

RADIOACTIVE WASTE MANAGEMENT AND DECOMMISSIONING IN SPAIN

1. NATIONAL FRAMEWORK FOR MANAGEMENT AND REGULATION OF RADIOACTIVE WASTE AND DECOMMISSIONING

1.1 National framework

1.1.1 Overview of national policy

Nuclear fuel cycle

Roughly 20% of the Spanish electricity production is provided by seven nuclear reactors, totalling 7,400 MWe. Six of these facilities are pressurized water reactors (Almaraz I&II, Ascó I&II, Vandellós II and Trillo I) while the seventh (Cofrentes) is a boiling water reactor. In the past there were also in operation three more power plants (José Cabrera, Vandellós I and Garoña) totalling 1,160 MWe which were shut-down and are currently at different phases of decommissioning.

Radioactive waste is produced by the above mentioned plants, by a nuclear fuel manufacturing facility (350 tU/year) and by some 800 institutional producers. For many years, Spain mined uranium ores and had three conversion plants. Nowadays, all these plants are closed.

Reprocessing is not considered an option for the nuclear fuel cycle, although in the past the spent fuel from Vandellós I (a graphite-gas cooled reactor) was sent to France for this purpose as well as some small amounts of spent fuel (SF) from Garoña. Presently, all spent fuel is currently considered a radioactive waste.

Spanish policy is to handle radioactive waste “from cradle to grave”, looking for a safety level that prevents any harm to people and the environment both today and in the future.

The main piece of legislation setting the principles for radioactive waste management is the Nuclear Act 25/1964, of 29th April, as subsequently amended. Spain is a party to the Joint Convention on the safety of spent fuel management and the safety of radioactive waste management. Spain is also a member of the European Union so EURATOM legislation as well as European Directives and regulations are national legislation.

The General Radioactive Waste Plan (GRWP)

The Spanish policy and strategy concerning spent fuel, radioactive waste management and decommissioning of nuclear power plants is periodically announced in the General Radioactive Waste Plan (GRWP). The GRWP is a document adopted by the Government which sets out the main courses of action, the timeframe for implementation and the economic and financial estimates for such implementation. The adoption of the GRWP is a requirement in the Spanish legislation.

According to the legislation in force, the GRWP is drawn up by Enresa and submitted periodically to the Ministry in charge of energy matters for adoption by the Government. The GRWP must contain all the elements enumerated in Article 12 of the Directive 2011/70/Euratom (hereinafter Nuclear Waste Directive).

According to the provisions of the Spanish legislation the responsibility for radioactive waste management rests on the waste producers. The ultimate responsibility of the management lies with the State. Radioactive waste management and dismantling and decommissioning of nuclear facilities are an essential public service whose title rests on the State and whose development is carried out by the Empresa Nacional de Residuos Radiactivos (Enresa). The main principles applicable are the following:

- The generation of radioactive waste shall be minimized as far as reasonably practicable, both in activity and in volume, by appropriate design measures and appropriate dismantling and decommissioning practices, including recycling and reuse of materials.
- The interdependence between all stages of generation and management of spent fuel and radioactive waste shall be taken into account.
- Spent fuel and radioactive waste shall be safely managed, even in the long-term including passive safety systems, based on an intrinsically safe design with components whose functionality is ensured by physical principles not dependent on external energy.
- The cost of the management of spent fuel and of radioactive waste will be borne by those who have generated such materials, with the exceptions provided for in the sixth additional provision of Law 54/1997 of November 27th of the electricity sector, declared in force by Law 24/2013, of December 26th, of the electricity sector.
- The implementation of measures for the safe management of spent fuel and radioactive waste will respond to a graduated approach process, so that the level of analysis, documentation and action is proportionate to the magnitude of the risks involved, the relative importance for safety, the purpose and characteristics of the facility or activity and any other factor considered relevant.
- Empirical evidence-based decision-making shall be applied and documented at all stages of the management of spent fuel and radioactive waste.

