fuel, high-level waste and special waste management

3.2.1. Temporary management

3.2.1.1. Current situation

In Spain, the initial decision was to reprocess the spent fuel (SF) from the Vandellós I, José Cabrera and Santa María de Garoña NPPs in facilities in France and the United Kingdom. This practice was discontinued in 1982, except for the first of these nuclear power plants, which ceased operations in 1989. The spent fuel (SF), of a different type from that of light-water nuclear power plants (NPPs), had to be reprocessed in its entirety for technical reasons. As a result of these activities, reprocessed materials were obtained, which, depending on the contracts, were to be returned to Spain or not. Currently, materials from the reprocessing of spent fuel (SF) from Vandellós I are still to be returned to Spain and remain in France.

Since 1982, all spent fuel (SF) generated in Spanish light-water nuclear power plants (NPPs) has been stored in the pools of the respective nuclear power plants (NPPs) (Figure 13). Faced with projections of these pools reaching their capacity limits, various projects were implemented in the 1990s to progressively replace the original racks with more compact and larger-capacity racks. In most cases, this significantly delayed the need to provide the Spanish system with additional spent fuel (SF) storage capacity beyond the capacity of the pools themselves, ensuring the continued operation of the nuclear power plants (NPPs). Furthermore, in 2020, the second phase of rack replacement was completed at the Vandellós II NPP pool, concluding the optimisation activities for pool capacity at nuclear power plants (NPPs), as no additional viable technical options were available.

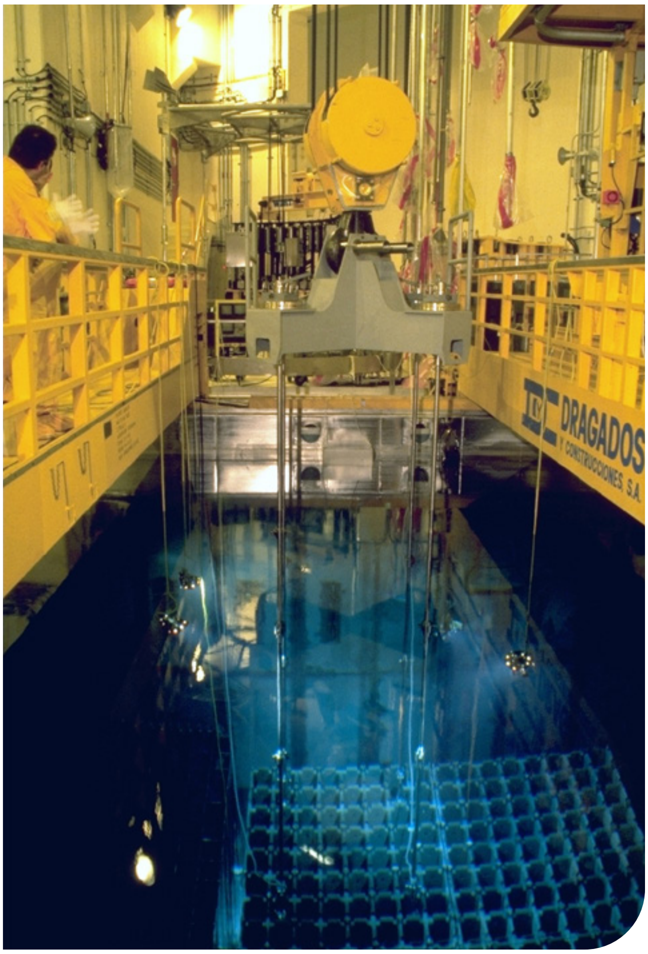


Figure 13. Spent fuel (SF) storage pool

Despite having carried out the aforementioned rack replacement actions, it has been necessary to develop other measures to provide the nuclear power plants (NPPs) with additional dry storage capacity beyond the pools on the respective power plant sites using Individualised Temporary Storage (ITS). The storage system used at each nuclear power plant is the result of the tender processes employed by Enresa.

Currently, operational Individualised Temporary Storage (ITS) exists at the Trillo, José Cabrera, Ascó, Santa María de Garoña, Almaraz and Cofrentes NPPs. Since the ITS at Ascó, Almaraz and Cofrentes does not have sufficient capacity, Enresa has scheduled the construction of new complementary ITS facilities at these plants, with their operation expected to begin in 2026. The construction of a new ITS facility is also planned to commence operations in 2026 at Vandellós II NPP, which is currently the only plant without dry storage.

- Trillo NPP: In 2002, an ITS facility was put into operation, consisting of a reinforced concrete building that allows the storage of up to 80 dual-purpose metallic casks (storage and transport) (Figure 14).

Figure 14. Trillo NPP ITS

- José Cabrera NPP: this plant definitively ceased operations in April 2006, and to facilitate its decommissioning, an ITS was put into service in 2009. The ITS currently stores all spent fuel (SF) (12 casks) and special waste (SW) (4 casks) from this plant. This ITS consists of a reinforced concrete slab with 16 storage positions, all occupied by systems of metallic capsules welded with a concrete enclosure (Figure 15).

Figure 15. José Cabrera NPP ITS

- Ascó I and Ascó II NPPs: in 2013, an ITS was put into service to serve both units, consisting of two independent slabs for 16 storage casks each. In 2022, this capacity was expanded to 18 casks. A storage system based on metallic capsules welded with a concrete enclosure, similar to that of José Cabrera NPP, was selected for this plant (Figure 16).

Figure 16. Ascó NPP ITS

- Santa María de Garoña NPP: this plant was shut down in 2012 and definitively ceased operations in August 2017, with its decommissioning commencing in July 2023 after the transfer of ownership to Enresa. Despite this, and under the assumption of the plant's continued operation, an ITS was licensed and constructed, receiving authorisation to be put into service in 2018. This ITS consists of two reinforced concrete slabs, initially authorised for 10 casks, and currently, the authorisation for the storage of the entire spent fuel (SF) inventory from the plant is being processed. The storage system selected for this plant involves dual-purpose metallic casks (Figure 17).

Figure 17. Santa María de Garoña NPP ITS

- Almaraz I and II NPPs: in 2018, authorisation was obtained for an ITS to be put into service based on two reinforced concrete slabs with a capacity for 20 casks (10 casks on each slab). This ITS serves both units of this plant, and a storage system based on dual-purpose metallic casks was selected (Figure 18).

Figure 18. Almaraz NPP ITS

- Cofrentes NPP: an ITS has been constructed for this plant, which began operation and stored the first casks in 2021. This ITS consists of two slabs with a capacity to house up to 12 positions each, providing a total storage capacity for 24 casks. A dual-purpose metallic cask was selected for this plant (Figure 19).

Figure 19. Cofrentes NPP ITS

- For the new ITS scheduled for Ascó, Almaraz, Cofrentes and Vandellós II NPPs, a storage system based on metallic capsules welded with a concrete enclosure has been selected, similar to the current Individualised Temporary Storage (ITS) at Ascó and José Cabrera NPPs.

As regards high-level waste (HLW) and special waste (SW) (components associated with the operation of fuel assemblies, such as control rods, BWR channels, primary and secondary sources, flow restrictor devices, etc.), whose final management is not planned at El Cabril Disposal Facility, they are temporarily stored in the pools. Due to a significant accumulation of these types of waste in some nuclear power plants (NPPs), occupying positions in the pool, projects for characterisation, segmentation and specific conditioning are being developed to separate the more activated parts, which will remain in the pools, from the less activated and manageable parts, which will be managed at El Cabril, depending on acceptance criteria.

Lastly, regarding the temporary management of spent fuel (SF) and high-level waste (HLW), it is worth noting that, as mentioned in Section 1.2 regarding the reference framework, the 6th General Radioactive Waste Plan (GRWP), approved on 23 June 2006, maintained the strategy of unified temporary management of spent fuel (SF), high-level waste (HLW) and special waste (SW) in a single facility, anticipating the commissioning of a Centralised Temporary Storage (CTS) facility.

To carry out the site selection process for this facility, Royal Decree 775/2006 was approved on 23 June 2006, establishing an interministerial committee to define the criteria for the location of the CTS. This led to a selection process, resulting in the designation of Villar de Cañas (Cuenca) as the location for this facility and its Associated Technological Centre, approved by the Council of Ministers on 30 December 2011.

Based on this, in January 2014, Enresa submitted a request for prior authorisation and authorisation for the construction of this facility to the Ministry of Industry, Energy and Tourism. The Nuclear Safety Council (CSN) issued a favourable report on the request for prior authorisation on 27 July 2015.

However, without granting either of these two authorisations, in July 2018, the State Secretariat for Energy requested the CSN and the State Secretariat for the Environment to suspend both the issue of the mandatory report on the construction authorisation and the processing of the environmental evaluation procedure until the approval of the 7th GRWP.

After considering the arguments made during the public information and consultation period, the difficulties in achieving the necessary degree of social, political and institutional consensus for the construction of such a facility became apparent. Hence, a CTS is considered unfeasible.

3.2.1.2. Strategic lines of action

Continuing the actions already undertaken, the storage capacity for spent fuel (SF) at the Individualised Temporary Storage (ITS) facilities at nuclear power plants (NPPs) will be expanded to facilitate their operation and decommissioning according to each plant's needs. A new ITS will be constructed at Vandellós II NPP, and a storage facility will be established at Vandellós I NPP to accommodate high-level waste (HLW) and special waste (SW) from the reprocessing of SF in France and, as the case may be, from the decommissioning of the plant.

The strategy involves storing SF, high-level waste (HLW) and special waste (SW) that cannot be managed at El Cabril in Decentralised Temporary Storage (DTS) facilities at the sites of the generating NPPs until their transfer to the Deep Geological Repository (DGR).

In line with the phased cessation of operations at nuclear power plants (NPPs), coordination and cooperation among operational entities (licensees and Enresa) will be maintained to optimise the management of SF from the last groups to cease operations. This includes considerations related to cask types and SF characteristics.

Decentralised Temporary Storage (DTS) facilities provide a suitable timeframe to develop a final storage solution, granting sufficient time to design, license, construct and commission the future Deep Geological Repository (DGR).

The seven sites with SF (Almaraz, Ascó, Cofrentes, Santa María de Garoña, José Cabrera, Trillo and Vandellós II) will each have a Decentralised Temporary Storage (DTS) facility with sufficient storage capacity to accommodate all SF, high-level waste (HLW) and special waste (SW) generated during the operation and decommissioning of each plant. The Decentralised Temporary Storage (DTS) facility will also have the necessary means for its operation until transfer to the Deep Geological Repository (DGR).

Each plant's Decentralised Temporary Storage (DTS) facility will consist of its ITS or, as the case may be, several ITSs, along with a new complementary facility or additional measures to perform maintenance and repair operations on its casks, ensuring the safety and recoverability function of the casks.

3.2.1.3. Scheduled actions

To enable the initial management of SF and radioactive waste (RW) without affecting plant operations or subsequent decommissioning, the following actions are planned:

- All nuclear power plants (NPPs) will be equipped with dry storage capacity at their sites (ITS). The ITS(s) will house spent fuel (SF) and special waste (SW) storage systems to provide additional space in the pool or facilitate its drainage, to allow the decommissioning of the plant as required.

  ITS facilities are designed and built according to the number and type of storage systems intended for use at each nuclear power plant, taking into account the characteristics of their respective locations.

- Various actions, such as those in ITS and the replacement of pool racks, allow some nuclear power plants (NPPs) (Ascó I and II, Vandellós II, Cofrentes) to continue operating until different times in 2027. Almaraz I and II NPPs are expected to cease operations in 2027 and 2028, respectively.

  On the specified dates, the Individualised Temporary Storage (ITS) facility at Ascó NPP will have reached its maximum capacity. The ITS facility at Cofrentes NPP will have radiological protection constraints with the current metallic casks, and the pool at Vandellós II NPP will become saturated. Hence, there is a need to establish additional operational spent fuel (SF) storage capacity by the end of 2026 at these nuclear power plants (NPPs). Almaraz NPP will also require new storage capacity to enable the draining of its pools. To optimise management, simplify necessary procedures and reduce costs, a unique storage solution will be developed for these nuclear power plants (NPPs).

  This unique solution will be based on the welded capsule system, providing enhanced radiological shielding. Currently, such solutions based on welded capsules exist in the ITS facilities of José Cabrera and Ascó NPPs

  Trillo NPP has an ITS building and a licensed metallic cask in use, allowing the plant to operate until its cessation and pool drainage.

- For the specific case of Vandellós I NPP, the construction of a warehouse is planned during its latency period, which will be operational by 2027 to accommodate high-level waste (HLW) and special waste (SW) currently stored in France as a result of SF reprocessing. Furthermore, it will house any radioactive waste (RW) resulting from the decommissioning of the plant.

- Each nuclear power plant with SF will be equipped with a Decentralised Temporary Storage (DTS) facility, consisting of one or more ITS facilities, along with a new complementary installation or additional measures. These additions will enable maintenance and repair operations on casks, ensuring the recovery of normal design conditions during anomalous events. DTS facilities will be equipped with all auxiliary and safety systems to operate independently from the plant's operations or decommissioning until the transfer of all SF to the Deep Geological Repository (DGR).

- For operational nuclear power plants (NPPs), the complementary installation will be operational before commencing the decommissioning of their SF pools. For José Cabrera NPP, in the final phase of decommissioning, recovery measures at the cask level will be implemented between 2024 and 2029. Santa María de Garoña NPP, in the process of decommissioning since July 2023, will have the complementary installation operational by 2026.

- Operational nuclear power plants (NPPs) have a recoverability capacity at the fuel assembly level provided by their own pool. As these pools will be out of use during the decommissioning of the plants, a facility will be established at one of the plant sites in 2031. This facility will have the means to guarantee recoverability throughout the operational life of the Decentralised Temporary Storage (DTS) facility until the transfer of spent fuel (SF), high-level waste (HLW) and special waste (SW) to the Deep Geological Repository (DGR). This facility will include a hot vault to handle SF and radioactive waste (RW), a storage capacity for casks to handle potential contingencies in the Decentralised Temporary Storage (DTS) facilities during their operational life, and a laboratory equipped with the necessary means to verify and inspect the condition of fuel and waste. Fuel assembly recoverability will be ensured, as a contingency measure, by transporting the cask or welded capsule, under appropriate safety conditions, to the facility with the hot vault. The licensing process for this facility will commence in 2025 with the request for a design modification authorisation for the respective plant, followed by other administrative procedures.

- Special waste (SW) will be considered for casks with characteristics and dimensions adapted to the capacities and characteristics of each nuclear power plant.

The implementation of the actions described in these sections will require, if necessary, the corresponding authorisation.

3.2.1.4. International situation

The management of spent fuel (SF) after its removal from nuclear reactors primarily depends on the strategy adopted for the nuclear fuel cycle (NFC). In the closed cycle, the fuel undergoes a preliminary heat evacuation process in the pools of nuclear power plants (NPPs) before being sent for reprocessing to separate uranium and plutonium. The corresponding vitrified high-level waste (HLW) and intermediate-level and long-lived technological waste are obtained from reprocessing. In the case of not harnessing these materials (open cycle), spent fuel (SF) is initially stored in the pools of nuclear power plants (NPPs) and subsequently in other transitory storage systems, if required, before its final management.

Both options require an intermediate period of temporary storage, either for spent fuel (SF) or for the radioactive waste (RW) resulting from reprocessing, until a final storage solution becomes available.

Currently, reprocessing is a strategy mainly limited to countries with industrial facilities designed to that end and generally under major nuclear energy supply programmes. In Europe, a reprocessing policy exists in France, Italy, the Netherlands and the Russian Federation. In the United Kingdom, the Government has established that reprocessing practices will cease shortly. Asia, India and Japan have reprocessing policies or contracts, and there appears to be a significant intent to follow this path in China. No American country reprocesses spent fuel (SF) from commercial power plants.

Country	SF as an energy source	Direct disposal	Reprocessing	Has reprocessed in the past	Observations
Germany	NO	YES	NO	YES	Reprocessing banned since 2005
Belgium	NO	YES	NO	YES	Reprocessing under moratorium since 1993
Canada	NO	YES	NO	NO	
Finland	NO	YES	NO	NO	
France	YES	NO	YES	YES	
Hungary	NO	YES	NO		Fuel returned to the Soviet Union
Italy	NO		YES	YES	
Japan	YES	NO	YES	YES	Own reprocessing plant under construction
South Korea	NO	YES	NO	NO	
Netherlands	YES	NO	YES	YES	
Russia	YES	Undetermined	YES	YES	Only reprocesses part of the fuel
Switzerland	NO	YES	NO	YES	Reprocessing banned in 2016
Sweden	NO	YES	NO	YES	Reprocessed small amounts in the 70s and 80s
United Kingdom	YES/NO	Only for PWR fuel	YES	YES	Does not reprocess PWR spent fuel (SF); Planned termination
United States	NO	YES	NO	YES	Reprocessing terminated after decision in 1979

Table 13. Reprocessing policies in different countries

Since the approval of the 6th GRWP, Germany, Belgium, Switzerland and the United Kingdom have announced the termination of their reprocessing policy. These countries join others such as the United States, Canada, Finland, Sweden, Spain and South Korea, which have been following an open fuel cycle policy for quite some time, even if some of them have reprocessed in the past.

Pending a disposal solution, the spent fuel (SF) and high-level waste (HLW) must be temporarily stored safely and responsibly. After the initial phase following reactor discharge, which requires storage in the pools of the nuclear power plants (NPPs) for the rapid and mass removal of residual heat, the spent fuel (SF) can continue to be stored in these pools or be transferred to other facilities with wet or dry storage technology. These facilities may be located in the nuclear power plants (NPPs) themselves or at other sites, depending on the strategic needs established for pre-disposal spent fuel (SF) management. It is noteworthy that experiences with pre-disposal storage technologies have proven successful and have been widespread, with around 50 years or more for wet storage technologies and about 35 years for dry storage technologies.

In practice, this range of options can be primarily summarised in two strategies: keeping the spent fuel (SF) in the nuclear power plants (NPPs) or, alternatively, centralising its storage in one or more locations along with other types of long-lived radioactive waste (RW). Countries managing high-level waste (HLW) from reprocessing typically gather them in one place awaiting their final management.

Country	Facility	Technology	SF/Vitrified Waste (V)
Germany	Ahaus Gorleben	Metal Casks Metal Casks	SF SF and V
Belgium	Dessel	Vault	V
Russian Federation	Mayak Krasnoyarsk Zheleznogorsk	Pool Vault Pool Vault Vault	SF V SF V SF
France	La Hague CASCAD	Pool Vault Vault	SF V V
The Netherlands	HABOG	Vault	SF and V
United Kingdom	Sellafield	Pool Vault	SF V
Sweden	CLAB	Pool	SF
Switzerland	ZWILAG	Metal Casks	SF and V

Table 14. Main Centralised Temporary Storage (CTS) facilities for SF/HLW

The casuistry of strategies for centralising the temporary storage of spent fuel (SF) and long-lived radioactive waste (RW) is very broad. Some countries, like the United States, have proposed centralised strategies for spent fuel (SF) storage, but their implementation has been hindered by public acceptance issues. Others, such as Sweden and the Netherlands, have successfully built facilities for this purpose with relative ease. Meanwhile, there are countries like Germany that have centralised part of their high-level waste (HLW) storage while simultaneously banning this practice in the future.

3.2.2. Final management

As indicated in the preamble of Council Directive 2011/70/Euratom of 19 July 2011, establishing an EU framework for the responsible and safe management of spent fuel (SF) and radioactive waste (RW), the generally accepted idea today is that a Deep Geological Repository (DGR) represents the most sustainable and secure option as the final point in the management of high-level waste (HLW) and spent fuel (SF).

Furthermore, complementary options are considered, such as advanced separation and transmutation. These approaches would allow, first, the separation of minor actinides, and subsequently, through the use of various types of reactors or subcritical assemblies, the generation of smaller volumes of high-level waste (HLW), theoretically with shorter half-lives, although this implies a larger volume of special waste (SW). However, the following considerations must be taken into account regarding this option:

- It is a theoretical option to reduce the toxic inventory of the radioactive waste (RW) to be managed.
- It requires significant research and development efforts, which should be addressed from an international cooperation perspective. The construction of a European transmuter has been approved, with its headquarters in Belgium.
- It will not eliminate the ultimate need for the final management of a significant amount of radioactive waste (RW) since, despite the potential reduction in the volume of long-lived radioactive waste (RW), the volume of special waste (SW) increases. Therefore, deep geological disposal will still be necessary.
- This involves the prior reprocessing of spent fuel (SF), subsequent treatment and significant investment in transmutation facilities, which will be challenging to implement on a strictly national level.

3.2.2.1. Current situation

Since 1985, efforts have been directed towards the option of final disposal in four basic directions:

1. Site Search Plan (SSP): this initiative, which was halted in 1996, has provided sufficient information to confirm the presence of abundant granite, clay and, to a lesser extent, saline formations in the subsurface of the Spanish geography. These formations are suitable for hosting a disposal facility, with a broad geographical distribution.

2. Conceptual design development: conceptual designs of a disposal facility have been created for each of the indicated lithologies, aiming to find common points among them.

3. Safety evaluation exercises for conceptual designs: safety evaluation exercises for designs in granite and clay have been conducted, integrating the knowledge acquired from successive R&D plans. These exercises demonstrate that geological repositories meet the safety and quality criteria applicable to such facilities.