1.1.2 Overview of relevant institutions

The main bodies having responsibility over RW management are:

- The Ministry for Ecological Transition (MITECO) is in charge of energy and environmental matters. In this role, the Ministry defines the policy and strategy in relation to radioactive waste, spent nuclear fuel management and decommissioning of nuclear facilities. It is also responsible for the submission of regulatory proposals for the development of the legislation, for the issuing of the corresponding permits and licenses and for applying the system of sanctions.
- The Nuclear Safety Council (CSN) is the body being solely responsible for nuclear safety and radiation protection. The licenses awarded by the MITECO are subject to a previous, mandatory and binding CSN report.
- The Empresa Nacional de Residuos Radiactivos (Enresa) is responsible for SF, radioactive waste management and decommissioning of nuclear facilities. Being entirely public in nature, ENRESA has as its shareholders the Centre for Energy-Related, Environmental and Technological Research (CIEMAT), a national research centre reporting to the Ministry of Science, Innovation and Universities, and the Spanish industrial holding company Sociedad Española de Participaciones Industriales (SEPI), which reports to the Ministry of Finance. ENRESA operates under the aegis of the MITECO, via the Secretariat of State for Energy, which undertakes strategic management and monitoring and control of the company's technical and economic actions and plans.

- Finally, the waste producers are responsible for the safe operation of their facilities and activities, in all cases in compliance with the requirements of the official documents, for whatever issues might affect the conditions of their authorizations and safety and radiological protection and, in general, for abiding by the regulations in force. Likewise, the producers are responsible for their facilities under whatever emergency situations might arise.

The following graphic provides an overview of the relevant institutions in radioactive waste management and their relationship. Further explanations will be given in the subsequent paragraphs.

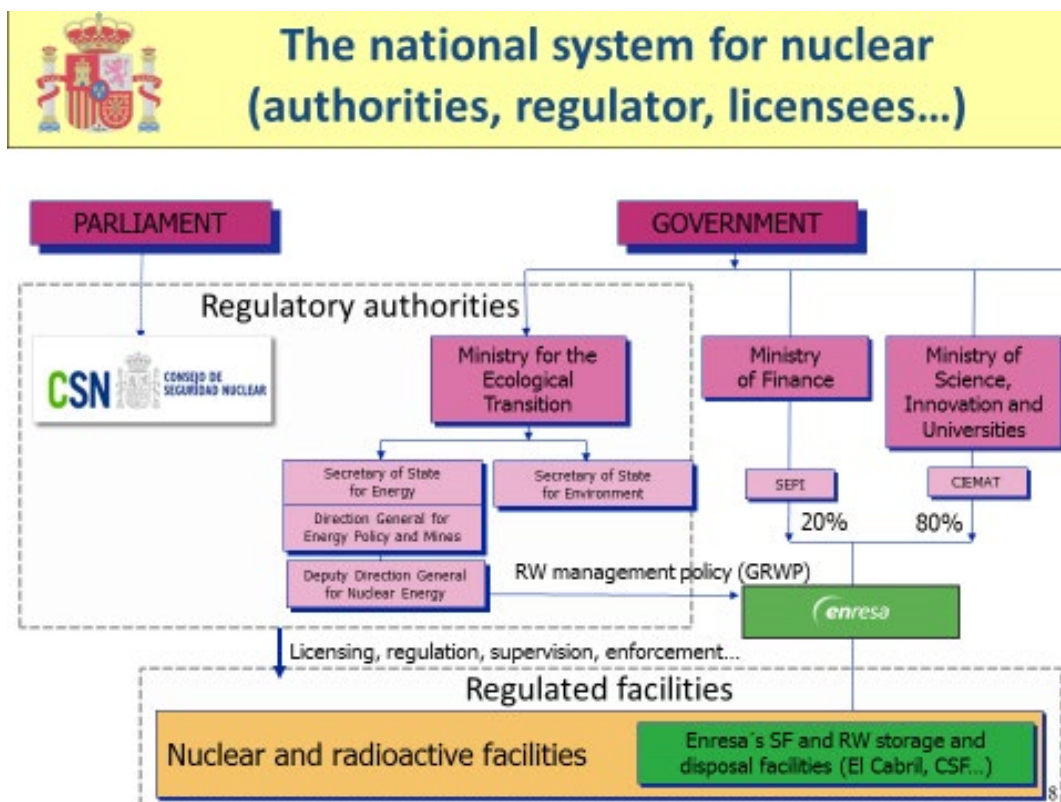


Figure 1: Institutional framework in Radioactive Waste Management in Spain

1.2 National regulatory organisation

The CSN was created by law in 1980 as the sole body competent in nuclear safety and radiation protection matters, independent from the Central Administration of the State. Among its functions are the following:

- To propose to the Government the necessary regulations regarding nuclear safety and radiological protection, as well as the revisions that it considers advisable. The CSN has the capacity to prepare and approve Instructions, Circulars and Guides of a technical nature. The instructions are technical standards, binding for the parties affected by their scope of application

and are usually published in the Official Gazette. The Circulars have an informational purpose and the Guides have a recommendatory nature,

- To issue reports to the MITECO prior to the adoption of the resolutions that the first might approve. Such reports are binding when they are of a negative nature as well as in terms of the conditions that the CSN may establish,
- To carry out all types of inspections and regulatory controls of nuclear and radioactive installations in all their lifetime stages and during operation,
- To propose on the initiation of the disciplinary proceedings; etc.

The CSN keeps the Government, the Congress and the Senate, the regional Governments and Town Councils concerned punctually informed of any circumstance or event affecting the safety of the nuclear and radioactive facilities or the radiological quality of the environment anywhere within the national territory.

The CSN workforce is made up of 459 people (2016) and its headquarters are in Madrid. The main sources of funding of the CSN are rates and public tariffs obtained by reports and inspections prior to authorizations for operation and closure of nuclear and radioactive facilities, inspection and control of operating facilities and granting of licenses to personnel. All this sources accounts for 99.7% of the total CSN budget in 2016.

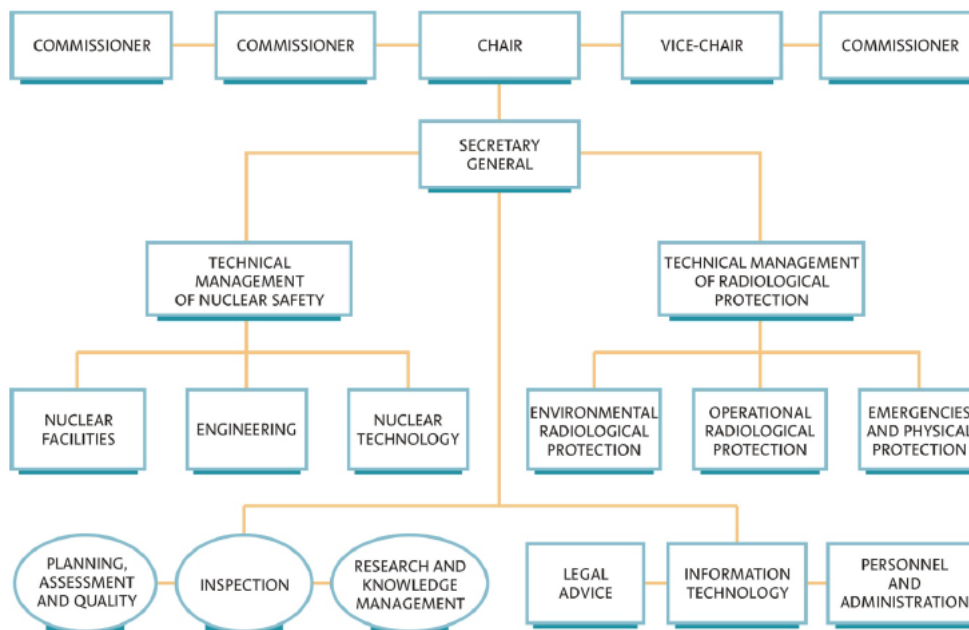


Figure 2.-Nuclear Safety Council (CSN)- organisational chart per 2016

1.3 National implementing organisations

The Spanish legal system provides a clear assignation of responsibilities to the bodies involved in RW management. The law ensures the primary responsibility of the license holder for activities and facilities of SF and RW management as well as the responsibility assigned to Enresa as the technical body in charge of fulfilling the State obligations in this area.