4. Development of R&D plans: successive R&D plans have evolved and adapted to Spain's spent fuel (SF) and radioactive waste (RW) management programme. These plans have facilitated the acquisition of technical knowledge and the formation of national working teams, participating in national/international research projects and demonstration projects in foreign underground laboratories.

In recent years, significant research efforts have also been devoted to separation and transmutation technologies in their various versions. However, the scale of these programmes requires international collaboration. Most of the work conducted is preliminary, involving the collection of basic data and feasibility analyses, with a predominantly theoretical content.

As a result of the work carried out between 1986 and 1996, which involved an analysis of geological formations suitable for hosting a Deep Geological Repository (DGR), an Inventory of Favourable Formations is now available.

Generic designs and associated safety evaluations for the aforesaid facility, adapted to host such environments as granite and clay, were also developed during this period. These advances will provide a solid foundation for the upcoming stages of site selection and Deep Geological Repository (DGR) implementation.

Finally, based on the results obtained, as established in the 6th General Radioactive Waste Plan (GRWP), the following reports were submitted to the Ministry of Industry, Energy, and Tourism in 2013:

- Management options for spent fuel (SF) and high-level waste (HLW): this report outlines the characteristics, constraints and management requirements for spent fuel (SF), along with a set of technically viable solutions in accordance with national and international safety principles. It analyses the advantages and disadvantages of these solutions, considering the opinions of international benchmark organisations, as well as the associated economic and socio-political aspects.

- Feasibility of new technologies: separation and transmutation: this report describes the main international and European projects in the field of radionuclide separation and transmuter systems. Based on this information, it identifies key aspects that require resolution for the industrial application of these technologies, including associated technological and economic needs.

- Generic basic projects:
    - Disposal in clay formations.
    - Disposal in granite formations.

  Both projects describe and integrate the results obtained by Enresa until 2004 regarding "Site selection", "Generic repository designs" and "Associated safety assessments" as fundamental elements of the final management of spent fuel (SF). The documents also indicate the results of R&D developed in support of the three aforesaid activities. These basic projects describe cases of disposal in granite and clay formations, considered technically, in terms of safety and costs.

- Decision-making experiences in spent fuel (SF) and high-level waste (HLW) management in some OECD countries: this analyses the most relevant or common characteristics of decision-making processes for site allocation in ten OECD countries, as well as the European Union and the NEA. The aim is to infer decision-making mechanisms that are useful for future initiatives by Spanish authorities.

These four documents complete the compilation of knowledge, technologies and experience related to the final management of spent fuel (SF) outlined in the 6th GRWP. These documents form the basis for establishing the long-term management strategy.

3.2.2.2. Strategic lines of action

For the purposes of this Plan, the preferred and basic option is considered to be temporary storage, followed by a disposal facility that, for economic calculations and planning purposes, would come into operation from the year 2073.

As regards final management, activities developed in previous plans have primarily focused on consolidating and updating the knowledge acquired, both in internal projects with the quality of existing information and formats, and through international developments in the field.

The strategic lines of action for the final management of spent fuel (SF) and high-level waste (HLW) will be geared towards maintaining and updating previously developed information. Furthermore, there will be an analysis and formulation of legislative proposals to establish the decision-making process and define the most appropriate participation framework.

Furthermore, the final management of spent fuel (SF) and high-level waste (HLW) requires the development of a regulatory framework that considers their specific characteristics and international developments in the field.

The main strategic lines of action, from which an indicative programme will be developed for the establishment of a disposal facility for spent fuel (SF) and high-level waste (HLW), are as follows:

- Update of knowledge and technology: use available information and developments from international R&D programmes that support the technological platforms of the European Union, from results from European Programmes (Euratom), the IAEA, NEA/OECD, and specific achievements from other advanced programmes.

- Alignment with international developments: propose a legal framework and necessary procedures in line with international developments to support the launch of a programme for the development of a Deep Geological Repository (DGR) in Spain.
- Documentation for decision-making: develop documentation for decision-making in site selection, considering previous experiences and international practices.
- Generic documentation for the facility: develop generic documentation for the facility and the methodology for assessing performance, considering the concept of reversibility of spent fuel (SF) and high-level waste (HLW), basic designs, the positive influence of increased cooling time provided by prior temporary storage, and updating knowledge.

3.2.2.3. Significant stages as regards the final management of high-level waste and spent fuel and the compliance programme

The programme for the development of a final storage facility for spent fuel (SF) and high-level waste (HLW) is highly dependent on the availability of a site. This site must not only be suitable to meet the technical requirements and safety criteria that such a facility demands but also receive the necessary social and political acceptance.

Therefore, it requires not only the scientific knowledge and technologies needed to implement the project and provide sufficient justification in the evaluation of the facility's performance within the required timeframe but also a procedure for site selection that considers public participation mechanisms that allow the necessary debate in society. The social acceptance of a facility of this nature conditions the entire process, thus providing the programmes with a high degree of uncertainty. Accordingly, the programme should be considered indicative.

However, in achieving the overall goal of ensuring a reliable and safe system for managing spent fuel (SF) and high-level waste (HLW), the availability of temporary storage capacity provides a framework of safety and flexibility for decades. This could provide a reasonably sufficient time frame for the development of the final management programme. A Deep Geological Repository (DGR) is a complex solution involving various stakeholders: technical, scientific, social and political. According to international experience, its development spans several decades. The ARTEMIS Mission recognised that the establishment of an operational Deep Geological Repository (DGR) is an iterative and lengthy process requiring careful and detailed planning. It stresses the importance of initiating the step-by-step development of the Deep Geological Repository (DGR) as soon as possible. Therefore, the existence of a specific legislative and procedural framework is considered necessary. This framework should cover, in the initial stage, the site selection process, facilitate operator-regulator dialogue at various project stages, and involve the necessary public participation.

The development programme for the Deep Geological Repository (DGR) project, considering its interdependencies with pre-disposal spent fuel (SF) storage, should also be based on the following principles for implementation and development: flexibility, systematic learning, evaluation, transparency and auditing.

The indicative programme includes the following stages:

Stage 1: Knowledge update (until 2025)

During this stage, scheduled until 2025, available technologies will be compiled and analysed based on the documents mentioned in Section 3.2.2.1. In addition, developments in international R&D programmes of the European Union and more advanced programmes, both in technical and sociological aspects, will be considered.

This stage will include the following actions:

- Review of information developed to date regarding sites, natural barriers, engineering barriers, design and associated evaluation of performance.
- Assessment of needs and review of the corresponding R&D Plan, to be developed throughout all the stages of this programme.
- Evaluation of available scientific and technological capabilities.
- Preparation of basic documentation for the proposed site selection process.
- Development of generic technical documentation for the facility and its corresponding performance evaluation methodology for the main available favourable lithologies in the country, to be proposed to the CSN (Nuclear Safety Council).

At the end of this stage, Enresa will present a detailed report, including the state of information developed and available capabilities. In addition, basic information will be available to propose a legislative and procedural framework supporting the DGR programme, including the site designation process and licensing.

Stage 2: Adoption of legislative and procedural framework (2026-2028)

During this three-year stage, the Government will analyse the information presented and guide subsequent stages based on the evaluation, especially regarding the site selection process. The necessary legal text will be adopted to regulate the site selection process and identify stakeholders to advance in the programme's next stages.

Also, the generic technical documentation will be presented to the CSN for evaluation, setting limits and conditions. Operator-regulator dialogue will be initiated to define, establish and consolidate the DGR facility's design foundations, improving the efficiency of the licensing process.

Furthermore, R&D plans and programmes, as well as international project monitoring activities, will continue to enhance knowledge and the state-of-the-art at these facilities.

Stage 3: Site selection process (2029-2032)

The designated process will be put into practice based on the legislative and procedural framework established. Decisions regarding the next steps will be made in light of the results.

The *a priori* unpredictable nature of the results requires a flexible and reversible process, allowing reformulation, if necessary, as stated in the standards and/or procedures established.

As the case may be, an inventory of possible sites will be made available, and analysed in detail in the next stage.

With the CSN's evaluation of the generic technical documentation and the limits and conditions established, this will then be revised and updated, and the proposal of basic design criteria for a DGR facility will be presented to the CSN for its evaluation, along with the preliminary site characterisation plan and the quality assurance plan and programme. The estimated total duration of this stage is four years.

Stage 4: Site analysis and selection of the final candidate (2033-2039)

This estimated seven-year stage will require preliminary characterisation work for the different sites, applying technologies primarily from the surface (geophysics, drilling, geology, geochemistry, etc.). The evaluation of results will allow the feasibility analysis of these sites to be undertaken and the final site proposed.

Furthermore, the detailed site characterisation plan will be presented to the CSN for evaluation, along with the underground laboratory project and surface support facilities. The environmental evaluation of this project will also be initiated.

Stage 5: Site characterisation, verification of suitability and start of licensing process (2040-2059)

After designating the selected site, this stage involves detailed characterisation, including the construction of an underground laboratory to test devices at the depth required to verify their suitability.

With the information available from the site characterisation and the verification of the key components, the detailed design of the facility will be developed, considering the reversibility concept of SF and HLW in line with international recommendations and following the criteria set by the CSN, along with the corresponding safety and environmental impact studies.

Documentation for the application for the preliminary or site authorisation, to be granted by MITECO, following a report from the CSN, will be prepared. During this stage, the environmental impact assessment will also be drawn up. Once the preliminary authorisation is obtained, the construction authorisation application will be processed, to be granted by MITECO, following a report from the CSN, in accordance with prevailing regulations on nuclear facility authorisations. The estimated total duration of this stage is 20 years.

Stage 6: Construction and operating authorisation (2060-2071)

This stage will begin once the construction authorisation has been obtained, involving the construction of the facility and procurement of equipment. Documentation corresponding to the application for the operating authorisation, to be granted by MITECO, following a report from the CSN, will be prepared and submitted.

Long-term trial data collection will continue to strengthen the design bases and support the operating authorisation.

Optionally, a pilot facility demonstrating the main components and processes of the facility's engineering barrier system will be constructed.

The total estimated duration for this phase is 12 years.

Stage 7: Initial operation and testing (2072-2073)

With the operating authorisation granted, this phase will begin with the disposal of spent fuel (SF) and high-level waste (HLW), comprising an initial testing phase. The operation is expected to commence in 2073.

Stage 8: Normal operation (2074-2100)

After the initial operation or testing phase, the normal operation phase will begin, until disposal is completed, which will be carried out taking into account reversibility criteria until the final sealing of the facility, expected to occur after 2100. During this period, disposal conditions will be monitored. After the final sealing, the facility will be maintained in a passive state under long-term institutional monitoring.

The total expected duration of the programme could be shortened according to the duration of stages 2 to 4, concluding with site selection. The estimated duration for stages 5 to 7 is short and seems unlikely to be reduced, considering the international experience of countries with more advanced programmes. If possible, future revisions of the GRWP will include shorter timelines.

3.2.2.4. Plan for the post-operational period of the DGR

Once the spent fuel (SF) and all the radioactive waste (RW) stored in the DGR have been conditioned, Enresa must prepare the documentation to apply for the corresponding decommissioning authorisation for surface facilities and the closure of the DGR. As provided for in the Regulation on Nuclear and Radioactive Facilities, approved by Royal Decree 1836/1999, of 3 December, this authorisation empowers the licensee to initiate final engineering and other necessary works to ensure the long-term safety of the disposal system. It also allows for the decommissioning activities of auxiliary facilities, ultimately enabling the delineation of areas that may need radiological or another type of monitoring and surveillance for a specified period, and the release from surveillance of the remaining areas of the site will be determined. The decommissioning and closure process will conclude with a declaration of closure issued by MITECO, following a report from the CSN.

In this regard, the Nuclear Energy Act (NEA), in its Article 38 bis 4, establishes that the State will assume ownership of radioactive waste (RW) once it has been definitively disposed of. In addition, Royal Decree 102/2014, of 21 February, on the responsible and safe management of spent fuel (SF) and radioactive waste (RW), establishes in Article 4.4 that the State will take over the monitoring of final storage facilities after their closure.

To preserve knowledge of the facility in the long term, the corresponding records will be kept, allowing understanding of both the development and characteristics of the facility and the inventory of disposed of waste.

In line with the analyses for evaluating the safety and performance of such facilities, actions considered for the post-closure period of disposal, encompassed under the generic concept of "institutional monitoring" (a set of activities to monitor the evolution of environmental and radiological parameters of a site during the period established by the competent authorities after closing the facility), include such activities as radiological and environmental monitoring, surveillance of meteorological and hydrogeological data, transfer of knowledge, maintenance of information in available formats, maintenance of the land, and physical safety surveillance.

3.2.2.5. International situation

There is currently an international consensus that deep geological storage is the best solution for the final management of spent fuel (SF) and high-level waste (HLW).

Since the approval of the 6th GRWP in 2006, significant events have occurred in the geological disposal programmes of the most advanced countries in this strategy.

In Finland, the management agency has initiated the excavation and construction of a geological repository, expected to start operating around the year 2025. This will be the world's first operational repository for high-level waste-generating heat.

In Sweden, the management agency applied for construction authorisation for its geological repository in 2022. Following the project's approval by the municipality hosting the facility, the next step is government approval.

Lastly, France, with a designated site, submitted its construction application in early 2023.

Moreover, a group of countries have launched site selection programmes, currently in progress, although they are still far from selecting specific locations to build their final disposal facilities. The most significant cases in this second group of countries are Canada and the United Kingdom. Both are actively engaging with potential candidate municipalities to host a Deep Geological Repository (DGR), parallel to intensive research and technical planning.

Furthermore, the entry into force of Council Directive 2011/70/Euratom, of 19 July 2011, has renewed the interest of other European countries, with or without nuclear power plants (NPPs), in finding solutions for the final management of high-level waste (HLW) and long-lived waste through deep geological solutions. In some cases, such as countries with small nuclear programmes and limited territory, the option of shared solutions continues to be a priority, although their implementation is expected to pose significant public acceptance challenges.

Apart from efforts for the final disposal of high-level waste (HLW), several countries continue to investigate the possibilities of using separation and transmutation technologies to achieve significant reductions in volume and radiotoxicity. As regards the indications of the previous GRWP, research progress in these areas is occurring slowly, given the complex technological and financial requirements involved in developing these nuclear systems. The strong connection between separation and transmutation and reprocessing processes, on the one hand, and advanced nuclear generation technologies, on the other hand, favours countries that are most involved in their development becoming the ones with a more decisive nuclear generation policy and, at the same time, with more nuclear power plants (NPPs).

As regards the relationship between the application of separation and transmutation technologies and the need for final disposal facilities, there is a common opinion among all experts and international organisations that these technologies will not eliminate the need for deep geological repositories.

Country	Current programme	Underground laboratory
Germany	Ongoing site selection process Site selection (planned): 2031	
Belgium	Detailed research in the Mol underground laboratory Repository studies Proposal for site selection plan pending government decision	Mol
Canada	Start of site selection process: 2010 Expressions of interest with 21 communities: 2012 Reduction in expressions of interest to 5 communities: 2018 Site selection (planned): 2024 Start of operations (planned): 2043	
United States	Yucca Mountain site feasibility research Site recommendation: 2002 Licence application: 2008 Project suspension decision: 2010 Site selection (planned): 2026 Design and licensing completion (planned): 2042 Start of operations (estimated): 2048	Yucca Mountain
Finland	Detailed research at four locations: 1983-2000 Governmental approval in principle: 2000 Parliamentary ratification and site selection (Eurajoki): 2001 Laboratory studies begin: 2006 Construction licence application: 2012 Construction authorisation granted: 2015 Start of underground facility construction: 2021 Estimated start of operations: 2025	Onkalo (In operation, will be integrated into the future repository)
France	Research Act: 1991-2006 Laboratory construction begins: 2000 Results report: 2006 Site selection: 2011 Application for repository construction authorisation: 2023 Construction (planned): 2025-2035 (First phase) Start of operations (estimated): 2035	Bure
United Kingdom	Revised site selection programme: 2018	-------
Sweden	Voluntary site presentations (7): 2001 Research programme: 2001-2007 Site proposals: 2007 Site selection (Östhammar): 2009 Construction authorisation application: 2022 Municipal approval: 2022 Government decision Start of operations (anticipated): 2033	Aspö
Switzerland	Proof of concept: 2006 Start of Sector Plan: 2008 Site selection: 2022 Operation (anticipated): 2050 for LILW and 2060 for HLW/SF	Grimsel Mt. Terri

Table 15. Main programmes for the implementation of geological repositories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4. Decommissioning and closure of facilities

Decommissioning is understood as the process by which, once the corresponding authorisation is obtained, the authorisation holder carries out decontamination activities, equipment dismantling, structure demolition and material removal to ultimately allow the full or limited release of the site.

To carry out the decommissioning of a nuclear facility, mandatory authorisation is required in accordance with the Regulation on Nuclear and Radioactive Facilities, approved by Royal Decree 1836/1999, of 3 December. Given that the decommissioning of nuclear facilities is commissioned to Enresa, this authorisation also involves the transfer of ownership of the facility from the operator to Enresa to perform this. According to this Regulation, decommissioning culminates with the "declaration of closure," which releases the authorisation holder from responsibility and defines, in the case of the limited release of the site, the applicable usage limitations and the party responsible for maintaining and monitoring compliance.

4.1. Current situation

In Spain, an established system exists for performing activities leading to the closure of regulated facilities, and the agents involved in this are also defined.

The system provides for the general framework of actions, the regulatory framework, the role of agents and the basic safety and operational conditions to be complied with and guaranteed in its application, including financing mechanisms.

As a relevant element, and unlike most countries, Enresa has direct responsibilities for the decommissioning and closure activities of some of these facilities, as provided for in applicable regulations.

In the case of nuclear facilities and, in particular, nuclear power plants (NPPs), the responsibility for such decommissioning falls directly on Enresa, in compliance with the Nuclear Energy Act, which grants the decommissioning of nuclear facilities the status of an essential public service, commissioned to Enresa. Decommissioning is carried out according to the technical-administrative specifications agreed upon between Enresa and the nuclear power plants (NPPs) and the specific annexes to this end, complemented by the necessary operating agreements. The financing mechanisms inherent therein are also defined and fully operational, established in the Sixth Additional Provision of the Electricity Sector Act 54/1997, of 27 November.

For mining and uranium concentrate production facilities, the responsibility lies with the facility's licensee.

In the case of the Juzbado fuel assembly factory, as a nuclear installation, the responsibility for decommissioning lies with Enresa. The financing mechanism for this decommissioning is also provided for in the aforementioned Sixth Additional Provision of Act 54/1997.

In the case of CIEMAT, the responsibility lies with the licensee, with the authorities establishing the form of Enresa's involvement in technical and financial aspects.

For radioactive facilities, the contract with Enresa for waste management allows licensees to agree with Enresa on how to proceed and ways to address closure, although it should be noted that the closure of these types of facilities does not usually pose special difficulties once the last radioactive waste (RW) has been removed in the operational stage.

Decommissioning activities and the closure of nuclear power plants (NPPs) may be affected by the removal and management of radioactive waste (RW) and spent fuel (SF). Furthermore, the decommissioning of large facilities produces significant amounts of residual materials with radioactive content, both low- and intermediate-level waste (LILW) and very low-level waste (VLLW), which must be managed at El Cabril Disposal Facility. Likewise, the closure of these facilities generates moderate amounts of special waste (SW), the final management of which cannot be carried out at El Cabril Disposal Facility, so it must be stored in a centralised storage facility or temporary storage facilities at the nuclear power plant sites.

Over recent years, Spain has accumulated considerable experience in this field, including the following projects:

- Decommissioning of existing facilities and restoration of the site of the Andújar Uranium Mill (FUA).
- Environmental restoration of areas affected by uranium mining exploration and operation at various sites.

- Decommissioning and environmental restoration of the site of the Uranium Ore Treatment Facilities in La Haba and in Saelices el Chico, involving large-scale mining and uranium concentrate production activities.
- Partial decommissioning of Vandellós I NPP (460 MWe), with a graphite-gas reactor.
- Closure of university research reactors (Argos and Arbi).
- Decommissioning and restoration of obsolete CIEMAT facilities (PIMIC Project).
- Decommissioning of José Cabrera NPP (160 MWe), with PWR (pressurised-water reactor) technology, currently ongoing and nearing completion.

Among these projects, the partial decommissioning of Vandellós I NPP and the ongoing total decommissioning of José Cabrera NPP since 2010 stand out due to their scale and importance, placing Spain among countries with comprehensive experience in this area. The execution of the José Cabrera NPP decommissioning project has been possible due to the existence of sufficient technical, administrative, institutional and business infrastructure in the country to ensure the financing of costs, the application of necessary technologies and the proper management of the radioactive waste (RW) generated, including its final storage.

The experience described has led to the development of various capabilities that are fully available today. Linked to this, generic and specific tools for the planning, organisation, management and optimisation of decommissioning activities have been developed and are in place. Furthermore, the projected decommissioning costs for nuclear power plants (NPPs) have been updated, taking into account the lessons learned from the actual decommissioning cost analysis of José Cabrera NPP.

The experience accumulated from projects such as Vandellós I NPP and José Cabrera NPP, encompassing organisational and documentary aspects, as well as interactions with the Nuclear Safety Council (CSN) and other authorities involved, will be crucial for planning and executing future decommissioning projects, particularly the decommissioning of Santa María de Garoña NPP, which has been in permanent shutdown since August 2017 and undergoing decommissioning since July 2023.

Furthermore, the experience acquired in integrating decommissioning activities with waste management, applying technologies for decommissioning large components and implementing volume reduction practices will be highly relevant in planning and executing future decommissioning projects.

Tables 16 and 17 provide the current status of decommissioning and closure activities for nuclear installations and uranium mining and concentrate production facilities, respectively.

Name of facility	Location (province)	Current status	Closure and decommissioning milestones
Vandellós I NPP	Tarragona	Partial decommissioning completed in 2003 Latency phase since 2005	1990. End of the operating license for the natural uranium-graphite-gas nuclear power plant after 17 years of operation 1994. Submission of the closure and decommissioning plan 1998. Decommissioning authorisation 2003. Completion of partial decommissioning works 2005. Authorisation for latency
Argos Research Reactor	Barcelona	Decommissioned in 2002	1977. Permanent shutdown 1992. Fuel removal 1998. Ministerial Order authorising decommissioning 2003. Declaration of closure
Arbi Research Reactor	Bilbao	Decommissioned in 2004	1972. Permanent shutdown 1992. Fuel removal 2002. Ministerial Order authorising decommissioning 2005. Declaration of closure
CIEMAT Facilities	Madrid	In the final stages of completion	2001. Approval of the Master Plan for the Improvement of CIEMAT Facilities 2002. Submission of the Decommissioning Plan to MINECO, CSN. Submission of the Environmental Impact Study to MINMA. Application for a construction licence to the City Council of Madrid 2005. Decommissioning authorisation 2006-2012. Execution of decommissioning works 2013-2015. Removal and management of contaminated land 2017-...Removal and shipment of radioactive waste (RW)
José Cabrera NPP	Guadalajara	Currently in progress	2006. Permanent shutdown 2009. Transfer of spent fuel (SF) to the ITS 2010. Authorisation for decommissioning 2010-2025. Execution of works and restoration 2013. Transfer of radioactive waste (RW) to the ITS
Santa María de Garoña NPP	Burgos	In permanent shutdown since 2017	Start of preparatory decommissioning activities in 2019 2023. Authorisation for Phase 1 of decommissioning

Table 16. Current status of decommissioning and closure activities for nuclear facilities

Uranium mining and concentrate production facilities	Location (province)	Current status	Process milestones
Andújar Uranium Mill Plant (FUA)	Jaén	Monitoring and maintenance phase	Decommissioning and restoration work completed in 1994 The monitoring period began in 1995
19 former uranium mines	Extremadura and Andalucía	Restored	Restoration work commenced in 1997 and concluded in 2000
Lobo-G Plant (La Haba)	Badajoz	Long-term monitoring phase	Decommissioning and restoration work completed Obtained the declaration of closure in 2004
Elefante Plant (Saelices el Chico)	Salamanca	Monitoring and maintenance phase	Decommissioning and restoration work carried out between 2001 and 2004 The monitoring period began in 2005
Saelices el Chico (mining operations)	Salamanca	Monitoring and maintenance phase	Final restoration work took place between 2004 and 2009 Currently in the phase of improving and reducing the treatment of acidic waters; a research and development project was set up to this end in 2017
Quercus Plant (Saelices el Chico)	Salamanca	Final shutdown	Currently undergoing the evaluation process by the CSN of the documentation for the application for authorisation of the first phase of decommissioning
Former uranium mines	Salamanca	Monitoring and maintenance phase	Restoration works for the mines, as required by the competent authorities, were performed between 2006 and 2007

Table 17. Current status of decommissioning and closure activities for uranium mining and concentrate production facilities

4.2. Strategic lines of action

The strategy established involves the total and immediate decommissioning of light-water nuclear power plants (NPPs), which includes all existing plants except Vandellós I NPP. For planning and cost estimate purposes, preliminary work is expected to commence between three and preferably five years before the definitive cessation date. This allows for the transfer of ownership and the start of decommissioning within a period not exceeding three years after the definitive cessation. This six-year timeframe is the minimum required to carry out activities such as emptying pools, preliminary decommissioning preparations, obtaining decommissioning authorisation and transferring ownership to Enresa. Once this authorisation is obtained, decommissioning works with an estimated duration of ten years will commence. This strategy has three fundamental aims:

- Ensure sufficient time before the cessation of operations of the nuclear power plant, particularly during the last three years of operation, to adequately design and plan decommissioning, considering CSN evaluation timelines, and initiate activities related to pool emptying.

- Harness the three years immediately following the definitive cessation (transition phase) to complete preparatory decommissioning activities, ensuring that actual decommissioning begins once decommissioning authorisation is obtained. This phase also includes completing pool emptying, including the last silo, if possible.

- Have a decommissioning programme (with an estimated duration of ten years) that considers both the timelines for executing activities and those necessary for authorisation.

With the experience acquired in recent years, Enresa's basic approach to activities in this area is outlined in the following lines of action:

- Conduct basic decommissioning studies of operational light-water nuclear power plants (NPPs) in collaboration with the licensees to better define types and volumes of radioactive waste (RW), and also provide more precise cost estimates based on experience acquired.

- Maintain coordination and cooperation with licensees to optimise the transition process from the operational stage through to decommissioning. This optimisation is based on anticipating the planning of decommissioning, including the preparation of the decommissioning plan, preparatory activities and pool emptying during the final stage of operation and the transition phase, if possible.

- Maintain the involvement of the operator's personnel in the decommissioning of nuclear power plants (NPPs) to facilitate the transfer of knowledge and ensure continuity in facility operation and maintenance.

During the final stage of operation and the transition phase, Enresa will undertake the following activities in collaboration with the licensee:

- Basic study of strategies, including, if applicable, the Fuel Management Plan.

- Decommissioning plan and preparation of the necessary documentation to apply for decommissioning authorisation and ownership transfer to Enresa.

- Preparatory decommissioning activities, which aim to collect essential information for project design and adapt the systems and facilities at the plant to decommissioning needs. These activities include, among others, the physical and radiological characterisation of the plant, decontamination and discharge of systems, conventional decommissioning, system modifications and the assembly of new systems for decommissioning, conditioning of storage facilities or preparation of new radioactive waste (RW) storage and treatment facilities, and any additional activities authorised as preparatory in the declaration of definitive cessation.

- In addition, coordinated actions related to the treatment and conditioning of certain operation waste streams, such as large components or metallic pieces, may be analysed with the licensees and, if applicable, implemented to optimise Enresa's storage capacities and put facilities into service to be used during decommissioning.

• Undertake the decommissioning of light-water nuclear power plants (NPPs), ensuring the transfer of experience acquired from one decommissioning to another, and performing such activities as dismantling systems, decontaminating and declassifying materials and surfaces, demolishing buildings, managing radioactive waste (RW) and restoring the site, allowing it to be released for use in compliance with prevailing regulations.

• Maintain efforts in integrating decommissioning and radioactive waste (RW) management to achieve a more efficient joint system for future decommissioning. Special mention should be made of managing large components, given that strategies for their segmentation directly impact the subsequent management of primary and secondary waste, including their conditioning and packaging.

• Continue implementing actions to reduce the volume of radioactive waste (RW) generated during decommissioning, such as segregation, declassification, decontamination, compaction, melting, use of casks for large pieces and those that maximise the amount of radioactive waste (RW) incorporated per unit volume.

• Continue participating, cooperating and monitoring international projects related to light-water nuclear power plants (PWR and BWR) to transfer international experience related to decommissioning and managing large components, and to optimise the duration and cost of future decommissioning, both at the same and different sites.

- Continue participating, cooperating and monitoring international projects related to graphite management to define internationally validated solutions for Spain, integrating this management route in the final phase of decommissioning of Vandellós I NPP.

- Collaborate with the licensee(s) to complete the decommissioning and environmental restoration activities at Saelices el Chico and other uranium mines, utilising previous experience acquired. In addition, and in line with previous experience in mining restoration projects, it is expected to address the restoration, maintenance and monitoring of old inactive mining operations operated by the former Nuclear Energy Board before 4 July 1984, as required by the responsible authorities.

- Maintain lines of activity and cooperation to optimise and carry out the future decommissioning of the Juzbado fuel assembly factory.

- Provide the necessary support to CIEMAT in completing the required waste management and restoration activities for its Madrid facilities, contributing to the experience acquired.

- Continue efforts to optimise long-term monitoring plans for facilities whose decommissioning has concluded, especially those related to the first part of the cycle.

- Increase Enresa's human resources in advance to meet the planned schedule, which will require the simultaneous execution of several decommissioning processes.

- Analyse the transportation processes resulting from the simultaneous decommissioning of several nuclear power plants (NPPs) and, if necessary, increase the necessary resources well in advance to carry them out.

4.3. Planned actions

4.3.1. Optimisation of decommissioning

The optimisation of decommissioning is based on an analysis of the lessons learned from projects executed to date, particularly from José Cabrera NPP, and the improvement needs identified. Specifically, the following actions are proposed from a planning perspective:

- Analysis of decommissioning planning from an authorisation and execution perspective, ensuring compliance with the established requirements and deadlines for the transfer of ownership and the conditions and deadlines for decommissioning works.
- Analysis of simultaneous decommissioning of multiple reactors, at the same or different sites, to facilitate execution within the planned timelines, and strengthen the human and technical resources required, taking into account decommissioning and licensing processes.
- Analysis and planning of Enresa's technical and human resources required to carry out the decommissioning of all nuclear power plants (NPPs) according to the planned programme.
- Development of methodologies and tools to facilitate the transfer of knowledge and management throughout the entire decommissioning programme.

The following actions are also proposed from a decommissioning process perspective:

- Digitise decommissioning through the development of tools based on 3D models of facilities to be decommissioned, facilitating planning, the management of both physical and radiological information and the definition of waste management strategies and plans. During the execution phase, these tools will also aid in monitoring and supervising the work.
- Analyse decommissioning and large component management plans and techniques for nuclear power plants (NPPs), to use advanced technologies to reduce costs, timelines and optimise conditioned volumes of radioactive waste (RW).
- Analyse improvements that facilitate surface decontamination with new technologies that replace manual processes and increase productivity, especially on high surfaces.
- Analyse improvements and extend processes applied in the José Cabrera NPP project for decontamination and volume reduction to future decommissioning processes, covering materials and soils. These volume reduction activities include segregation, compaction and melting, as well as the use of new casks for large pieces and those that maximise the amount of waste incorporated per unit volume.
- Analyse improvements in on-site characterisation processes of materials and radioactive waste (RW) streams to optimise segregation in different categories, and reduce subsequent rejections in both very low-level waste (VLLW) characterisation processes and declassification.

- Analyse improvements that facilitate declassification processes of materials and surfaces using measurement techniques to replace manual processes that require a large number of human resources and time. Advanced methods, such as low-background measurement equipment, drone use and the automation of measurement processes for large surfaces, etc., should be considered to increase productivity.
- Continue improving and automating measurement technologies for the restoration of contaminated land to facilitate the final characterisation of the site.

4.3.2. Planned actions at different sites

4.3.2.1. Vandellós I NPP

As regards Vandellós I NPP, following the decommissioning and demolition of buildings and structures outside the biological shield of the reactor, this has been transformed into a passive facility. It will remain in this state during the latency period (25 years) until a total decommissioning is completed, planned to commence in 2030, once a graphite management plan is defined. The activities at the experience consolidation centre, called the Mestral Technology Centre, located on the site, continue (Figure 20).

Figure 20. Appearance of Vandellós I NPP site before and after partial decommissioning

The Vandellós I latent facility has static and passive systems that require minimal operation and are of great simplicity since the parameters to be monitored have evolved slowly and do not require any immediate intervention.

The activities planned during the latency period of Vandellós I include:

- Continue optimising the monitoring of the reactor vault based on the analysis of the results of the monitoring plan.
- Operation and monitoring of the temporary storage facility on-site.
- Monitor and analyse possible management options for the irradiated graphite remaining at the facility. Participate in international R&D programmes and, concurrently, explore the possibility of managing it as low- and intermediate-level radioactive waste (RW).
- Continue with the reconditioning activities of stored low- and intermediate-level waste (LILW) and very low-level waste (VLLW), to reduce its volume and plan future shipments to El Cabril Disposal Facility.
- Contribute to the development, within the European Inno4graph project, of physical and digital tools and work methodologies to optimise the decommissioning of graphite reactors, test them in a full-scale industrial demonstrator, and subsequently use them in the design and execution of the decommissioning of Vandellós I NPP.
- Continue studies and work on the detailed Total Decommissioning Plan and prepare the necessary documentation to apply for the next phase of the decommissioning authorisation.

4.3.2.2. José Cabrera NPP

As regards the decommissioning of José Cabrera NPP (Figure 21), where work began in February 2010, all the works have now been executed: segmentation of the vessel and inside the reactor, decontamination, declassification and demolition of its main radiological buildings (containment, auxiliary, evaporator and waste storage) and the demolition of conventional buildings.

Figure 21. Appearance of the decommissioning of the José Cabrera NPP: before and after (depicted) total decommissioning

The activities planned are summarised below:

- Shipment of the remaining radioactive waste (RW) to El Cabril Disposal Facility.
- Final radiological restoration and monitoring.

- Operation and monitoring of the ITS/DTS until the casks it houses are transferred to the DGR.

4.3.2.3. Santa María de Garoña NPP

In the specific case of this plant, due to its particular circumstances and the inability to plan its decommissioning or preparatory activities during the final stage of operation, a two-phase decommissioning alternative has been selected. This approach allows the decommissioning process to start earlier and the overall execution period to be reduced.

The Regulation on Nuclear and Radioactive Facilities, approved by Royal Decree 1836/1999 of 3 December, requires that, before granting the decommissioning authorisation, the holder of the operating authorisation has unloaded the reactor's spent fuel (SF) and the pools or, in the absence of the latter, has a Fuel Management Plan approved by MITECO, with a prior report from the CSN.

Under this requirement, the two-phase immediate decommissioning alternative involves conducting the first phase with the spent fuel (SF) in the pool, and the second phase, once it has been evacuated to the ITS, and the decommissioning and remodelling activities of the turbine building planned for the initial phase have been completed.

The activities planned for this alternative identify two clearly defined periods:

- Phase 1 of decommissioning: concludes when the spent fuel (SF) has been evacuated from the pool, the decommissioning activities planned for phase 1 have been carried out, and authorisation for phase 2 of decommissioning has been obtained. This primarily includes the following activities:
    - Engineering and licensing to apply for authorisation for phase 2 of decommissioning.
    - Dismantling of equipment and remodelling of the turbine building.
    - Evacuation of the remaining spent fuel (SF).
- Phase 2 of decommissioning: with completion expected seven years later. This primarily includes the following activities:
    - Dismantling of the remaining buildings and facilities of the nuclear power plant, including the dismantling of systems and components, followed by the decontamination and demolition of such buildings as are determined, concluding with the final radiological restoration and monitoring of the site.

4.3.2.4. Centre for Energy-related, Environmental and Technological Research

Enresa has collaborated with CIEMAT on the decommissioning of obsolete facilities in Madrid (PIMIC Project), including the shipment of radioactive waste (RW) to El Cabril Disposal Facility from 2006 to 2018.

Enresa will continue to support CIEMAT in the final phase of this project in the management of the remaining radioactive waste (RW), including characterisation, decontamination and declassification processes, and the removal of contaminated land.

4.3.2.5. Uranium mining and concentrate production facilities

Monitoring and maintenance activities will continue at the former Andújar Uranium Mill Plant (Jaen). Enresa will also participate with the licensee in the decommissioning, restoration and monitoring of mining and uranium concentrate production sites and facilities, as detailed below:

- La Haba Site (Badajoz): long-term monitoring and oversight programme for the former Lobo-G plant in La Haba.
- Former uranium mines in Castile and Leon: monitoring and maintenance programme at the Casillas de Flores and Valdemascaño mines.
- Saelices el Chico Site (Salamanca): monitoring and oversight programme for the Elefante Plant and monitoring and maintenance programme for mining operations.

Since the completion of the final restoration works of the mining operations in Saelices el Chico, Salamanca, in 2009, acidic waters requiring proper treatment continue to be generated. To minimise the annual volume of water still requiring treatment before discharge and to reduce the associated costs, hydraulic corrective actions have been implemented at the site. In addition, a research and development project was initiated in 2017 that sought to apply combinations of soils made from organic and inorganic waste (technosols) to prevent the generation of acidic waters and eliminate the current, very costly, treatments. Depending on the project results, the application of technosols to the entire site is planned.

Monitoring and maintenance activities, with the scope and duration required by the CSN, at all restored mining/uranium concentrate manufacturing sites that are in the compliance phase (Elefante Plant and restored mining operations in Saelices el Chico, mines in Castile and Leon and the FUA) or in long-term monitoring after the declaration of closure (Lobo-G Plant), primarily aim to verify compliance with the environmental and radiological targets of the Restoration Project. The responsibility for actions at the sites of these facilities lies with their licensees, with Enresa overseeing the technical supervision and providing the funding allocated to it, as provided for in the agreements signed with these licensees.

4.4. International situation

The decommissioning of nuclear facilities has gained increasing importance in recent years, as a significant number of them have reached the end of their operational life, and a substantial increase in their number is anticipated in the coming years. This scenario highlights challenges related to the planning, execution, financing and, particularly, the management of significant inventories of resulting materials and radioactive waste (RW).

The decommissioning of nuclear facilities has been taking place for the past 50 years in various countries worldwide. While considerable experience has been acquired in terms of technical and technological aspects, as well as understanding and interpreting essential elements for planning, management and financing, in practice, only a few large nuclear facilities and commercial power reactors have been fully decommissioned. To date, this has been the case for only a small number of the over 160 commercial reactors that have ceased operations.

Country	Facility	Type	Electrical power (MWe)	Year of definitive shutdown	Year of completion of decommissioning
Germany	Grosswelzheim	HDR Prototype	25	1971	1998
	Greifswald 1-5	VVER	408	1990	2014
	Wuergassen	BWR	640	1994	2014
	Kahl	Experimental BWR	16	1985	2010
	Niederaichbach	GCHWR	106	1974	1995
United States	Pathfinder	Superheat BWR	63	1967	1992
	Elk River	BWR	58	1968	1974
	Shippingport	PLWBR	60	1982	1988
	Fort St Vrain	HTGR	330	1989	1997
	Rancho Seco	PWR	913	1989	2009
	Shoreham	BWR	820	1989	1994
	Yankee Rowe	PWR	180	1991	2007
	Trojan	PWR	1130	1992	2005
	Haddam Neck	PWR	582	1996	2007
	Big Rock Point	BWR	71	1997	2006
	Maine Yankee	PWR	860	1997	2005

Table 18. The main fully decommissioned nuclear power plants (NPPs)

Currently, decommissioning projects for power reactors are underway in various countries, including the United States, Germany, France, Japan, the United Kingdom and Spain. As anticipated, a significant number of nuclear power plants (NPPs) are expected to be decommissioned in the coming years in other countries such as Sweden, Switzerland, Canada, South Korea and the Russian Federation, as they have reached the end of their operational life. Decommissioning activities resulting from the early closure of facilities will also be undertaken, as in the case of Bulgaria, Lithuania, Italy and Slovakia.

In this context, the global trend for nuclear power plants (NPPs) is towards adopting strategies of total and immediate decommissioning, in line with the Spanish policy. In some cases, the lack of management capabilities for radioactive waste (RW) hinders the start or progress of decommissioning. The availability of these capabilities and infrastructure to handle significant volumes of radioactive waste (RW) generated over a relatively short period becomes a critical aspect, especially for cases with an accelerated programme and concurrent timing of multiple decommissioning projects.

International cooperation and the exchange of experiences are particularly important nowadays, as most organisations have limited experience in decommissioning projects. In this regard, Enresa actively participates in working groups promoted by the NEA/OECD and the IAEA and collaborates with organisations responsible for the decommissioning of other countries, contributing to the experience acquired, primarily from the projects at Vandellós I and José Cabrera NPPs.

As regards the management of waste from uranium mining and concentrate production, the uranium mining industry in Europe is declining, with most mines closed after decades of activity. Currently, uranium extraction is concentrated in six major producing countries: Canada, Australia, Niger, Russia, Namibia and Kazakhstan.

It can be stated, first and foremost, that all countries, given the volumetric, radiological and temporal characteristics of this type of waste, manage it differently from radioactive waste (RW) produced in other areas (nuclear power generation, medical and industrial applications, etc.).

This differentiated treatment is observable both in international regulations and in the management and configuration of national inventories related to waste generated from uranium mining and concentrate production by different countries. As regards Directive 2011/70/Euratom, which establishes an EU framework for the responsible and safe management of spent fuel (SF) and radioactive waste (RW), this does not apply to waste from uranium mining. In addition, data from national inventories presented in successive review cycles of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management are recorded independently, distinguishing between uranium mining and concentrate manufacturing activities and other nuclear energy applications.