1.3.1 ENRESA

The Nuclear Energy Act declares the management of RW and the dismantling and decommissioning of nuclear facilities an essential public service for which the State is responsible. The Empresa Nacional de Residuos Radiactivos, S. A. (Enresa) is commissioned to manage this public service in accordance with the GRWP. In this respect, Enresa is set up as a resource and technical service of the Administration, carrying out the functions assigned to it by the Government.

Such responsibilities are, *inter alia*:

- Elaborate and manage the national inventory of SF and RW,
- To propose to the government the draft of General Radioactive Waste Plan,
- Treat and condition SF and RW, without prejudice to the responsibilities of the waste generators,
- Search for sites, design, build and operate facilities for storage and disposal and establish systems to ensure the safe management of SF and RW in those facilities,
- Establish systems for the collection and transport of SF and RW,
- Decommission and dismantle nuclear and radioactive installations,
- Manage the Fund for the financing of the activities of the GRWP,
- Carry out Research & Development activities and coordinate the necessary R&D Plan to fulfill the needs of the GRWP.

Enresa, established in 1984, is the licensee and the operator of the facility for the disposal of VLLW and LILW in El Cabril in the province of Córdoba (Andalucía). It is also the licensee and implementer of the dismantling and decommissioning tasks in Vandellós 1 NPP and José Cabrera NPP. Transportation of RW is also under the responsibilities of the company either by its own technical means or by way of subcontracting.

Enresa has a staff of 328 (2016) people, of which roughly 60% are employed at the Madrid head office, being the rest engaged in El Cabril and the other of installations operated by it.

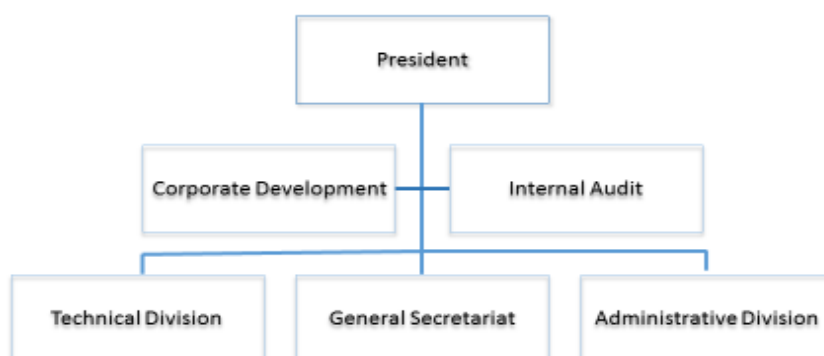


Figure 3. – Empresa Nacional de Residuos (Enresa) – organisational chart

2. LEGAL FRAMEWORK

2.1 Primary Legislation and General Regulations

Spain is a Member State of the European Union since 1986 and therefore the Euratom Treaty and all its secondary legislation are applicable in the field of nuclear energy. Additionally, Spain is a party to most of the relevant international treaties in the field of nuclear energy, in particular on nuclear safety and RW management.

In the Spanish Constitution, the State retains exclusive competence vis-à-vis the Autonomous Communities to regulate on the basis of the mining and energy regimes, which means that the basic legislation in the field of nuclear energy is adopted by the Central Government.

In the field of nuclear energy, the most relevant Spanish pieces of legislation are the following:

- The Nuclear Energy Act 25/64, adopted in 1964. This law establishes the institutional framework of radioactive waste management and a comprehensive set of mandates in the licensing regime, nuclear safety, liability, non-proliferation, etc.
- Law of Creation of the CSN, of 1980 (latest amendment 2007) and, in this respect, the Law on tariffs and fees for services rendered by the CSN of 1999, amended in 2005. These pieces of legislation set up all the responsibilities of the regulator of nuclear safety.
- Electricity Industry Act 54/1997 of 1997 as amended by the new Electricity Industry Act 24/2013 of 2014 where the regime of financing the activities concerning radioactive waste management and dismantling of nuclear facilities is defined.
- Law 21/2013 of 9 December, on environmental assessment.