Looking not only at how they are recorded in inventories but also at the waste management practices from uranium mining and concentrate production, the following common features can be observed internationally:

- Responsibility for their management falls directly on the companies that generated them in the first part of the fuel cycle, and are not attributed to the organisations and institutions responsible for managing the rest of the radioactive waste (RW).
- In the case of legacies from mining companies that ceased to exist decades ago, the State assumes their management, either directly or by commission. In the United States, the Department of Energy has taken over the management of mining waste generated before 1978 when the U.S. Mining Waste Control Act was enacted. In Germany, the company that had generated the same waste has been restructured, funded with public money: Wismut GmbH.
- Once environmental restoration activities are completed, institutional monitoring becomes the responsibility of the State after a variable period of time.
- Financial responsibilities are established before or during the waste management period and the subsequent years (the so-called "compliance period" in Spain, before institutional monitoring begins), the aim being for the mine or concentrate plant operator to bear the unforeseen costs of restoration. These responsibilities can take the form of financial guarantee mechanisms.
- As regards management methods, the common practice is the treatment, stabilisation, and monitoring of waste *"in situ"*, meaning at the location where it was generated.

5

5. Logistics for the management of radioactive waste and spent fuel

In accordance with the provisions of Royal Decree 102/2014, of 21 February, for the responsible and safe management of spent fuel (SF) and radioactive waste (RW), Enresa is responsible for establishing systems for the collection, transfer and transport of spent fuel (SF) and radioactive waste (RW), and for adopting safety measures, both in terms of technological safety and physical safety, during its transportation, in accordance with the specific regulations on the transport of hazardous goods and the requirements of the relevant authorities and competent organisations.

In fulfilling this responsibility, Enresa is committed to all activities aimed at ensuring the safe transport of radioactive waste (RW). This includes active road safety by putting into service safer transport equipment and packaging specifically designed for the transport of radioactive waste (RW), as well as passive safety by collaborating with different public authorities to improve transport routes and access to its facilities.

Within the scope of the aforementioned responsibilities, Enresa assumes the role of the "shipper" in the transport of radioactive waste (RW). Regardless of the origin or type of radioactive waste (RW), the transfer of responsibility occurs when the vehicle has crossed the fence of the production facility.

The application of this criterion has required the development of two fundamental types of actions. First, the establishment of a 100% inspection system for radioactive waste (RW), prior to the vehicle's departure. Second, the development of transport equipment and packaging suitable for radioactive waste (RW) shipments, ensuring strict compliance with applicable regulations and providing additional safety measures for transport.

Depending on the nature of the producer, Enresa has established two differentiated work systems: one for radioactive waste (RW) from non-nuclear facilities (mainly those regulated by Title III of the Regulation on Nuclear and Radioactive Facilities), and another for radioactive waste (RW) generated at nuclear facilities.

In the first case, although the annual volume removed is not significant (between 15 and 20 m^3), the pre-inspection system is developed in two stages. The first includes a preliminary inspection before scheduling the removal and mainly applies to waste without radiological data, doubtful waste or that resulting from newly established techniques.

Once the radioactive waste (RW) is radiologically characterised, either by prior inspection or reliable data sent by the generating facility, Enresa supplies the producers with suitable packaging for transport. At the time of loading, in most cases, a second inspection is carried out to verify compliance with the acceptance criteria established in the technical-administrative specifications for the acceptance of radioactive waste (RW), simultaneously forming the packages of radioactive waste (RW) to be removed.

As regards transport equipment and packaging, the fundamental safety of these shipments is based on the concept of the "package," which includes the radioactive waste (RW) to be transported and the container packaging. In this regard, Enresa has developed more than 20 different transport packages adapted to the type of radioactive waste (RW) to be packaged, ensuring compliance with prevailing regulations.

It is noteworthy that, since the entry into force of Royal Decree 110/2015, of 20 February, on waste from electrical and electronic equipment, radioactive sources from ionisation smoke detectors are managed within the system established for radioactive waste (RW) from non-nuclear facilities.

Very low-level waste (VLLW) and low- and intermediate-level waste (LILW) from nuclear facilities account for the largest volume entering El Cabril Disposal Facility, currently between 2,000 and 3,000 m^3 per annum, which translates to an average of approximately 250 shipments per annum. While these values may be considered reasonable, this trend will increase over the coming years, reaching peak values during the overlap of several nuclear facility decommissioning projects. In these cases, once the radioactive waste (RW) is accepted by Enresa for management through the corresponding characterisation process, inspection primarily focuses on verification at the time of removal and on the proper loading of the vehicle transporting the waste.

Given the nature of nuclear facilities, the producer provides the packaging, while Enresa focuses on developing transport equipment that allows less interaction with the radioactive waste (RW). This minimises radiation doses to staff involved in both loading and unloading at El Cabril Disposal Facility, as well as to the general public during vehicle movements.

Enresa uses specially designed vehicles to transport radioactive waste (RW). For transportation originating from nuclear facilities, articulated vehicles with a maximum authorised mass of 40 tonnes are used. For waste from hospitals, laboratories and research centres, smaller vehicles are used to allow greater accessibility to loading locations.

Another fundamental requirement is the training of drivers, aimed at proper action in the event of incidents. They are adequately trained to deploy the corresponding safety systems carried by the vehicle. At any event, unforeseen events or accidents that may occur during shipment are covered in the "Contingency and Accident Response Plan for Radioactive Waste Transport". This allows the implementation and coordination of appropriate measures and procedures to manage the incident, minimising intervention times and risks.

The transport of spent fuel (SF), along with its classification as the transportation of hazardous goods, has physical characteristics (length and mass) that require additional road safety measures due to the application of the corresponding regulations. The transport of spent fuel (SF) and radioactive waste (RW) will be carried out using casks approved by the competent authorities. These casks are designed, licensed and manufactured bearing in mind the specific characteristics of the spent fuel (SF) and radioactive waste (RW) from each nuclear facility. Currently, Enresa has metal dual-purpose casks and specific transport casks for metal capsules, as described in Section 3.2. This stock of casks will be expanded according to the needs and characteristics of the spent fuel (SF) and radioactive waste (RW) from each nuclear facility. For the final management at a Deep Geological Repository (DGR), it will be necessary to transport the waste from Decentralised Temporary Storage (DTS) facilities to the DGR, which involves seven different routes.

A plan for transporting spent fuel (SF) casks will be developed, addressing various aspects and coordinating with authorities responsible for this matter. This plan will cover the means of transport to be used (road, rail and multimodal), and the resources required: transport logistics, radiation protection, emergency response and physical protection in the different phases.

At any event, whenever spent fuel (SF) is transported to a destination outside the nuclear facility, Enresa will prepare a Shipping Plan with its foreseeable content, considering the most suitable transportation routes available in each case.

According to regulations, transportation must have a special travel authorisation that establishes applicable road safety conditions. This authorisation includes, among other requirements, the mandatory use of a pilot vehicle.

The use of a pilot vehicle aims to alert other vehicles to the movement of a vehicle with dimensions and mass above the standard values (40 tonnes and 18 metres) and, in general, travelling at a speed below the maximums established depending on the type of road.

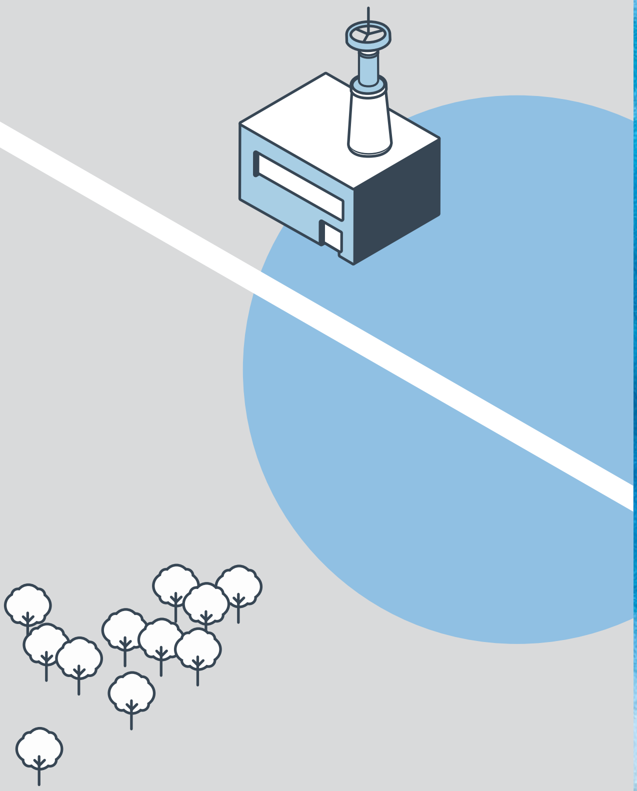
Regardless of what is established in different regulations, Enresa will implement additional safety measures to ensure the proper development of transportation. In the event of an accident or incident, these measures will minimise impacts on both people and the environment.

This additional package of safety measures focuses on two fundamental aspects:

- In the event of a breakdown, avoid unscheduled stops on route.
- In the event of an accident, establish the corresponding radiological safety measures in the shortest possible time.

To avoid unscheduled stops due to a vehicle breakdown, Enresa will have a network of repair workshops along the different routes to be used. This network will ensure that a workshop vehicle arrives at the breakdown site within two hours to carry out the repairs. To minimise the downtime, especially given the specific features of the semi-trailers, it is anticipated that the vehicle will carry repair parts that are considered susceptible to breakdown on route and can be transported due to their dimensions and weight.

As regards the establishment of radiological safety measures in the event of an accident, Enresa, in addition to the measures established in the "Contingency and Accident Response Plan for Radioactive Waste Transport", will have a team of personnel trained in radiological protection accompanying the transport vehicle from its origin to its destination. The purpose is to take immediate radiological safety measures in the event of any incident, avoiding radiation doses both to the shipment personnel and the public in the vicinity.



6

6. Other actions

6.1. Radiological monitoring of metallic materials

Following the incident that occurred in May 1998 at a steel plant located in southern Spain, where the inadvertent melting of a radioactive source of Cesium-137 took place, originating from outside the country and found among the scrap metal used in its production process, the need to adopt measures to prevent the recurrence of similar events and, in the event they occur, limit their consequences, became evident.

To prevent incidents at industrial facilities for the recovery or processing of metallic materials and to oversee any radioactive releases resulting from such incidents, a "Collaboration Protocol on Radiological Monitoring of Metallic Materials" was signed in November 1999. The signatories include the relevant ministerial departments, the CSN, Enresa, industrial associations engaged in metal recovery and manufacturing, and the main trade unions. Other organisations have joined since it was signed.

The Protocol outlines a series of commitments and actions to be carried out by each signatory party and by all companies wishing to sign up to it. The goal is to ensure radiological monitoring of metallic materials and manage radioactive materials detected in them or generated as a result of an incident. Companies signing up to this Protocol are registered in the Register of Radiological Monitoring Facilities, maintained by the Directorate-General of Energy Policy and Mines of MITECO.

Since the signing of the Protocol, a significant number of detections of radioactive material accompanying metallic materials of various types have occurred. Some incidents involving the inadvertent melting or processing of radioactive sources have resulted in 43 m^3 of waste to date. Although predicting such detections is challenging, waste collections are estimated to be between 1 and 2 m^3 per year. In all cases, Enresa has conducted the necessary removal and management of radioactive waste (RW) generated. Enresa has also organised and conducted various training courses each year for personnel in relation to the Protocol.

Within this context, Royal Decree 451/2020, of 10 March, on the oversight and recovery of orphan radioactive sources, transposing Council Directive 2013/59/Euratom, of 5 December 2013, which establishes basic safety standards for protection against the dangers arising from exposure to ionising radiation, addresses orphan sources. The aim is to avoid or minimise exposure to ionising radiation due to the existence of sources that are, essentially, outside regulatory oversight and therefore lack supervision in this area.

This Royal Decree establishes measures, monitoring and oversight requirements, and procedures to be followed in the event of the detection or processing of sources at facilities for the recovery, storage and handling of metallic materials for recycling. It also establishes Enresa's role in such cases.

With the approval of this Royal Decree, some commitments voluntarily assumed by the signatory parties of the Protocol are incorporated into the legal framework.

In addition, the Royal Decree imposes an obligation on major seaports to establish a radiological monitoring and oversight system to monitor inadvertent movements or illicit trafficking of sources through a protocol of action, such as the Megaport Protocol mentioned below. The Royal Decree also encourages other significant transit locations for people or goods to consider the suitability of establishing similar protocols.

6.2. Megaport Protocol

The "Protocol of Action in the Event of the Detection of Inadvertent Movement or Illicit Trafficking of Radioactive Material at Major Ports" (Megaport Protocol) was signed in 2010, on an initiative from the national authorities as part of the actions resulting from the agreement between Spain and the United States, within the framework of their collaboration in the fight against terrorism. The content and operational mechanisms took into account the experience acquired from the previous protocol, with necessary adaptations to the subject matter. Enresa is one of the signatory organisations of the Megaport Protocol, as the manager of radioactive waste (RW) generated in national territory and provider of the corresponding essential public service on behalf of the State.

Since it entered into force, there have been a limited number of detections, none of a criminal nature, which have been resolved based on established mechanisms.

Enresa has removed some materials and radioactive sources detected in ports, with a total volume of 0.18 m^3, following authorisation from the "holder" to transfer them to Enresa as radioactive waste (RW). In addition, Enresa participates in training courses organised by the State Tax Administration Agency for operators of the radiological oversight system.

6.3. Support for emergency response

One of Enresa's assigned functions under Royal Decree 102/2014, of 21 February, for the responsible and safe management of spent fuel (SF) and radioactive waste (RW), is to act in the event of nuclear or radiological emergencies in the manner and circumstances required by competent organisations and authorities. The scope of these actions is defined at a very basic level in applicable regulations and in more detail in certain national plans and programmes.

In addition to responding to emergencies at its facilities and emergencies in the transport of radioactive material according to its own Action Plan for Contingencies and Accidents in the Transport of Low- and intermediate-level waste (LILW), based on the "Basic Guideline for Civil Protection Planning against the Risk of Accidents in the Transport of Dangerous Goods by Road and Rail", approved by Royal Decree 387/1996, of 1 March, Enresa acts to provide support to the National Civil Protection System and State law enforcement agencies, as required by competent organisations and authorities in the event of:

- Emergencies at nuclear power plants (NPPs), regulated by the Basic Nuclear Emergency Plan (PLABEN), approved by Royal Decree 1546/2004, of 25 June, as a member of the response "Radiological Group", managed by the CSN.
- Emergencies occurring at radiological facilities and those regulated by the Basic Guideline for Civil Protection Planning against Radiological Risk, approved by Royal Decree 1564/2010, of 19 November.

To fulfil its assigned tasks, Enresa has established several capabilities complementary to its own, including:

- Integrated activation coverage mechanism.
- Full temporary support service for conducting interventions and removal of radioactive materials.
- Support services for radiological measurement and analysis capabilities.

The national system regularly conducts exercises and drills to prepare for such situations, in which Enresa regularly participates.

In addition, Enresa collaborates in training activities related to radiological protection and radioactive waste (RW) management for State Law Enforcement Agencies and other institutional groups whose participation in such situations is essential.

6.4. Management of radioactive lightning rods

By means of Royal Decree 1428/1986, of 13 June, on radioactive lightning rods, it became mandatory to formalise the existence of such devices according to the regulations on radioactive facilities or their removal by Enresa as radioactive waste (RW).

Enresa has been conducting the removal and management of radioactive lightning rods and their contained sources, exporting them for recycling in the case of containing Am-241 and for final storage in the case of containing Ra-226. The process was formally concluded in the spring of 2004. However, such devices continue to appear regularly, numbering in their tens annually, making it necessary to maintain sufficient removal capacity. On 31 December 2022, 22,942 radioactive lightning preventors had been removed without any major incidents.

6.5. Other radioactive materials appearing outside the regulatory system

In addition to the specific cases described in the previous sections, the national system has established two basic mechanisms for the safe removal and management of any radioactive material that may appear outside regulatory oversight. Authorities activate these mechanisms through intervention orders or transfer resolutions, involving Enresa as appropriate in each case. In this context, Council Directive 2013/59/Euratom, of 5 December 2013, establishing basic safety standards for protection against the dangers arising from exposure to ionising radiation, is of particular importance. This Directive is in the advanced process of transposition, and its provisions on orphaned radioactive sources have been incorporated into the aforementioned Royal Decree 451/2020, of 10 March, on the oversight and recovery of orphaned radioactive sources.

Enresa has undertaken a limited number of interventions in response to intervention orders, involving the removal and management of radioactive sources used in medical applications in the first half of the 20th Century, some cases of consumer product dealers under government intervention, and instances of regulated or unregulated facilities without a traceable owner.

Actions related to transfer resolutions are more common and essentially involve sources and other radioactive materials at facilities (regulated or not) due to activities carried out in times when there was no regulatory framework for radiological protection and nuclear safety, and therefore, they did not follow the currently established procedures. Also significant are cases involving sources included in equipment that does not require authorisation as a radioactive facility for commercialisation and use and that, at the end of their life cycle, require Enresa's management at the discretion of the authorities.

The types of sources and radioactive materials removed through these mechanisms are varied, and the volumes are generally not significant.

6.6. Management of residual materials with radioactive content of natural origin

Another action considered in the national system is the removal by Enresa of NORM (Naturally Occurring Radioactive Material) materials managed as radioactive waste (RW), present in facilities and activities not subject to the authorisation regime of nuclear legislation. In Spain, as in many other countries, some industrial activities use and process raw materials with naturally occurring radioactive content, resulting in the generation of residual materials with radioactive content. Following EU standards, Spanish regulations in the radiological field address such activities and establish conditions under which oversight is necessary for radiological reasons.

Order IET/1946/2013, of 17 October, regulating the management of waste generated in activities using materials containing natural radionuclides, establishes concentration activity values (exemption/declassification levels) that, if not exceeded, allow conventional waste management. Otherwise, the activity licensee must conduct a radiological impact study to determine the resulting annual effective dose for the public and workers. If certain values are exceeded, the materials must be managed by Enresa as radioactive waste (RW).

The types of radioactive waste (RW) removed through this mechanism are varied, and the volumes are generally not significant, although the experience acquired cannot be considered representative of potential future removal processes.

Within the scope of the "Collaboration Protocol on Radiological Monitoring of Metallic Materials" and the technical-administrative specifications for the acceptance of radioactive waste (RW) corresponding to transfer authorisations granted to NORM facilities, the volume of NORM radioactive waste (RW) removed by Enresa has not exceeded 20 m^3 to date.

However, it is foreseeable that there will be a need to manage larger volumes of this type of waste in the near future. Since there is currently no reliable forecast of NORM waste generation, an update of the inventory of activities and companies conducted in 2010 has been initiated, based on the "Registry of work activities with exposure to natural radiation" maintained by MITECO. The purpose is to quantify the volume of materials that may require management as radioactive waste (RW). The estimate of this inventory relies heavily on the definition of conditional declassification levels that take into account origins, types and possible management routes, contributing to minimisation through separation, melting or decontamination techniques. The result of this inventory will determine the solutions to be adopted and submitted for authorisation, if necessary, regarding potential storage needs at El Cabril Disposal Facility.

For their management at El Cabril Disposal Facility, these types of waste must necessarily comply with the requirements established in the operating permit of said facility.


7

7. Research and Development activities

Research and Development (R&D) constitute fundamental elements in generating the knowledge, technologies and expertise necessary for the development of activities applied at various stages of radioactive waste (RW) management, decommissioning and facility closure to ensure their safety and viability. Therefore, the objectives and priorities of R&D are closely associated with the established management guidelines.

In its implementation, R&D follows guidelines that aim to balance the development of Spanish capabilities in collaboration with universities, research centres (particularly CIEMAT) and other organisations, with the acquisition of developments from other countries. It also involves the joint use of facilities by relevant entities in the country, universities and other research centres, as well as participation in projects of the European Union, the International Atomic Energy Agency (IAEA), and the Nuclear Energy Agency/Organization for Economic Cooperation and Development (NEA/OECD).

Enresa has systematically conducted R&D programmes since 1986. The 8th Programme spans the period 2019-2023. The funding for R&D established in this Plan is primarily provided by Enresa, with small contributions from the European Union through participation in projects and programmes, and from other organisations, particularly CIEMAT, through partnership agreements. In addition, the CSN carries out its own R&D plan (on a five-year basis), encompassing strategic lines, including those related to the operation and management of high-level radioactive waste (RW) (HLW) (including dry storage and transportation at the end of its lifecycle), material performance and waste management.

7.1. R&D in the management of very low-level waste, low- and intermediate-level waste

Optimising the storage capacity of El Cabril Disposal Facility is a strategic and priority objective in the management of this type of radioactive waste (RW), primarily generated during the operation and decommissioning of Spanish nuclear facilities. In addition, efforts to enhance the efficiency and safety of El Cabril Disposal Facility operations must continue.

The planned actions in this area are grouped into the following three areas:

a. Improvements in the management of very-low level waste and low- and intermediate-level waste (LILW).

  - Support for activities aimed at increasing and optimising the storage capacity at El Cabril Disposal Facility (existing and future).
  - Boosting activities to reduce volumes and condition new waste streams.
  - Continued R&D focused on improving safety: better understanding of the radionuclide/barrier interaction and confinement materials.
  - Technological improvement of site characterisation and monitoring, as well as visual representation.
  - Radiological protection and environmental restoration: analysis, verification and selection of suitable technologies for application in land restoration.
  - Improvement of knowledge and technologies applicable to the management of waste from the decommissioning of nuclear facilities.

b. Improvement of the operation of El Cabril Disposal Facility:

  - General optimisation of processes through the application of more advanced technologies that simplify operations without compromising safety.
  - Improved understanding of the characteristics of the inventory of packages through the use of increasingly precise analytical techniques.
  - Optimisation and improvement of environmental oversight technologies.

c. Management of irradiated graphite.

  - Continuation of treatment and management activities.
  - Participation in international collaboration projects related to the management of irradiated graphite.
  - Study of other actions on graphite, such as treatments with microorganisms, and its use in mortars.

7.2. Research and Development (R&D) in the management of spent fuel and high-level waste

R&D must contribute in the short term to activities that support the temporary management of spent fuel (SF) and special waste (SW) and their facilities (site, engineering barriers, monitoring and support for safety and environmental studies) through specific projects.

As regards final storage, at the national level and in recent years, synthesis work has been carried out on activities in the areas of site characterisation, generic designs, safety assessments and management options, documented in the corresponding reports. In addition, participation in European projects and programmes related to fuel performance, engineering barriers, facility monitoring, radiological protection and separation and transmutation has been ongoing.

At an EU level, the European Union initiated the creation of the technological platform for R&D for the implementation of geological storage (IGD-TP), aiming to have an operational Deep Geological Repository (DGR) in Europe by 2025. Enresa forms part of this platform to contribute to decision-making on proposed R&D activities and to maintain capabilities and access to the latest knowledge and technologies generated.

Planned actions in this area will focus on:

a. Temporary storage.

  - Programmes aimed at improving knowledge of engineering barriers (mainly metallic and concrete capsules) and their monitoring.
  - Programmes focused on life management and improving understanding of conduct during the dry storage of fuel and associated systems.
  - Support programmes for characterisation, conditioning, and acceptance of spent fuel (SF), as well as its transport and long-term dry storage.
  - Development of technologies for the preparation of a storage or transport system for damaged fuel from long-term dry storage facilities.
  - Programmes associated with the verification and acceptance of components, systems and materials.
  - Analysis of the impact on the final storage programme, considering additional cooling times and conditions of temporary storage, in terms of safety, operability and costs.
  - Comprehensive monitoring programme for the facility and the environment.
  - Modelling and continuous safety evaluation of the facility, incorporating improvements developed.

b. Final disposal.

- Review and analysis of information generated by R&D associated with long-term management: assessment, selection and management of knowledge, technologies, applicable models, etc.

- Continuation of R&D projects associated with fuel performance under long-term disposal conditions. Monitoring international programmes.

- Continuation of R&D projects associated with the development of confinement systems (capsule, bentonite barrier and concrete-based materials) and site characterisation related to safety assessments of long-term storage facilities. Monitoring of international programmes, applications, etc.

- Contribution to the development of the R&D programme associated with underground research laboratories.

- Continued monitoring of European activities in the field of transmutation and associated separation.

7.3. Research and Development (R&D) in the decommissioning of facilities

R&D must look closely at systems and technologies for reducing the volume of decommissioning waste, both related to materials from the facility itself and those generated during actions aimed at releasing land. Improving characterisation technologies also facilitates the declassification of materials, surfaces and land.

In preparation for the decommissioning of Santa María de Garoña NPP and other future decommissioning of nuclear facilities, the aim is to continue innovating and improving processes related to planning and monitoring, characterisation, declassification, volume reduction and automation.

Actions planned in this area will focus on:

- Development and application of waste volume reduction technologies.

- Development of specific techniques for soil treatment and decontamination to minimise radioactive waste (RW) generation.

- Application of advanced techniques for characterisation and declassification.

- Improvement of decontamination techniques for various materials to be decommissioned.

- Enhancement of material oversight and management techniques.

- Design and verification of storage and transport casks for various types of waste generated.

- Improvement and fine-tuning of planning and monitoring methods for nuclear facility decommissioning processes.

- Participation in European projects.

7.4. Coordination of R&D activities and knowledge management

The coordination of R&D activities at Enresa has facilitated the achievement of some objectives, cost adjustments and the attainment of consistent and balanced results across different areas of activity and management needs. Coordination has also sought to pass on the immediate transfer of R&D results to waste management.

These activities have been strengthened in recent years to update and review the significant volume of assets generated by R&D associated with the long-term management of high-level waste (HLW) and, along with considerations related to previous designs, form an important basis for the long-term radioactive waste (RW) management plan of high-level waste (HLW).

The fundamental idea within knowledge management is to ensure its transfer to new generations of technicians that join Enresa, taking into account the extended timelines for management, development, operation and monitoring after closure of the different waste management options.

To achieve this, the following activities are considered:

- Analysis and updating of R&D assets for consideration in the long-term storage programme. Complete the review, update and reorganisation of assets generated under each plan, and then integrate them into a single database.

- Technological monitoring to ensure accurate information is available on capabilities and knowledge in areas even beyond radioactive waste (RW) management that are potentially applicable. Monitoring results from external programmes and technological platforms such as IGD-TP (focused on DGR), SNE-TP (related to nuclear energy) and those performing equivalent tasks in radiological protection included under the European Joint Programme (EJP) Concert (MELODI, ALLIANCE, NERIS and EURADOS). Noteworthy is the first EJP in radioactive waste (RW) management, which arose in 2019 as a product of the JOPRAD project, with ambitious activities in knowledge management and transfer, along with training areas.

- Training programmes in specific project DGR topics.

7.5. Activities aimed at consolidating and ensuring access to knowledge and technology

In order to consolidate and ensure access to knowledge and technologies, the following activities to be developed have been taken into account:

- Organise and disseminate the knowledge acquired.
- Collaborate with organisations and research centres (such as CIEMAT) in common lines of R&D interest.
- Provide support in training and communication aspects, as required.
- Participate in initiatives and projects of the NEA/OECD, IAEA and other national and European R&D forums related to the preservation of knowledge, documentation and capabilities in radioactive waste (RW) management.

7.6. R&D technology platforms

R&D activities are defined and developed considering both the experience of Enresa's own programmes and those derived from existing platforms.

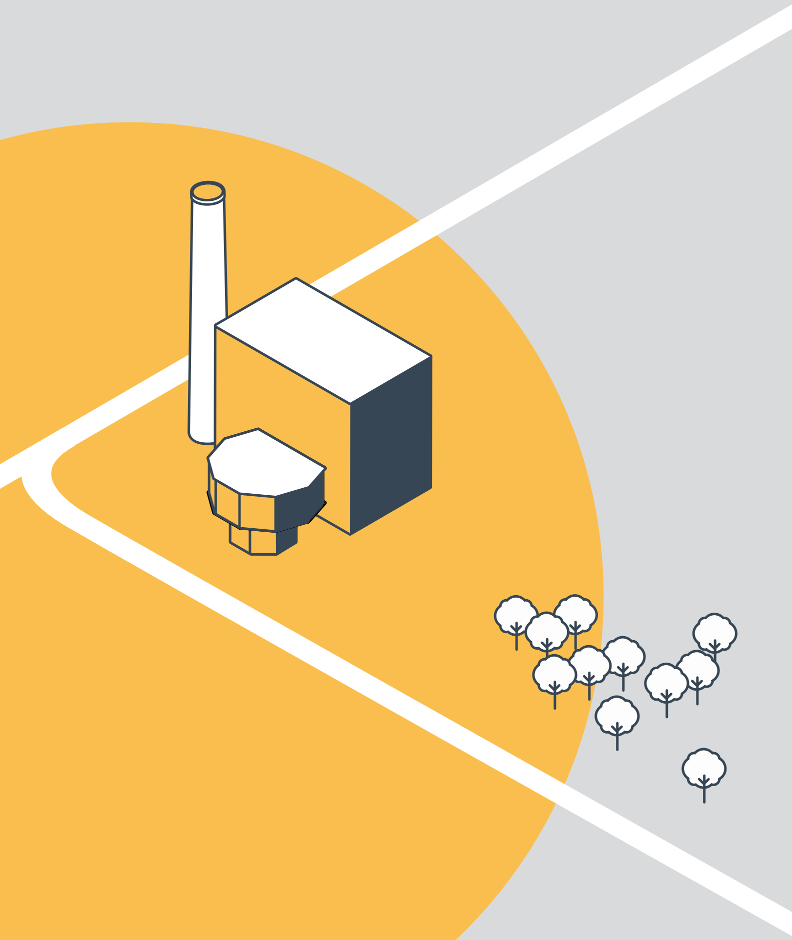
In this regard, active participation will be maintained in the Spanish R&D platforms CEIDEN (The Nuclear Fission Energy Technology Platform), PEPRI (The National Radiation Protection R&D Platform) and the European platforms IGD-TP (The European Implementing Geological Disposal of Radioactive Waste Technology Platform), SNE-TP (The European Sustainable Nuclear Energy Technology Platform), as well as other European R&D radiological protection platforms. While these platforms do not generally have legal entities, seeking synergies with their members such as CIEMAT and ENSA has been very beneficial in the overall programme.

7.7. International collaboration

Participation in European Programmes (Euratom Programme) will be maintained, as well as in projects proposed by the international agencies NEA/OECD and IAEA, and in multilateral projects of interest to Enresa in the field of R&D.

The European Commission has promoted the creation of a European Joint Programme (EJP), in which Spain participates, which gathers common needs related to R&D for the management of radioactive waste (RW) from different national programmes of EU Member States and other associated countries, to be evaluated in 2023; this EJP may be replicated in an EJP-2 for the period 2025-2029.

Under this programme, a Strategic Research Agenda (SRA) and implementation plans have been defined, which are periodically reviewed and updated. Three groups participate in the programme management and in the preparation of strategic documents (vision, SRA, etc.): one consisting of radioactive waste (RW) agencies from each country, a second composed of technical support organisations (to regulatory bodies) and a third that brings together public research centres (universities and others). Enresa is included in the first group, and CIEMAT in the second.



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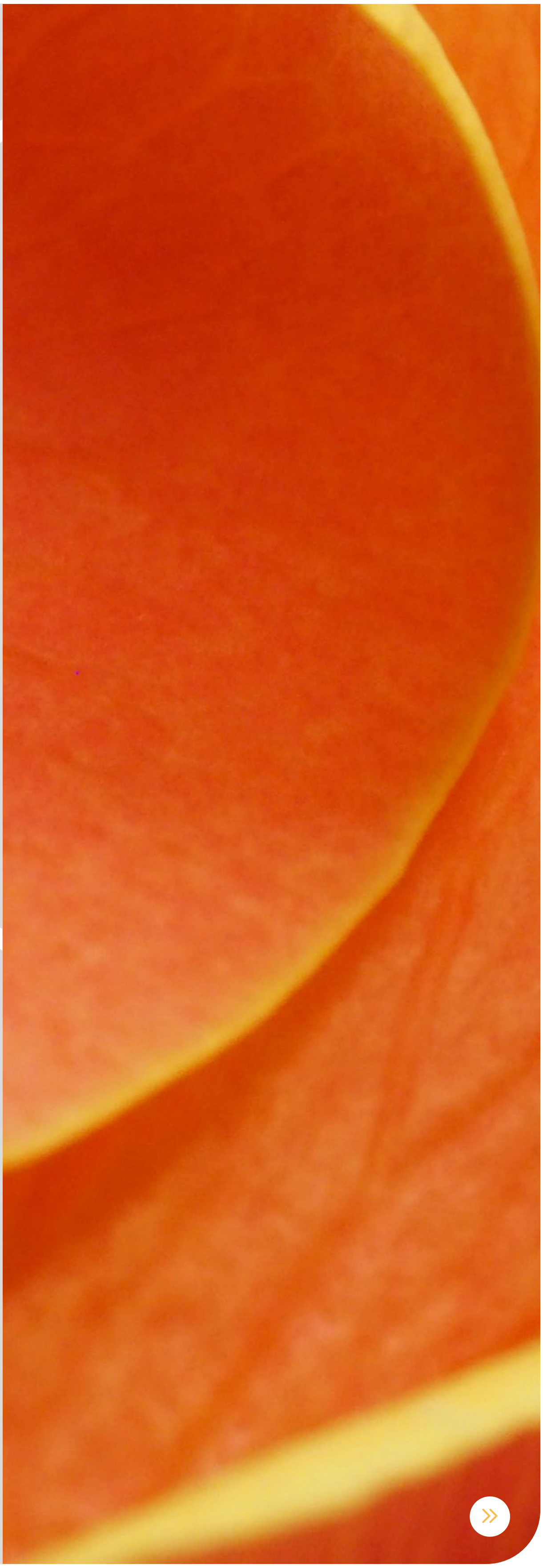


8. Responsibilities regarding the implementation of this Plan

The current legal and regulatory framework established in Spain for the management of radioactive waste (RW) and spent fuel (SF), which is integrated into Spanish nuclear energy legislation, is consistent with the evolution of international regulatory requirements.

The following responsibilities are defined in this framework:

Government

As provided for in Article 38 bis. 2 of the Nuclear Energy Act (NEA), it is the responsibility of the Government to establish policies on the management of radioactive waste (RW), including spent fuel (SF), and the decommissioning and closure of nuclear facilities, through the approval of the GRWP. The Government will approve this Plan based on a proposal from MITECO, following a report from the CSN, and after consulting the Autonomous Regions on territorial planning and the environment. The approved Plan will subsequently be submitted to the Spanish Parliament.

Ministry for the Ecological Transition and Demographic Challenge (MITECO)

This ministerial department has the following functions:

- Definition of radioactive waste (RW), in accordance with the NEA, following a report from the CSN.
- Establishment of the radioactive waste (RW) strategy, proposing the approval of the GRWP to the Government.
- Oversight of Enresa, through the State Secretariat for Energy, which monitors and oversees actions and technical and economic plans.
- Granting authorisations for nuclear and radioactive facilities, including those related to physical protection, except for category 2 and 3 radioactive materials or in regions where this function has been transferred.
- Development of nuclear regulations.
- Instruction and resolution of disciplinary procedures.
- Authorisation of the transportation of radioactive material and approval of casks for storage and transport.
- Management of administrative records in the field.
- Monitoring compliance with international commitments signed by Spain, including those derived from the application of nuclear safeguards.
- Relations with international organisations specialised in the field.
- Processing and resolution of strategic environmental assessment procedures for the GRWP in accordance with Law 21/2013, of 9 December, on environmental assessment.
- Processing and resolution of environmental impact assessment procedures for nationally competent projects under Law 21/2013, of 9 December.

Ministry of Home Affairs

This ministerial department has the following functions:

- Preparation, development and execution of State plans for civil protection and emergencies related to nuclear facilities and, if applicable, radioactive facilities.
- Competencies assigned by prevailing regulations regarding the physical protection of nuclear and radioactive facilities.

Nuclear Safety Council (CSN)

This is the sole competent body for nuclear safety and radiological protection and has the following functions:

- Issuing reports related to nuclear safety, radiological protection and physical protection, required for authorisations for nuclear and radioactive facilities.
- Providing input on MITECO's proposal for the GRWP.
- Granting licenses to operational personnel of nuclear and radioactive facilities.
- Conducting all classes of inspections at nuclear and radioactive facilities, with the authority to suspend their operations for safety reasons.
- Proposing regulations on nuclear safety and radiological protection and approving technical instructions, circulars and guidelines.
- Collaborating with competent authorities in developing criteria for external emergency plans and physical protection plans for nuclear and radioactive facilities and participating in their approval once drafted.
- Proposing the initiation of disciplinary procedures for non-compliance with nuclear safety, radiological protection and physical protection requirements.
- Controlling and monitoring the radiological quality of the environment nationwide.
- Collaborating in emergency matters.
- Issuing reports in exceptional circumstances regarding the removal and safe management of radioactive waste (RW).
- Establishing and monitoring research plans within its scope of competence.
- Informing the public regarding matters within its scope of competence.
- Providing an annual report to Parliament on its activities.

Autonomous Regions

- Provide prior information before granting authorisations for category 1 nuclear and radioactive facilities in the fuel cycle regarding territorial planning and the environment.
- Issue a report on the GRWP regarding territorial planning and the environment.
- Grant authorisations for category 2 and 3 radioactive facilities in regions to which MITECO's functions have been transferred. Instruction and resolution of disciplinary procedures related to these facilities.

Enresa

In accordance with Royal Decree 102/2014, of 21 February, for the responsible and safe management of spent fuel (SF) and radioactive waste (RW), Enresa has the following responsibilities:

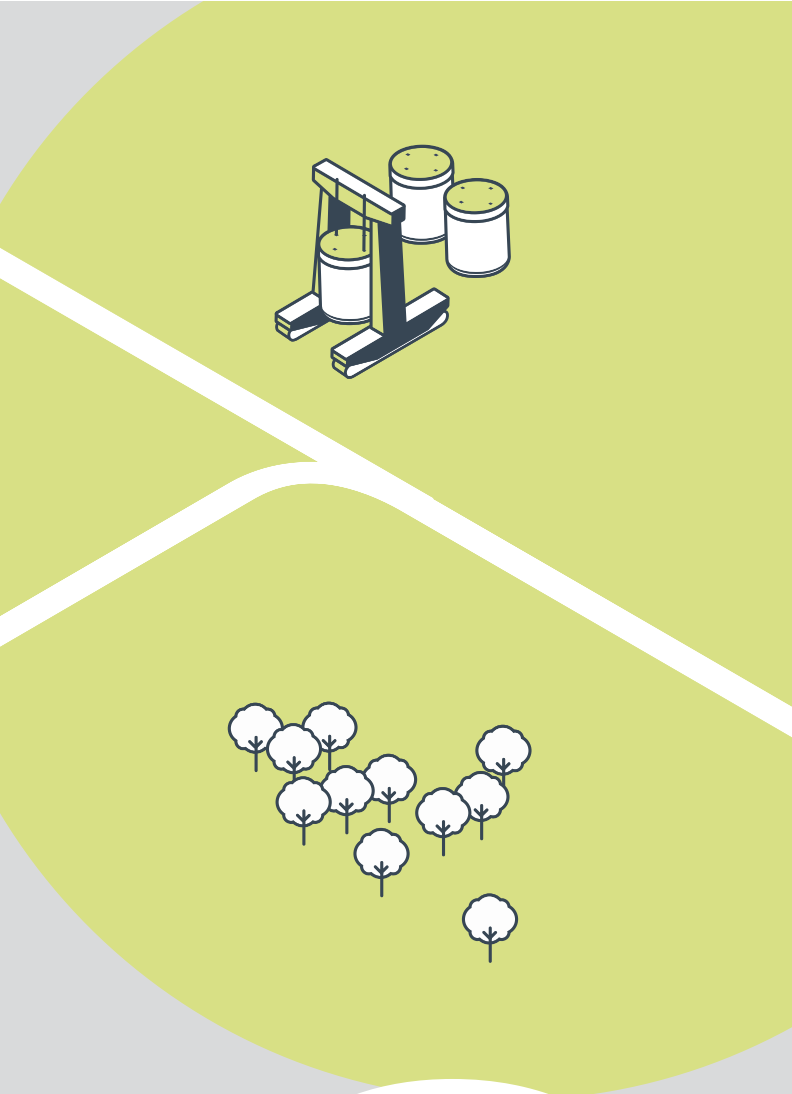
- Treat and condition spent fuel (SF) and radioactive waste (RW), without prejudice to the responsibilities of the generators of these materials or the holders of authorisations to whom such responsibility has been commissioned.
- Select sites, design, construct and operate facilities for the temporary storage and final disposal of spent fuel (SF) and radioactive waste (RW).
- Establish systems to ensure the safe management of spent fuel (SF) and radioactive waste (RW) at its facilities for temporary storage and final disposal.
- Establish systems for the collection, transfer and transport of spent fuel (SF) and radioactive waste (RW).
- Develop and manage the National Inventory of spent fuel (SF) and radioactive waste (RW). This inventory will continue to include spent fuel (SF) and radioactive waste (RW) disposed of permanently after the closure of the facility where they are disposed of.
- Adopt safety measures for the transport of spent fuel (SF) and radioactive waste (RW), in accordance with the specific regulations on the transport of dangerous goods and as determined by the competent authorities and organisations.
- Manage operations related to the decommissioning and closure of nuclear facilities and, where applicable, radioactive facilities.
- In the event of nuclear or radiological emergencies act in the manner and circumstances required by the competent authorities.
- Establish training plans and R&D plans within the framework of the State Plan for Scientific and Technical Research and Innovation, covering the needs of the GRWP and allowing the acquisition, maintenance and ongoing development of the necessary knowledge and skills.
- Conduct the necessary technical and economic-financial studies that take into account the deferred costs derived from its tasks to establish the corresponding economic needs.
- Manage the Fund for the financing of GRWP activities.
- Any other activity necessary for the performance of the above tasks.
- Submit to MITECO, every four years or as required by this department, a review of the GRWP.

- Submit to MITECO for monitoring and oversight of the activities that Enresa carries out in compliance with the GRWP, with the corresponding periodicity:
    - The updated economic and financial study of the cost of the activities provided for in the GRWP, as well as the adequacy of the existing financial mechanisms for these costs.
    - A report that includes technical and economic aspects related to the activities of the previous year and the degree of compliance with the corresponding budget.
    - A budget monitoring report for each calendar quarter.
    - A technical and economic justification of the annual budget.
- Submit information to the CSN on the activities carried out in the previous year and the forecasts for the current year in relation to the provisions of the GRWP.