- Law 27/2006 (Aarhus Law) of 18 July, regulating the rights of access to information, public participation and access to justice in environmental matters, amended by the Royal Legislative Decree 1/2008 of 11 January, approving the revised text of the Law on environmental impact assessment of projects.

2.2 General Regulations

Some of the most important regulations in the nuclear energy regime are (this list not being exhaustive):

- The Regulation on Nuclear and Radioactive Facilities (Royal Decree 1836/1999), enacted in 1999 and amended for the last time in 2014. The main purpose of this Regulation is to establish and regulate the administrative licensing regime both for nuclear and radioactive facilities and for other specific activities related to the application of ionizing radiation. Moreover, this Regulation also considers the personnel's accreditation regime within nuclear sector, the obligations for the licensees and the inspection and control regime.
- Royal Decree 102/2014, of February 21st, for the responsible and safe management of spent nuclear fuel and radioactive waste. This Royal Decree regulates the responsible and safe management of spent fuel and radioactive waste coming from civil activities in all stages, from generation to disposal, as well as some aspects related to the financing of these activities, all in compliance with the European framework. This Royal Decree establishes the general principles regarding the management of spent nuclear fuel and radioactive waste. It also regulates the responsibilities associated with its management, the duties and tasks entrusted to Enresa and the principles and content of the Spanish National Program, or GRWP, as well as the financing system of the activities contemplated therein.
- Royal Decree 738/2001, of the 6th of July, which sets the Regulation on Sanitary Protection against Ionising Radiations adopted in 2001, which is being subsequently adapted to the new Euratom legislation on Basic Safety Standards. There is a number of Regulations in addition to this one in the field of radiation protection - on the radiological protection of external workers (1997); in respect of persons undergoing medical examination or treatment (1990); etc.
- Royal Decree 1440/2010 of 5 November, approving the Statute of the CSN.
- Royal Decree 229/2006 of 24 February, on the control of high level sealed sources and orphan sources, as the main instrument of transposition of the corresponding Euratom Directive.
- Royal Decree 243/2009 of 27 February, on the supervision and control of shipments of RW between Member States and into and out of the Community as the main instrument of transposition of the corresponding Euratom Directive.
- Regulation on nuclear risk coverage (Decree 2177/1967 of 22 July), amended for the last time in 2011.

2.3 Specific Regulations on radioactive waste management

The main piece of legislation specifically ruling on SF and RWM is the Royal Decree 102/2014 on the safe and responsible management of spent nuclear fuel and radioactive waste. This Royal Decree has been enacted in 2014 as a consequence of the adoption of the Nuclear Waste Directive, in order to complete its transposition into Spanish law. Most of the provisions of the Nuclear Waste Directive were already present in the law and practice of RWM in Spain before 2014, but it was deemed necessary to unify the different

provisions existing and to add some new ones. The Royal Decree enounces the general principles in RW management. It also establishes the responsibilities associated with this management and the characteristics and contents of the GRWP, as well as some aspects relating to its financing. Some other elements of the Nuclear Waste Directive, such as the export control regime, are introduced.

2.4 Regulatory Documents

According to its Law of Creation, the CSN has the power to elaborate and approve instructions, circulars and guidance of technical nature in relation with nuclear and radioactive installations.

2.4.1 *Radioactive Waste Management*

The instructions of the CSN most relevant to the management of SF and RW are:

- Instruction IS-13, dated 21 March 2007, on the Radiological Criteria for the Release of Nuclear Installation Sites.
- Instruction IS-19, of October 22nd 2008, on the requirements of the nuclear facilities management system.
- Instruction IS-20, of January 28th 2009, establishing safety requirements relating to spent fuel storage casks
- Instruction IS-26, of 16th June 2010, on basic nuclear safety requirements applicable to nuclear installations.
- Instruction IS-29, of 13th October 2010, on safety criteria at spent fuel and high-level radioactive waste storage facilities.
- Instruction IS-34, of 18 January 2012, on criteria in relation to radiation protection measures, the notification of non-conformities, the availability of people and means during emergencies, and load surveillance during the transport of radioactive material.