Licensee of the facility generating the radioactive waste or spent fuel

Royal Decree 102/2014, of 21 February, for the responsible and safe management of spent fuel (SF) and radioactive waste (RW), establishes the following:

- The primary responsibility for spent fuel (SF) and radioactive waste (RW) lies with those that generate them or, where appropriate, the holder of the authorisation to whom that responsibility has been commissioned, under the circumstances provided for by the Nuclear Energy Act (NEA) and the Regulation on Nuclear and Radioactive Facilities, approved by Royal Decree 1836/1999, of 3 December.
- Licensees of nuclear and radioactive facilities must subscribe to the technical-administrative specifications for the acceptance of spent fuel (SF) and radioactive waste (RW), with a view to their collection and subsequent management by Enresa.
- This same obligation extends to the licensees of facilities or activities not subject to the authorisation regime of nuclear legislation, where radioactive waste (RW) may potentially be produced.



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9. Result indicators to monitor the progress of the execution of the Plan

The evolution of the Plan, as established in this document, must be monitored through parameters indicating the degree of alignment of the reality with the planned objectives. These indicators should report on the attainment of objectives from a strategic perspective, the development of planned activities from an operational standpoint, and finally, economic and financial aspects. These indicators will be reported, as applicable, in the documents provided for in Articles 10, Section A and 12, section 2 of Royal Decree 102/2014, of 21 February, for the responsible and safe management of spent fuel (SF) and radioactive waste (RW).

In addition, the environmental monitoring of the Plan will be carried out through environmental monitoring measures and indicators proposed in the EsAE, incorporating the monitoring of the determinations of the DAE. This monitoring will comprehensively compile the attainment of environmental objectives and determinations for each action, providing a joint and individual assessment of impacts and measures taken. A comprehensive environmental monitoring report, reflecting the results of proposed indicators and the degree of compliance with environmental determinations and measures proposed in the EsAE, along with existing challenges and measures to overcome them, will be submitted to the environmental authority every three years.

9.1. Strategic indicators

The basic aim of management is to safely store radioactive waste (RW) in accordance with accepted models, depending on the type of radioactive waste (RW) to be managed in each case. There are two types of radioactive waste (RW) to consider: very low-level waste (VLLW)/ low- and intermediate-level waste (LILW) and spent fuel (SF)/high-level waste (HLW)/special waste (SW). For very low-level waste (VLLW)/low- and intermediate-level waste (LILW), the management model is defined and operational, so the associated indicator should confirm whether the objective is attained over time, meaning sufficient storage capacity exists for anticipated needs. For spent fuel (SF)/high-level waste (HLW)/special waste (SW), the final management model is defined, but its actual implementation is distant in time. In the meantime, there must be sufficient temporary storage capacity until implementation of the final solution.

For very low-level waste (VLLW)/low- and intermediate-level waste (LILW) management, there is authorised capacity for very low-level waste (VLLW) that exceeds the projected inventory. In the case of low- and intermediate-level waste (LILW), the construction of new cells is planned, with the first phase expected to be operational by 2028. The indicator, in this case, is the degree of compliance with the programme for constructing new cells for low- and intermediate-level waste (LILW) and the achievement of new capacity in that year.

As regards spent fuel (SF)/high-level waste (HLW)/special waste (SW), indicators must be established based on the periods in their management (temporary and final). In temporary management, the indicators should be associated with the storage capacity at nuclear power plant sites. In final management and the operation of the DGR, the indicators should be associated with the start of the site selection process, the development of a procedure and programme for decision-making on site selection, the establishment of a regulatory framework as a preliminary step to site selection, the start of the licensing process, the start of construction, and finally, the operation of the facility.

The projects for the decommissioning and closure of nuclear power plants (NPPs) are tied into scenario variables, such as the lifespan of reactors and the expected periods for their development (spent fuel (SF) unloading and preparatory activities, execution of works and obtaining the declaration of closure). Given the number of cases and the peculiarities of each, it is difficult to establish a global strategic indicator. Nevertheless, spent fuel (SF) removal impacts decommissioning, and the execution of decommissioning, with the consequent removal of very low-level waste (VLLW)/low- and intermediate-level waste (LILW), conditions the management of El Cabril Disposal Facility. Accordingly, a closure indicator is related to meeting the aforementioned dates regarding the availability of storage capacity for spent fuel (SF) and the construction of new low- and intermediate-level waste (LILW) cells at El Cabril Disposal Facility.

Indicators for the implementation of both storage capacity and decommissioning projects are Project Management indicators.

The storage capacity availability indicator is established based on meeting the dates for significant milestones in each of the stages:

- Site selection, if applicable.
- Submission of licensing documentation to regulatory bodies.
- Submission of the project execution plan to the municipality.
- Commencement of construction works.
- Commencement of nuclear tests, if applicable.
- Commencement of facility operation.

9.2. Operating indicators

The operating indicators defined are for monitoring storage capacities and availability in the management of radioactive waste (RW), as well as for monitoring and overseeing the execution timelines in the projects and activities of decommissioning and closure of nuclear facilities outlined in the Plan.

As regards very low-level waste (VLLW)/low- and intermediate-level waste (LILW), indicators have been considered that relate the estimated inventory for each type of waste to disposal capacity and the degree of available occupancy.

In the Plan calculations, programmes are established for the removal of waste, assuming a certain degree of occupancy of the disposal cells. It is necessary to oversee this at each moment, based on the available capacity, allowing the adjustment of reality to the forecasts. The main indicators defined are:

- **Index of the degree of very low-level waste (VLLW) cell occupancy**

  Index of degree of occupancy = Positions occupied / Total positions built

- **Index of the degree of low- and intermediate-level waste (LILW) cell occupancy**

  Index of degree of occupancy = Positions occupied / Total positions built

- **Index of the total storage capacity required for very low-level waste (VLLW)**

  Index of total capacity required = (Volume of VLLW (m^3) occupied + Projected volume of VLLW (m^3)) / Total volume of VLLW (m^3) storage authorised

- **Index of the total storage capacity required for low- and intermediate-level waste (LILW)**

  Index of total capacity required = (Volume of LILW (m^3) occupied + Projected volume of LILW (m^3)) / Total volume of LILW (m^3) storage authorised

In the case of spent fuel (SF)/high-level waste (HLW)/special waste (SW), since additional capacity is required at the nuclear power plant site, it is necessary to verify that this capacity is sufficient until the DGR becomes operational. The indicators are related to the capacity of the Individualised Temporary Storage (ITS) facilities. A relevant measure is the number of discharges that can be stored with the available capacity (pool + ITS) and how this aligns with the number planned. Therefore, the main indicators defined are:

- Index of the discharge capacity per NPP

  Index of discharge capacity = (Free positions in the pool + available capacity of ITS (in spent fuel (SF) assemblies)) / Number of elements per discharge

- Index of the refuelling possibility per NPP

  Possibility of refuelling = Free positions in the pool - Positions needed for discharge in the pool

- Index of the degree of pool occupancy per NPP

  Index of degree of pool occupancy = Positions occupied / Total positions available

- Index of the degree of ITS occupancy per NPP

  Index of degree of ITS occupancy = Positions occupied / Total positions

Decommissioning and closure projects of nuclear power plants (NPPs) involve three basic stages: the removal of spent fuel (SF) and preparatory activities, decommissioning and obtaining the declaration of closure. Operational indicators should compare the actual work performed with the planned work, within the scheduled timelines outlined in the Plan. Therefore, the monitoring indicators are linked to the dates of compliance with timeline milestones such as:

- Spent fuel (SF) removal milestone.
- Document licence submission milestone.
- Start of decommissioning and closure project milestone.
- Declaration of closure milestone.

In addition, each decommissioning project will have indicators established for project monitoring and oversight, such as:

- Index of the degree of technical progress (%)

  (Work completed / Work planned) * 100

- Earned value

  The earned value of a project as of a certain date, based on the total budget, the cumulative actual cost and the percentage of progress calculated as the weighted average of the technical progress degrees of the project phases. Standard indices associated with this project management technique will also be used.

9.3. Economic-financial indicators

For the establishment of economic-financial indicators, the cost of management and the availability of funds must be considered.

The cost indicator is derived by comparing the estimated cost in the Plan with the latest available estimation.

- Index of the economic deviation of GRWP

  Estimated costs in the current version of the GRWP and the update of these in each Financial and Economic Study (FES).

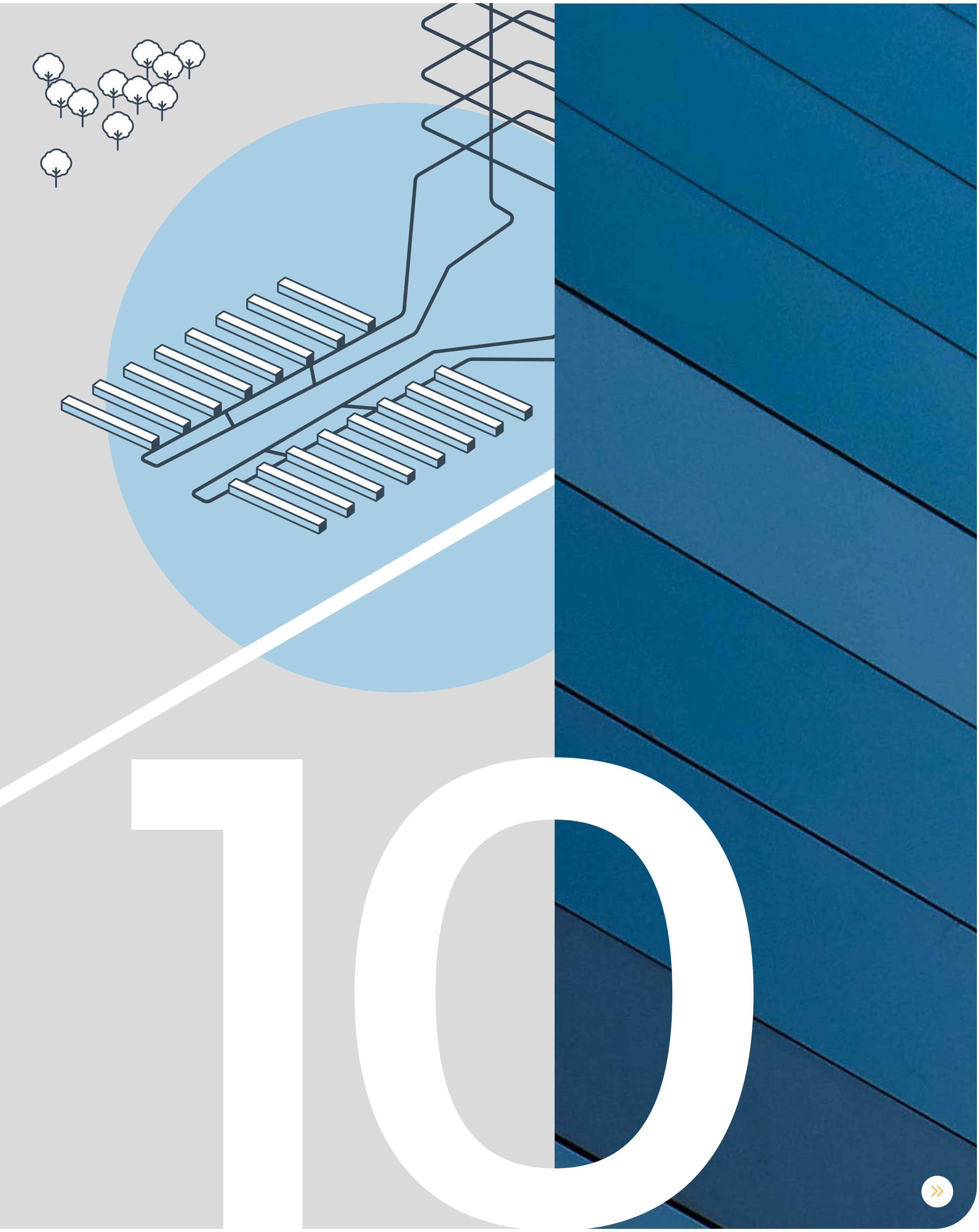
The financial indicator is related to the evolution of the Fund for the financing of GRWP activities, i.e. verifying that the Fund at a given time is as scheduled in the Plan to cover future costs. An additional indicator would be the relationship between the value of the Fund at a given date and the future cost from that date, i.e. the degree of coverage of the financing system.

- Evolution of the Fund

  Estimated and real value of the Fund.

- Degree of coverage of the financing system

  Value of the Fund at a given date and the future cost from that date.



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10. Costs of the activities outlined in the General Radioactive Waste Plan (GRWP) (2024-2100)

This section aims to evaluate the future costs associated with various activities outlined in the GRWP, in line with the scenarios, strategies and action programmes outlined in the previous sections. It also summarises the overall cost of management, taking into account past costs incurred.

The global costs of management are assessed as the sum of those corresponding to various activities, grouped into the following lines of action: management of very low-level waste (VLLW) and low- and intermediate-level waste (LILW), management of spent fuel (SF), high-level waste (HLW) and special waste (SW), the closure of facilities, other actions and R&D, and Enresa's structural costs.

The management costs from 1985 to 2023 (2023 is estimated) are separated from future costs (2024-2100), with the latter being disaggregated through the application of distribution coefficients by producer. From a practical perspective, Enresa distinguishes between short-/medium-term costs, obtained from the updating of Enresa's corresponding budget for those years, regularly reviewed and overseen, and long-term costs, evaluated either based on extrapolations of current data (low- and intermediate-level waste (LILW) management, R&D, structural) or on Enresa's own estimates based on specific studies conducted (temporary storage facilities, Deep Geological Repository (DGR) and the decommissioning of nuclear power plants). Future costs include activities related to the decommissioning and final sealing of the Deep Geological Repository (DGR), as well as institutional monitoring.

Next, the costs incurred from 1985 to December 2023 (2023 is estimated) and the anticipated future costs of management are defined and detailed for each line of action or basic concept, as the sum of the corresponding stages from their removal to their final storage, in the case of radioactive waste (RW), or the activities involved, for the rest.

10.1. Costs of the management of very low-level waste low- and intermediate-level waste

The management of low- and intermediate-level waste (LILW) is subdivided into five sections described below, including those related to very low-level waste (VLLW) and low- and intermediate-level waste (LILW).

- Preliminary management

  This encompasses all management activities before the arrival of very low-level waste (VLLW)/low- and intermediate-level waste (LILW) at El Cabril Disposal Facility, including inventory and acceptance of radioactive waste (RW), the planning of the removal, characterisation and verification of the quality of packages, programmes to reduce the volume of radioactive waste (RW) from nuclear power plant operations at source, and the transportation of very low-level waste (VLLW)/low- and intermediate-level waste (LILW) from producers to treatment centres or final management. The only exception to these activities, as regards their location, is the quality verification carried out in the laboratories at El Cabril Disposal Facility.

- Final management

  This is the core activity of management, which includes the treatment, conditioning and final disposal of waste at El Cabril Disposal Facility. Treatment considers the physical and chemical processes to which waste is subjected to reduce its volume and/or incorporate it into a stable solid matrix (incineration, compacting, immobilising, melting, etc.), conditioning takes into account the production of disposal units (basically the manufacture of containers and their sealing), and storage includes the construction of cells or disposal systems, the placement of disposal units in them, the closure and final covering of storage areas, as well as institutional monitoring after the facility’s closure.

- Support services

  This heading includes all activities that directly or indirectly complement the activities of the previous section, i.e. operation and maintenance of facilities other than final management (including temporary storage facilities), physical protection and administration of the disposal centre, radiological and environmental protection, as well as personnel costs at El Cabril Disposal Facility.

- Allocations to municipalities

  These are payments derived from prevailing regulations for waste storage. Currently, these payments derive from Order IET/458/2015, of 11 March, regulating allocations to municipalities surrounding nuclear facilities, modified by Order TED/295/2023, of 23 March, charged to the Fund for the financing of GRWP activities, for municipalities surrounding El Cabril Disposal Facility, for the disposal of waste there.

- Ecological tax

  This section encompasses historical costs for the tax under Law 12/2006 of 27 December, on complementary taxation of the budget of the Autonomous Region of Andalusia, and payments to be made for the tax in compliance with Law 15/2012, of 27 December, on fiscal measures for energy sustainability, for the storage of very low-level waste (VLLW) and low- and intermediate-level waste (LILW).

Next, the costs of managing very low-level waste (VLLW)/low- and intermediate-level waste (LILW) for the period 1985-2023 are presented below.

VLLW/LILW management	Cost at 31-12-2023 (thousands of €)	Cost at 31-12-2023 (thousands of € 2023)
Preliminary management	150,143	211,848
Final management	360,423	590,943
Support services	446,451	636,403
Municipal allocations	74,090	104,328
Ecological tax	125,430	148,233
Total	1,156,536	1,691,754

Table 19. Costs of managing very low-level waste (VLLW)/low- and intermediate-level waste (LILW) for the period 1985-2023

The summary of the projected costs for the management of very low-level waste (VLLW)/ low- and intermediate-level waste (LILW), in thousands of euros at 2023 values (thousands of euros 2023), for the period 2024-2100, is presented below.

VLLW/LILW management	Projected cost (thousands of € 2023)
Preliminary management	249,840
Final management	703,166
Support services	716,892
Municipal allocations	230,709
Ecological tax	723,098
Total	2,623,704

Table 20. Projected costs of very low-level waste (VLLW)/low- and intermediate-level waste (LILW) management for the period 2024-2100

The summary of the projected costs for the management of very low-level waste (VLLW)/ low- and intermediate-level waste (LILW), in thousands of euros at 2023 values (thousands of euros 2023), for the period 1985-2100 is presented below.

VLLW/LILW management	Projected cost (thousands of € 2023)
Preliminary management	461,687
Final management	1,294,109
Support services	1,353,294
Municipal allocations	335,037
Ecological tax	871,331
Total	4,315,459

Table 21. Total costs of very low-level waste (VLLW)/low- and intermediate-level waste (LILW) management for the period 1985-2100

10.2. Costs for the management of spent nuclear fuel, high-level waste and special waste

The costs of this line of action are broken down as follows:

- Preliminary management

  This includes the inventory of the spent fuel (SF), studies, programming and monitoring of generic projects, characterisation, high-level waste (HLW) management optimisation projects and the future transport of spent fuel (SF) and vitrified waste to the Deep Geological Repository (DGR).

- Temporary storage

  This refers to the replacement of racks in the nuclear power plant pools, the design, construction and operation of the temporary storage facilities at nuclear power plants (NPPs), the emptying of the spent fuel (SF) of the nuclear power plant pools and all costs related to the licensing, construction, operation and decommissioning of the facilities necessary to fulfil the recoverability function at the fuel assembly level and to perform the functions of inspection and characterisation of the fuel and the radioactive waste (RW).

- Reprocessing

  This includes all costs related to the reprocessing in France of the spent fuel (SF) from Vandellós I NPP and in the United Kingdom of part of the spent fuel (SF) from Santa María de Garoña NPP, shipped at the start of the 1980s.

- Final management

  This includes everything related to the final disposal of spent fuel (SF) and high-level waste (HLW), i.e. site selection and characterisation, design, construction, operation, closure, sealing and institutional monitoring of the necessary facilities (DGR), as well as the monitoring of new technological developments.

- Allocations to municipalities

  These are the payments derived from the regulations in force for the storage/disposal of waste. Currently, these payments are derived from Order IET/458/2015, of 11 March, modified by Order TED/295/2023, of 23 March, for municipalities in the area surrounding the nuclear facilities for the temporary storage of spent fuel (SF), high-level waste (HLW) and special waste (SW).

- Ecological tax

  This is the tax payable by Enresa in compliance with Law 15/2012, of 27 December, for the centralised storage of spent fuel (SF), high-level waste (HLW) and special waste (SW).

The costs of managing spent fuel (SF)/high-level waste (HLW)/special waste (SW) for the period 1985- 2023 are presented below.

SF/HLW management	Cost at 31-12-2023 (thousands of €)	Cost at 31-12-2023 (thousands of € 2023)
Preliminary management	10,836	13,081
Temporary storage	852,831	1,071,193
Reprocessing	879,783	1,463,329
Final management	113,258	237,982
Allocations to municipalities	636,490	915,525
Ecological tax	0	0
Total	2,493,197	3,701,110

Table 22. Costs of spent fuel (SF)/high-level waste (HLW)/special waste (SW) management for the period 1985-2023

The summary of the spent fuel (SF)/high-level waste (HLW)/special waste (SW) management costs for the period 2024-2100 is presented below:

SF/HLW management	Cost forecast (thousands of € 2023)
Preliminary management	86,501
Temporary storage	4,551,053
Reprocessing	34,171
Final management	4,097,683
Allocations to municipalities	1,505,935
Ecological tax	554,127
Total	10,829,470

Table 23. Expected costs of spent fuel (SF)/high-level waste (HLW)/special waste (SW) management for the period 2024-2100

The following table summarises the total costs of the management of spent fuel (SF)/high-level waste (HLW)/special waste (SW), in thousands of euros 2023, for the period 1985-2100.