2.4.2 *Decommissioning*

The instructions of the CSN most relevant to the decommissioning of nuclear installations are:

- Instruction IS-04, of 5th February 2003, regulating the transference, filing and custody of documents relating to the radiation protection of the workers, the general public and the environment prior to the transference of the licence ownership of the NPPs for dismantling and decommissioning
- Instruction IS-13, dated 21 March 2007, on the Radiological Criteria for the Release of Nuclear Installation Sites
- Instruction IS-24, of 19th May 2010, regulating the filing and periods of retention of the documents and records of nuclear facilities.

2.5 Licensing Procedure

The licensing procedure for nuclear and radioactive installations is established in the Regulation of Nuclear and Radioactive Installations (hereinafter RINR). The licensing authority is the Ministry in charge

of Energy, currently the MITECO. The competence for licensing second- and third-category radioactive facilities, which are the less hazardous types, can be transferred to the Autonomous Communities (if this is the case, the operation permits with regard to those facilities are valid for the entire Spanish territory). In any case, the CSN is the safety authority competent for reporting during the licensing procedure. Licenses are required for siting and construction, operation, modifications of the design or conditions of operation, dismantling and decommissioning and dismantling and closure, this latter license in the case of spent nuclear and radioactive waste disposal facilities.

The licensing procedure for nuclear installations can be described as follows: the MITECO sends a copy of each application and the accompanying documentation to the CSN for its mandatory report. The CSN reports are mandatory and binding whether they are negative and deny authorization, or if they impose conditions when they are positive. Where appropriate, the MITECO will send a copy of all the documentation to the Autonomous Communities with competence in matters of land usage and the environment where the facility or the area included in the basic regulations on planning for nuclear and radiological emergencies is located. On receiving the report from the CSN, and subject to any relevant rulings, reports or representations, the MITECO will adopt the appropriate resolution. A principle of graded approach rules where the licensing requirements are commensurate with the complexity and risk of the facility or activities involved.

2.6 Information and Participation of the Public

The activities in RW management are ruled by Public and Environmental Law, and, having a great impact on the public opinion, also by some additional specific measures. Spain has adopted internal law in the area of information and participation of the public. The most relevant instruments in this field are:

- The Act 21/2013 on Environmental Assessment, which unifies in a single legal instrument two former Acts on strategic environmental assessment and environmental impact assessment. In the area of RW management, this Act is relevant in the licensing procedures of nuclear facilities and in the adoption of the next update of the GRWP.
- Another relevant and recent instrument is Act 19/2013 on Transparency, Access to Public Information and Good Governance. This law is applicable to the public sector, which includes both the authorities MITECO and CSN and the public company Enresa. This Act contains a set of obligations regarding institutional and organizational information, as well as on the planning, on the financial aspects and statistics.
- The obligations set in the Aarhus Convention are incorporated into Spanish law in the Act 27/2006, on the Rights of Access to Information, Public Participation and Access to Justice in Environmental Matters, which transposes Directives 2003/4/CE and 2003/35/CE

Apart of these general rules of Environmental Law, some provisions in nuclear law also concern the regulation of the rights of public information and participation. The figure of the “Information Committees” was introduced in the RINR of 1999 and lately amended in 2008 to reinforce this provision. In its current version, article 13 of the RINR establishes that during the construction, operation and decommissioning of NPPs, Information Committees must be set up for the purpose of informing on the development of the activities in course in the NPP and encourage dialogue. These Committees are composed by representatives of the regional and central administration, the CSN and the municipality, and their scope of work covers also the management of RW and SF in the context of the NPP.

3. WASTE MANAGEMENT STRATEGY AND CURRENT PRACTICE

3.1 Waste classification and quantities

3.1.1 Waste Classification

Radioactive waste (RW) in Spain is classified according to the facilities where is to be disposed of, those authorised for a certain volume, radiological inventory and certain limits regarding specific activity concentrations based on the nature of the different radioactive elements in waste. Actually, the different categories match the radioactive waste classification criteria adopted by the International Atomic Energy Agency (IAEA) and the European Commission:

- Low and Intermediate level waste (LILW) includes waste, the activity of which involves the presence of beta- or gamma-emitting radionuclides with a short to medium semi-disintegration period (under 30 years) and whose content in long-lived radionuclides is very low and limited. Very low level waste (VLLW) is also included since it is considered a sub-group of low and intermediate level waste that, in general, presents specific activities of 100 Becquerel per gram as an average value, although it can also reach several thousands in the case of some low radiotoxicity radionuclides or in case of small amounts.
- Special Waste (SW) includes nuclear fuel attachments, neutron sources, in-core instrumentation or the components replaced from the reactor vessel system and internal components of the reactor, generally metallic, which, due to their radiological features cannot be disposed of at the Spanish facility for LILW. Its storage and disposal routes are associated to high level waste.
- High Level Waste (HLW) is waste containing long-lived alfa-emitting radionuclides with a semi-disintegration period exceeding 30 years in remarkable concentration generating heat due to the effects of radioactive disintegration, since they have high specific activity. The main contributor to this category of waste is spent fuel (SF) discharged from nuclear reactors which, according to Spanish regulations, is considered waste. It is currently stored in the pools of nuclear power plants (NPPs) and in the individual storage facilities (ISFs) at the sites of some NPPs. In the future, it will be stored in the planned Centralized Storage Facility (CIS) above ground. Disposal will be in a deep geological repository facility (DGR).

3.1.2 Spent fuel and waste quantities

At the end of 2016, 42,285 m³ LILW and VLLW had been disposed of in Spain, of which about 31% could be categorized as VLLW. Additionally, 11,020 m³ of VLLW and 6,836 m³ of LILW were stored. Disposed waste is in El Cabril, temporarily stored waste is mainly in the centers where it was generated. On that same date there were 185 m³ of Special Waste stored at NPP Vandellós I and at NPP José Cabrera.

As for the HLW, about 4,975 tU have been generated in the Spanish NPPs. As regards the small quantities of SF sent abroad, the return from France of 2m³ of HLW is expected.

The long-term planning of the GRWP is organised around a central scenario where it is assumed that NPPs will be operational for a lifetime of 40 years. In those conditions, the expected volumes of SF and radioactive waste would be those shown in Table 1.

	Type	Total Amount
LILW + VLLW	LILW	56,000 m ³
	VLLW	120,000 m ³
	TOTAL LILW+VLLW	176,000 m ³
ILW-LL (Special Waste)	Canister CSD-B	12 m ³
	Canister CSD-C	2 m ³
	Waste from reactors dismantling	530-600 m ³
	TOTAL Special Waste	544-614 m ³
SF (UO₂)	PWR	5136 tU
	BWR	1504 tU
	TOTAL SF	6640 tU

Table 1. Long term estimates of waste generation according to the GRWP

3.2 Waste Management Strategy

3.2.1 Nuclear Fuel Waste

The reference option for SF, HLW, ILW and other long-lived waste, in the long term, is its disposal in a deep geological repository. In the case of SF that solution will be in the form of direct disposal as reprocessing is not considered an option since 1984.

All the spent fuel generated by the Spanish LWRs (Light Water Reactors) has been stored on site. In the early days of the operation of the NPPs, storage was implemented in the plants' pools. Some 10 to 15 years later, throughout the 1990's, and in view of the foreseen saturation of the capacity of these pools, the original storage racks were progressively replaced by new more compact units. Saturation was thus delayed but, at the turn of the century, additional storage capacity was needed in most of the NPPs, so that individual storage facilities (ISF) were progressively commissioned and built on the site of some plants.