SF/HLW management	Total cost (thousands of € 2023)
Preliminary management	99,582
Temporary storage	5,622,246
Reprocessing	1,497,500
Final management	4,335,665
Allocations to municipalities	2,421,460
Ecological tax	554,127
Total	14,530,580

Table 24. Total costs of spent fuel (SF)/high-level waste (HLW)/special waste (SW) management for the period 1985-2100

10.3. Costs of decommissioning and closure of facilities

In relation to the decommissioning and closure of nuclear facilities, the following items have been differentiated by type of facility:

- Decommissioning and closure of nuclear power plants (NPPs)

  These are the costs relating to the studies, preparatory activities and execution of the decommissioning of all Spanish nuclear power plants (NPPs) (including the complementary activities for their development), as well as the latency of Vandellós I NPP, without considering the final management of radioactive waste (RW) generated during decommissioning.

- Decommissioning and closure of facilities in the 1st part of the nuclear fuel cycle (NFC)

  This refers to the future decommissioning of the Juzbado fuel assembly factory, without including the management of the radioactive waste (RW) generated, the restoration and monitoring of former uranium mines, and the decommissioning and monitoring of Uranium concentrate plants (FUA, La Haba and Saelices el Chico) in accordance with the participation established in the agreements subscribed with Enusa for the facilities under its ownership.

- Decommissioning and closure of other facilities

  This refers to the Integrated Plan for the improvement of CIEMAT facilities (PIMIC Project).

- Allocations to municipalities

  This consists of payments to the municipalities in the vicinity of the nuclear power plants (NPPs) being decommissioned, currently, those derived from Order IET/458/2015, of 11 March, modified by Order TED/295/2023, of 23 March.

The decommissioning and closure costs for the period 1985-2023 are presented below.

Closure	Cost at 31-12-2023 (thousands of €)	Cost at 31-12-2023 (thousands of € 2023)
Closure of NPPs	564,293	735,146
Closure of 1st part NFC of facility	130,423	218,949
Closure of other facilities	35,436	48,145
Allocations to municipalities	16,064	20,615
Total	746,216	1,022,854

Table 25. Decommissioning and closure costs of facilities for the period 1985-2023

The decommissioning and closure costs for the period 2024-2100 are presented below:

Closure	Forecast cost (thousands of € 2023)
Closure of NPPs	4,630,288
Closure of 1st part NFC of facility	41,398
Closure of other facilities	7,221
Allocations to municipalities	86,066
Total	4,764,973

Table 26. Projected costs of decommissioning and closure of facilities for the period 2024-2100

The following table summarises the total decommissioning and closure costs in thousands of euros in 2023 for the period 1985-2100.

Clausura	Total cost (thousands of € 2023)
Closure of NPPs	5,365,433
Closure of 1st part NFC of facility	260,346
Closure of other facilities	55,366
Allocations to municipalities	106,681
Total	5,787,827

Table 27. Total costs of decommissioning and closure of facilities for the period 1985-2100

10.4. Costs of other actions

This item includes the management of atypical waste (radioactive lightning rods, orphan sources, etc.), interventions due to incidents (including the treatment at El Cabril Disposal Facility of the radioactive waste (RW) generated in such incidents), as well as support for the operating system in emergencies.

10.5. R&D and structural costs

R&D projects and structural costs must be added to the four lines or items described above. R&D is associated with the aforementioned lines of action (decommissioning, commissioning and closure) and is derived from the corresponding Enresa R&D Plans, drawn up in close relation to the EU Framework Programmes. Structural costs refer to those of Enresa's head offices and those not attributable, in principle, to any of the items described above, corresponding to management, international relations, administrative or technical tasks of a horizontal nature, as well as personnel costs at Enresa's headquarters in Madrid.

10.6. Summary of management costs

The following is a summary of the costs of the six lines of action for the period 1985-2023.

Total cost	Cost at 31-12-2023 (thousands of €)	Cost at 31-12-2023 (thousands of € 2023)
VLLW/LILW management	1,156,536	1,691,754
SF/HLW management	2,493,197	3,701,110
Closure	746,216	1,022,854
Other actions	39,183	65,383
R&D	178,326	298,778
Structural	781,486	1,156,002
Total	5,394,945	7,935,881

Table 28. Summary of costs for the period 1985-2023

The summary of the future costs of the six basic items for the period 2024-2100 is presented below:

Total cost	Forecast cost (thousands of € 2023)
VLLW/LILW management	2,623,704
SF/HLW management	10,829,470
Closure	4,764,973
Other actions	14,548
R&D	336,922
Structural	1,650,317
Total	20,219,933

Table 29. Summary of projected costs for the period 2024-2100

From the above values, it can be seen that the management of the spent fuel (SF)/high-level waste (HLW) entails the highest future cost, in the order of 54%.

The following table summarises the total management costs in thousands of euros in 2023 for the period 1985-2100.

Total cost	Total cost (thousands of € 2023)
VLLW/LILW management	4,315,459
SF/HLW management	14,530,580
Closure	5,787,827
Other actions	79,931
R&D	635,699
Structural	2,806,319
Total	28,155,815

Table 30. Total costs for the period 1985-2100

The comparison between the 6th GRWP and the final version of the 7th GRWP is presented below.

Total cost (thousands of € 2023)	6th GRWP	7th GRWP	Difference	%
VLLW/LILW management	2,250,416	4,315,459	2,065,043	92%
SF/HLW management	8,639,140	14,530,580	5,891,441	68%
Closure	3,617,394	5,787,827	2,170,433	60%
Other actions	75,847	79,931	4,084	5%
R&D	496,380	635,699	139,320	28%
Structural	2,937,520	2,806,319	-131,201	-5%
Total	18,016,697	28,155,815	10,139,118	56%

Table 31. Comparison of total costs for the period 1985-2100

The future cost structure is depicted in Figure 22.

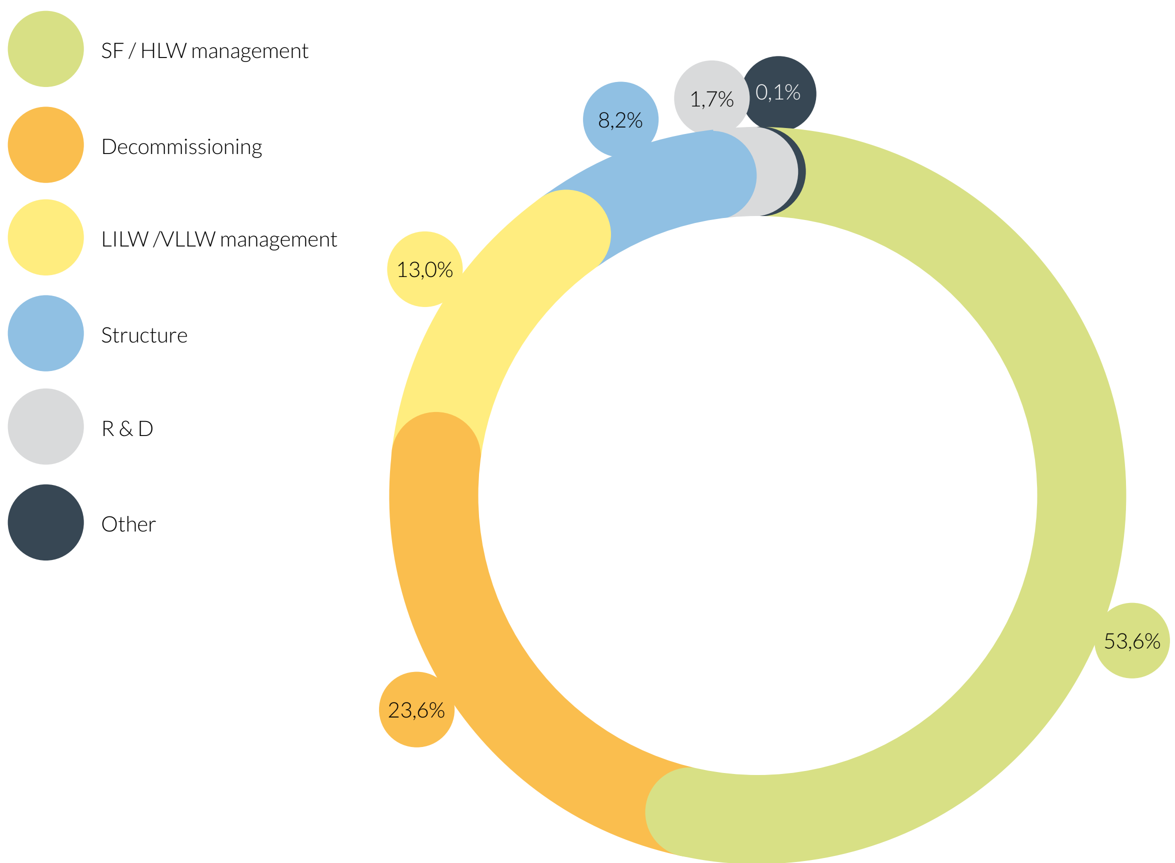

Figure 22. Structure of future management costs by main items

The distribution of costs in the period 2024-2100 for the different items considered, whose profile is in line with the execution and economic value of the programmes and actions envisaged, is presented in Figure 23.

Evolution of management costs since 2024

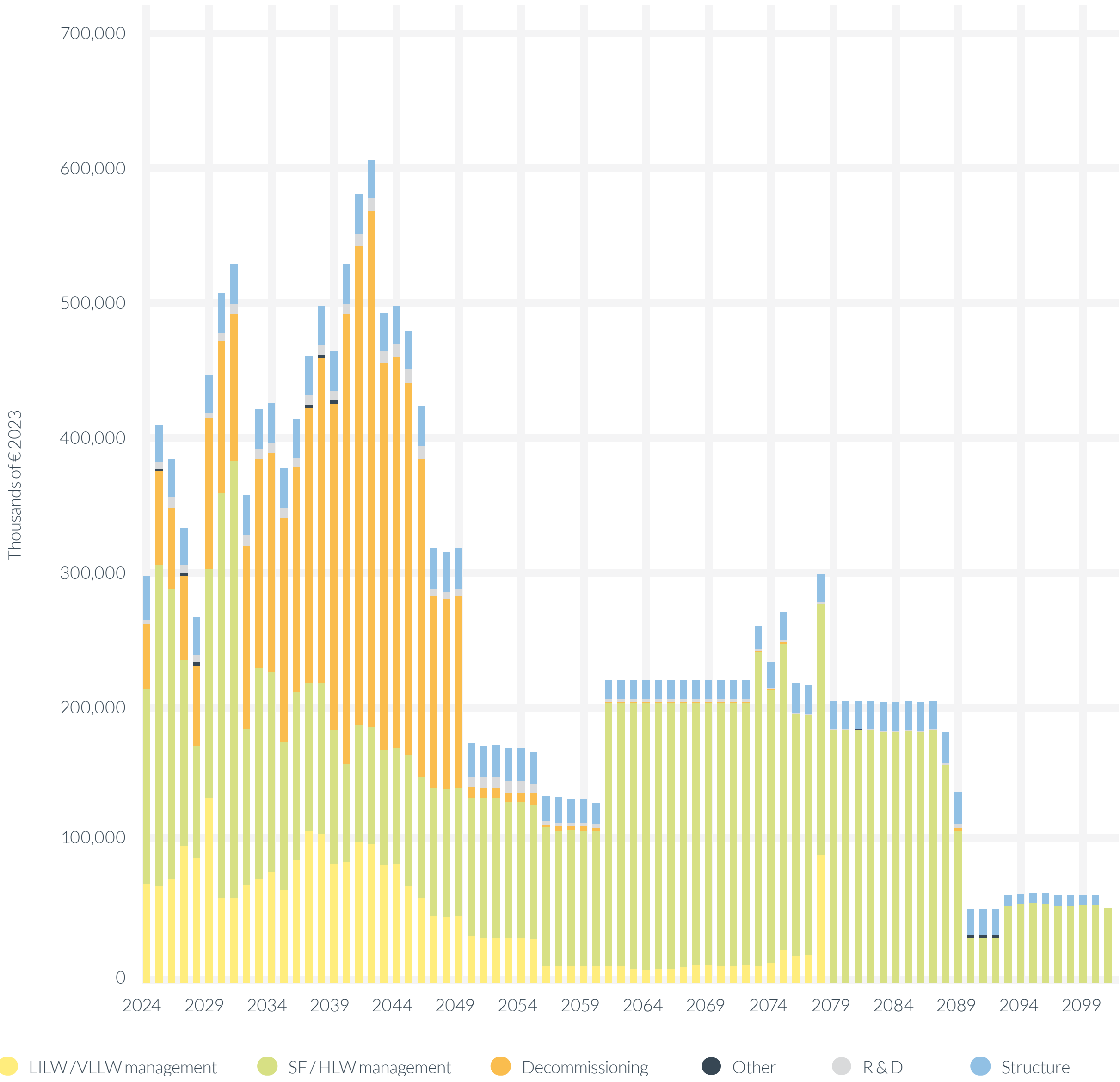

Figure 23. Distribution of future management costs over time

Enresa, as part of its obligations under Royal Decree 102/2014, of 21 February, for the responsible and safe management of spent fuel (SF) and radioactive waste (RW), submits an updated economic-financial report to MITECO each year on the costs and income of the activities provided for in the GRWP.

11

11. Resources and financing regime

The resources required to carry out the Plan's activities are, on the one hand, the human resources corresponding to Enresa's staff and the necessary hiring of material resources and services for the execution of the projects and, on the other, the financial resources required to cover project costs.

The medium-term human resources requirements are included in the company's multi-year plans and the financing regime is described in Section 11.2.

11.1. Resources required to implement the Plan

For the development of the activities set out in this Plan, all public and private agents involved in these activities must equip themselves with the necessary human and material resources and capacities sufficiently in advance.

Enresa, as the public enterprise in charge of managing radioactive waste (RW), spent fuel (SF) and the decommissioning and closure of nuclear facilities, is responsible for compliance with the objectives, strategies and activities established in this Plan regarding their scope and timelines. In order to perform this undertaking, it must have staff that will need to be configured and adjusted according to the planning of tasks and projects in the short-, medium- and long-term, in response to the needs foreseen at any given time, requiring the continuous hiring of its human resources.

In addition to the basic workforce, Enresa will provide itself with the human resources required to meet its objectives. Prior to the start of each major project or new activity, the resources required for its execution will be estimated based on the development of plans and detailed organisational charts of profiles and roles. Subsequently, their availability within the current basic workforce will be reviewed, together with the training and qualification needs that may be required, and in the event of non-availability, new incorporations will be planned.

This estimate of new incorporations will be made sufficiently in advance and their formalisation will be included in Enresa's human resources management plans. Likewise, training and qualification requirements will be defined and integrated into the company's different training plans, according to the needs identified by each department.

Current estimates of Enresa's human resources indicate that some 12 people will be required for the operation of each of the temporary storage facilities located at the nuclear power plant sites, and around 125 for the DGR, considering in both cases the resources at headquarters and the facilities themselves.

As regards the need for Enresa resources to carry out the decommissioning and closure of a nuclear power plant, this has been estimated at around 35 people, taking into account the resources at headquarters and at the facility. In the case of sites with two reactors to be decommissioned, current estimates indicate that 15 additional people will be required. Likewise, the operation of El Cabril Disposal Facility will require three additional people for each decommissioning underway.

Furthermore, the provision of material resources (materials, equipment, consumables, etc.) and services (engineering, consultancy, support, etc.) are managed within the projects and planned activities themselves. Their contracting is framed within the Public Sector Contracts Act and the corporate procurement policy.

11.2. Fund for the financing of GRWP activities

The radioactive waste (RW) and spent fuel (SF) management system, including the decommissioning and closure of nuclear facilities, has a financing system based on the principle of "polluter pays", which relies on allocations to the so-called "Fund for the financing of GRWP activities" (hereinafter, the Fund), in accordance with the provisions of the Sixth Additional Provision of the Electricity Sector Act 54/1997, of 27 November.

The aforementioned Sixth Additional Provision was extensively amended by Law 11/2009 of 26 October regulating Listed Property Market Investment Companies, which established a financing system based on four fees according to the type of producers or services. Since that legal amendment, which came into force on 1 January 2010, the Fund has been endowed by means of income from the fees indicated below, including the financial returns generated by them. The Public Sector Contracts Act 9/2017, of 8 November, in its Eleventh Final Provision, modifies the First Additional Provision of the General Taxation Act 58/2003, of 17 December, in such a way that the fees for financing the activities of the General Radioactive Waste Plan (GRWP) now have the legal nature of non-tax public economic contributions.

- **Non-tax public economic percentage on network tariffs:** this constitutes the means of financing the costs corresponding to the management of the radioactive waste (RW) and spent fuel (SF) generated at the nuclear power plants (NPPs) whose operation has definitively ceased before 1 January 2010, as well as to their decommissioning and closure, those future costs corresponding to the nuclear power plants (NPPs) or fuel assembly factories which, after their operation has definitively ceased, were not foreseen during said operation, and those which, where appropriate, may arise from the early cessation of facility operations for reasons beyond the licensee's intentions.

  Also included in this contribution are the amounts intended to endow the part of the Fund for the financing of the costs of radioactive waste (RW) management from those research activities that MITECO determines to have been directly related to the generation of nuclear power, the decommissioning and closure operations to be carried out as a consequence of the mining and production of uranium concentrates prior to 4 July 1984, the costs deriving from the reprocessing of spent fuel (SF) sent abroad prior to the entry into force of the law establishing this and such other costs as may be specified by Royal Decree.

  The Sixth Additional Provision of Law 54/1997 establishes the rate of taxation on the total income derived from the application of the fees referred to in this law.

- **Non-tax public economic contribution relating to operating nuclear power plants (NPPs):** this is the means by which all costs incurred as of 1 January 2010, corresponding to the management of the radioactive waste (RW) and spent fuel (SF) generated at operational nuclear power plants (NPPs), will be financed by the licensees of the nuclear power plants (NPPs) during their operation, regardless of the date of their generation, as well as those corresponding to their decommissioning and closure.

  Likewise, the licensees of the nuclear power plants (NPPs) will finance the allocations earmarked for the municipalities affected by nuclear power plants (NPPs) or storage facilities for spent fuel (SF) and radioactive waste (RW), under the terms established by MITECO, as well as the amounts corresponding to the taxes accrued in relation to spent fuel (SF) and radioactive waste (RW) storage activities, regardless of their date of generation.

  The fee payable by each of the nuclear power plants (NPPs) during the operation of the facility is the result of multiplying the gross nuclear electricity generated, measured in kWh and rounded down to the nearest whole number, by the fixed unit tariff and the corrective coefficient applicable in accordance with the scale defined in the Sixth Additional Provision of Law 54/1997.

- **Non-tax public economic contribution relating to the Juzbado fuel assembly factory:** this covers the provision of radioactive waste (RW) management services derived from the production of the fuel assembly, including the decommissioning of fuel assembly facilities. The Sixth Additional Provision of Law 54/1997 establishes the rate of taxation on the volume of nuclear fuel produced each year.

- Non-tax public economic contribution relating to other facilities: this covers the provision of radioactive waste (RW) management services generated at facilities other than those indicated above, such as radioactive facilities (medicine, industry, agriculture and research), CIEMAT or other companies. All of them are directly charged the costs at the time the services are provided. The fee payable by the facilities is the result of multiplying the volume or unit of waste delivered for management by the tax rates defined in the Sixth Additional Provision of Law 54/1997.

The allocations to the Fund may only be used to finance the actions provided for in the GRWP and, at the end of the period of management of the radioactive waste (RW) and decommissioning of the facilities established in the GRWP, the total amounts paid into the Fund, through the different financing channels, should cover the costs incurred in such a way that the final balance resulting therefrom is zero.

The economic-financial study that Enresa submits to MITECO during the first half of each year includes an update of the costs of the activities established in the GRWP in force, as well as an analysis of the adaptation of the elements that make up the quotas relating to the four economic contributions through which the Fund is financed to these costs.

The calculation of income, which will be obtained through the economic contributions, is based on the outstanding collection, i.e. the difference between the present value of the future costs, discounted at a rate of 1.5%, attributable to each economic contribution, and the fund available for each one. Obtaining the future cost attributable to each economic contribution involves apportioning the costs by producers or services provided that make up the management thereof. The value of the discount rate may be updated by a resolution of the Secretary of State for Energy, based on the economic-financial study that Enresa submits to MITECO during the first half of each year.

Pursuant to the Law, the tax rates and tax elements to determine the amount of these economic contributions may be revised by the Government by Royal Decree, based on an updated economic-financial study of the cost of the corresponding activities. The fees set by the aforementioned Law 11/2009, of 26 October, are currently in force, with the exception of the economic contribution relating to other facilities, which was amended by the Sustainable Economy Act 2/2011, of 4 March, and the fixed unit tariff for the economic contribution relating to nuclear power plants (NPPs) in operation, which was amended by Royal Decree 750/2019, of 27 December.

The management of the Fund, which is the responsibility of Enresa, is governed by the principles of security, profitability and liquidity, and there is a Monitoring and Oversight Committee, attached to MITECO through the State Secretariat for Energy, which is responsible for the supervision, oversight and qualification of the transitory investments relating to the financial management of the Fund.

The diagram in Figure 24 provides an overview of the funding system for GRWP activities and the mechanisms for its oversight:

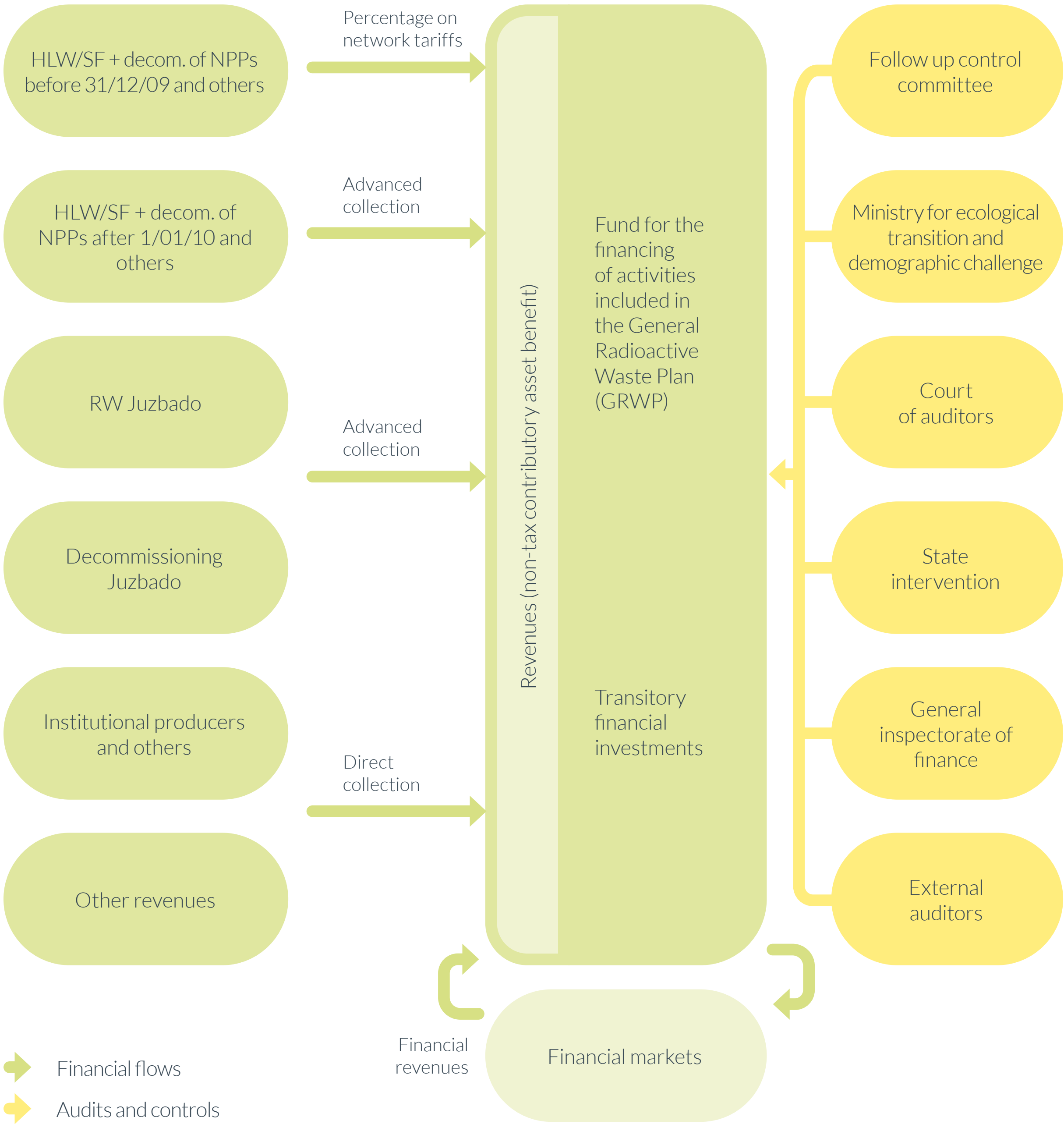

Figure 24. Funding scheme for GRWP activities

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12. Transparency and social responsibility policy

The implementation of the GRWP not only raises technical and financial, but also social and environmental issues. Activities related to nuclear energy are not always well understood and accepted by social sectors, sometimes due to a lack of knowledge and misinformation, and sometimes due to the nature of the activities themselves. Hence the importance of the communication and participation of society, as well as Corporate Social Responsibility (CSR), in the implementation of the GRWP.

12.1. Information and public participation

12.1.1. Implementing legislation on public information and participation

The right of the public to access environmental information is regulated by Law 27/2006, of 18 July, regulating the rights of access to information, public participation and access to justice in environmental matters (incorporating Directives 2003/4/EC and 2003/35/EC), a right that is reinforced by Law 19/2013, of 9 December, on transparency, access to public information and good governance. Both laws are, as the case may be, applicable to the scope of the activities of the GRWP, and the different agents involved in the GRWP are subject to these regulations, in particular the General Government, the CSN and Enresa.

For its part, public participation in decision-making in relation to radioactive waste (RW) management is provided for in both the aforementioned Law 27/2006, of 18 July, and in Law 21/2013, of 9 December, on environmental assessment.

Law 27/2006, of 18 July, regulates, inter alia, the rights of citizens to participate in an effective and real way in decision-making procedures on matters that directly or indirectly affect the environment, and whose preparation or approval corresponds to the General Government, such as the preparation, modification and review of those plans, programmes and provisions of a general nature related to the environment included in their scope of application.

For its part, Law 21/2013, of 9 December, establishes the bases that must govern the environmental assessment of plans, programmes and projects that may have a significant effect on the environment, guaranteeing a high level of environmental protection nationwide, to promote sustainable development.

As regards nuclear safety and radiation protection - areas of exclusive competence of the CSN - Law 15/1980, of 22 April, creating this Authority, which was extensively reformed in 2007 in line with the aforementioned Law 27/2006, of 18 July, regulates public information and participation by the CSN.

12.1.2. Transparency in the Plan’s activities

Social acceptance is a fundamental strategic component of the optimal development of radioactive waste (RW) management, and given that this management is framed within a sphere of personal risk perception that does not always obey scientific parameters, the credibility of the institutions involved in radioactive waste (RW) management plays a fundamental role in the adoption of the necessary decisions to carry out this management.

In this respect, it should be borne in mind that transparency is the basis for achieving this credibility, and effective public information must be guaranteed to all parties involved, including local authorities and society.

In this regard, the technical solutions developed within the scope of activities of the GRWP, the present reality and prospects concerning the management of radioactive waste (RW) must be accompanied by a dissemination effort to facilitate their understanding by society. All the agents involved, and Enresa in particular, will continue to focus their efforts on the dissemination of their activities and projects through different information channels and media.

Local and regional authorities that may be involved in decision-making will always play a leading role in the context of voluntary participation, transparency of information and dialogue and the open participation of their citizens.

The characteristics of Enresa’s activities therefore require a strong social involvement, with openness and transparency and a significant commitment to communication with society in general and the areas where it carries out its activities in particular, so that the function and guarantees offered by its management can be clearly perceived. For this reason, each of the company’s work centres has an information area where the public can learn first-hand about the characteristics of the materials to be managed, as well as the technology and experience

Enresa has for safe management. The information areas will be updated when technological advances or the development of Enresa's activities so warrant.

In order to contribute to the aforementioned transparency and reuse of information, Enresa will offer the data relating to its activity that the regulations allow, in open and reusable formats, through public open data portals such as datos.gob.es or its own portal.

In addition, one of Enresa's key tools is its website, a portal aimed at experts in the sector, journalists, students and lay users. Furthermore, this dissemination activity is also carried out through publications, audiovisuals and collaborations with museums, exhibitions and other channels and areas, adapting to new forms of communication. Enresa has its own Transparency Portal on the corporate website, in accordance with Law 19/2013, of 9 December.

For its part, the General State Administration has its own Transparency Portal, also regulated by Law 19/2013, of 9 December, and in the field of transparency, it has its own Transparency Portal, regulated by Law 19/2013, of 9 December.

The Ministry for the Ecological Transition and Demographic Challenge reports on its website not only regarding general issues and actions, but particularly on draft regulations that must be submitted for public information and consultation in accordance with applicable regulations, or regarding those projects or plans and programmes that must be submitted for environmental assessment.

Likewise, in the application of its transparency policy, one of the main instruments used by the CSN is its website, which it employs to provide information on its activities, regulatory projects, etc. It is also present on social media. Furthermore, since 2010, an Advisory Committee for information and public participation has been in operation, responsible for issuing recommendations to guarantee and enhance transparency, as well as proposing measures to encourage access to information and public participation in matters within the CSN's scope of competence.

12.2. Corporate Social Responsibility

Different institutional initiatives at a European and national level have highlighted the vital importance of CSR actions for companies and public authorities. Accordingly, CSR must be identified as a vehicle for competitiveness, sustainability and social cohesion, lending importance to shared value and establishing trust in the long term through the integration and management of risks and opportunities derived from economic, social and environmental development.

Enresa's CSR consists of a vision of how to manage the company, taking into account the impacts that its activity generates on its customers, employees, shareholders, local communities and the environment, in other words, on society in general and its surroundings. This not only implies compliance with national regulations, such as Order IET/458/2015, of 11 March, regulating allocations to municipalities in the vicinity of nuclear facilities, as amended by Order TED/295/2023, of 23 March, charged to the Fund for the financing of GRWP activities, and international regulations, at a social, employment, environmental and human rights level, but also other types of voluntary actions that the enterprise undertakes, through its conviction of the need to promote business initiatives and social action in projects that benefit the groups and stakeholders identified, for these purposes, as a preferential action by the company.

Accordingly, the strategic lines to be followed are directly related to environmental sustainability, improving knowledge of Enresa's activity, contributing to the economic and social development of the municipalities in the areas of influence of the nuclear facilities, in particular the facilities owned by Enresa, excellence in radioactive waste (RW) management (fostering R&D in radioactive waste (RW) management, promoting training and the transfer of knowledge, etc.), and promoting CSR and its integral cross-cutting management, good governance and transparency.

Enresa, as a public enterprise, works to comply with the roadmap of the international community and national strategic lines in the challenge of collaborating in the construction of a more certain, supportive and sustainable future for people and the environment, adopting the necessary measures within the scope of its management to combat the main problems of the planet within the framework of the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs), adopted in 2015 by the United Nations.

Enresa develops specific plans, which firm up the actions to be implemented within the framework of the strategic lines indicated and the SDGs.

Future projects deriving from the implementation of the Plan will consider the strategic measures for environmental integration, the preventive, corrective and compensatory measures defined in the EsAE, as well as the environmental determinations included in the DAE, as a result of the consultations, allegations and the technical analysis carried out by this environmental body, without prejudice to the measures and recommendations included in the strategic environmental study.

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13. Agreements with Member States and third countries on radioactive waste and spent nuclear fuel management

Spain currently has no agreements in force with third countries on the management of radioactive waste (RW) or spent fuel (SF), although an agreement is still in force with a Member State of the European Union – France – as a result of the reprocessing in that country of spent fuel (SF) from Vandellós I NPP, which it was decided to reprocess for technical reasons, by means of a contract signed between Hifrensa, as the operator of the nuclear power plant, and Cogema (subsequently Areva and currently Orano), as the French company in charge of the reprocessing.

This required an agreement between Spain and France on the radioactive waste (RW) resulting from reprocessing, in the form of an exchange of letters in 1989. Under this agreement, the Government of Spain undertook not to take any initiative that might prevent Cogema from returning the resulting radioactive waste (RW) to Spain, and to facilitate such return. For its part, the Government of France undertook not to take any initiative that might impede the performance of the contract between the companies. Enresa, which became licensee of the nuclear power plant in 1998 in order to undertake its decommissioning, subrogated Hifrensa's position in the aforementioned contract in 2001.

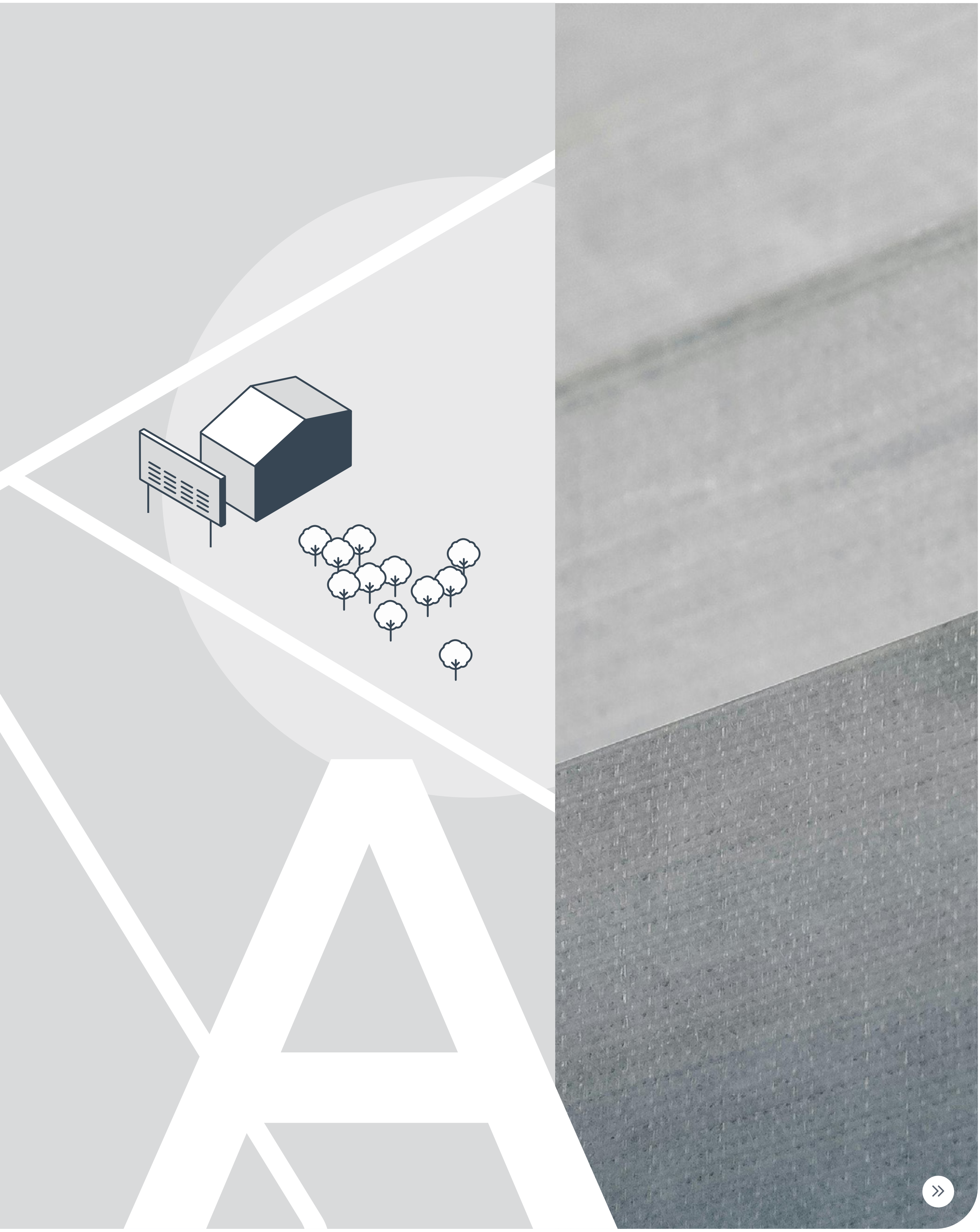
The purpose of the contract was the closure of the reprocessing activities of cores I, II and III of Vandellós I NPP, with the return to Spain of the radioactive waste (RW) generated in the reprocessing of core III, and the transfer of ownership of the uranium and plutonium resulting from the reprocessing to France. As a result of subsequent negotiations between Enresa and Areva, the clauses were modified. Thus, during 2012, the contract was amended, resulting in a commitment to return three types of radioactive waste (RW) to Spain: vitrified high-level waste (HLW), vitrified intermediate-level waste and compacted technological intermediate-level waste, in which a significant reduction in the corresponding volumes was achieved.

In accordance with the Spanish strategy, the waste returned by France will be managed in a storage facility at Vandellós I NPP prior to its transfer to the DGR. The aforementioned contract establishes a daily bond for failure to comply with the deadlines established for the return of radioactive waste (RW). The bonds began to be applied on 1 July 2017 and will be returned when the radioactive waste (RW) returns to Spain.

Furthermore, in 1974, the company Nuclenor, operator of the Santa María de Garoña NPP, signed a contract, subsequently renegotiated on several occasions, with the company British Nuclear Fuel Limited (BNFL), in charge of the British reprocessing facilities, for the treatment of the spent fuel (SF) corresponding to the first operating cycles of this nuclear power plant, which was sent to Sellafield (United Kingdom) at that time.

The contract between Nuclenor and BNFL, which did not require any agreement between States, did not provide for the return of the radioactive waste (RW) resulting from reprocessing to Spain, although it did provide for the fissile materials obtained (uranium and plutonium) to be made available to the Spanish company. As a result of the implementation of this agreement, BNFL and its successor - the Nuclear Decommissioning Agency (NDA) - made the corresponding volumes available to Nuclenor.

While the ownership of the uranium resulting from the reprocessing was transferred to the international market, the same did not happen with the resulting plutonium, which remained stored in the UK. Negotiations between Nuclenor, the NDA and Enresa concluded in early 2017 with an agreement to transfer ownership of this material to the British company, which became its owner.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Appendix: glossary of acronyms and abbreviations

A glossary of the most commonly-used acronyms and abbreviations is presented below, in alphabetical order.

ALLIANCE	"European Radioecology Alliance" Research platform to promote research in radioecology.
Areva	French group specialised in the nuclear and renewable energy sector. Created from the merger of, among others, CEA ("Commissariat à l'énergie atomique") -Industrie, Cogema ("Compagnie générale des matières nucléaires"), Framatome. Currently Orano.
ARs	Autonomous Regions.
ARTEMIS	"Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation".
BWR	Boiling Water Reactor.
CA El Cabril	Name given to the El Cabril Disposal Facility in Sierra Albarrana (Cordoba).

CEIDEN	Technology Platform for Nuclear Fission Energy.
CIEMAT	the Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas is the Spanish Centre for Energy-Related Environmental and Technological Research.
CSN	Nuclear Safety Council.
CSR	Corporate Social Responsibility.
CTS	Centralised Temporary Storage for spent fuel (SF) and high-level waste (HLW) from all nuclear power plants (NPPs) and other sources.
DGR	Deep Geological Repository.
DTS	Decentralised Temporary Storage facility for spent fuel (SF) and high-level waste (HLW) from a nuclear power plant, which will have all the safety and auxiliary systems required to be able to operate as an independent nuclear facility once the plant has been declared decommissioned. In addition to the storage facilities, it will have a complementary installation or additional measures required for the maintenance and repair of its casks, equipped with the material and auxiliary and safety systems required to allow for the recovery of normal design conditions in the event of anomalous events.
€	Euro.
EC	European Commission.
EFF	Economic and Financial Study.
EJP Concert	"European Joint Programme for the Integration of Radiation Protection Research".
Enresa	Empresa Nacional de Residuos Radiactivos, S.A., S.M.E. constituted by Royal Decree 1522/1984, of 4th July, with a view to its undertaking the management of radioactive waste in SPAIN.
ENSA	Equipos Nucleares, S.A., S.M.E. is a multisystem supplier of nuclear components. It was founded on July 10th1973 to satisfy the demand of the Spanish nuclear civil program pertaining to the manufacturing of large nuclear components.
Enusa	Enusa Industrias Avanzadas, S.A., S.M.E. is a public company owned by SEPI and CIEMAT. It´s purpose is to develop innovative nuclear and environmental solutions at a global level, contributing to the sustainable progress of society".

EU	European Union.
EURADOS	European Radiation Dosimetry Group.
Euratom	European Atomic Energy Community.
FUA	Andújar Uranium Mill.
GRWP	General Radioactive Waste Plan.
IAEA	International Atomic Energy Agency.
IGD-TP	"Implementing Geological Disposal of radioactive waste Technology Platform".
INLA	International Nuclear Law Association.
IRRS	Integrated Regulatory Review Service.
ITS	Individualised Temporary Storage facility for spent fuel (SF) and high-level waste (HLW) from a nuclear power plant (NPP).
JOPRAD	"Towards a Joint Programming on Radioactive Waste Disposal".
LWR	Light Water Reactor.
MELODI	Multidisciplinary European Low Dose Initiative.
MITECO	Ministry for Ecological Transition and Demographic Challenge.
MWe	Megawatts of electricity. Unit of power = 10^6 watts.
NEA	Nuclear Energy Act 25/1964, of 29 April 1964.
NEA	Nuclear Energy Agency of the OECD.
NERIS	"European Platform on preparedness for nuclear and radiological emergency response and recovery".
NFC	Nuclear fuel cycle.
NORM	Naturally Occurring Radioactive Material.
NPP	Nuclear power plant.
NPPs	Nuclear power plants.

OECD	Organisation for Economic Co-operation and Development.
PEPRI	National R&D Platform in Radiological Protection.
PIMIC	Integrated Plan for the Improvement of CIEMAT Facilities.
PLABEN	Basic Nuclear Emergency Plan (national in nature and scope).
PNIEC	National Integrated Energy and Climate Plan.
PWR	Pressurised Water Reactor.
R&D	Research and Development.
RAA	High-level waste (HLW).
RBBA	Very low-level waste (VLLW).
RBMA	Low- and intermediate-level waste (LILW).
RE	Special waste (SW).
SF	Spent nuclear fuel.
SSP	Site Search Plan
SNE-TP	European Sustainable Nuclear Energy Technology Platform.
VVER	"Water-Cooled Water-Moderated Power Reactor".

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