In the medium term, the main strategy for SF, HLW and especial waste is to store all them in a single site or Centralised Storage Facility (CIS). The municipality of Villar de Cañas, in the province of Cuenca, was designated as the preferred site in 2012. Presently, Enresa is involved in the process of getting the site and construction license. Until this site becomes operational, SF will continue to be temporarily stored in the NPPs sites.

3.2.2 Low and Intermediate-Level Radioactive Waste

Since 1992, Spain has a near surface disposal facility for LILW in El Cabril in the province of Córdoba. In the same site there are also two disposal cells for VLLW (start of operation in 2008) and a series of facilities where the waste coming from institutional producers or the secondary waste generated in

El Cabril can be treated, incinerated, and conditioned. The center is equipped with a waste quality verification laboratory at which characterization studies and tests are carried out on real packages and waste samples from the nuclear power plants.

LILW are conditioned in concrete containers (called disposal units) and when that container is full, it is immobilized by means of injected mortar, forming a compact block, which is deposited in the disposal vault. Once the vault is completed, it is back-filled with gravel, closed and protected. After completion of a disposal area, a final cover of topsoil will enable its integration into the environment. A site's monitoring and surveillance phase of around 300 years is also envisaged. There are 28 vaults for the disposal of LILW in El Cabril,

El Cabril facility also permits the disposal of VLLW. Before 2008, both VLLW and LILW were disposed of in the vaults described above. Taking into account their very low-level activity, the VLLW are currently disposed of in specific vaults separated from the platforms housing the 28 vaults that were licensed in 2008. There are two vaults already constructed for that purpose, with another two already licensed and to be constructed depending on the disposal needs. An institutional surveillance period of around 60 years is envisaged for those vaults.

El Cabril is the cornerstone of the Spanish system for managing any low activity radioactive waste. Any waste not suitable to be disposed of at El Cabril will be stored at the Centralised Storage facility mentioned in 3.2.1.

3.3 Waste management issues at national level

3.3.1 The Centralized Interim Storage (CIS) Facility

The basic strategy set out in the 6th GRWP, currently in force, for the provision of additional capacity for the short and medium term storage of spent fuel focuses on the construction of a Centralized Storage Facility (CIS) to house spent fuel, high level waste (HLW) and special waste (SW) using a dry storage system, until the availability of a final solution.

This strategy was proposed to the Government by a unanimous resolution of the Congressional Commission for Industry – made up of representatives of all the Parliamentary Groups - in December 2004, and was supported by the following considerations:

- It enables management under optimum conditions and in a unified manner for all spent fuel, HLW and SW, while keeping temporary management independent of final management.
- It provides room to the Spanish management system as to manoeuvre in response to future contingencies, such as the need for the premature dismantling of a plant.
- It reduces the number of spent fuel, HLW and SW storage facilities in Spain, and consequently the number of nuclear sites spread throughout the country, with the corresponding reduction of the risks and obligations associated with this type of facility. This reduction should become more significant over time and is particularly important in relation to the physical security of facilities.
- It allows the decommissioned nuclear facility sites to be released for other unrestricted uses.
- From an economic point of view, it implies a highly significant reduction of the overall cost of the HLW and SW temporary management system, compared to the option of storage at each plant and the other necessary temporary storage facilities.

- It enables the rationalisation and optimisation of operation and support services.

Once the Centralized Storage Facility becomes available, the spent fuel from all the Spanish LWRs will be gradually moved to it, pending its final management.

The licensing process for the CIS started in August 2013, when the Environmental Impact Assessment process was initiated, and continued in January 2014, when Enresa submitted the applications for the site authorisation and for the construction authorisation, for which reports from the CSN are required. These processes are still ongoing. Pursuant to the construction programme currently in force, the CIS main facility is expected to start operation in 2024, with a temporary loaded cask building (AEC) conceived to manage the inflow of containers from the NPPs and to temporary store casks before unloading, that could start operation in 2021. From that date, the SF from all the NPPs will be gradually transported to the CSF, until the availability of a final management facility. A design operation period of 60 years has been established.

Although these estimates have been recently defined according to current circumstances, the process is not exempt from a high degree of uncertainty, especially taking into account the opposition to the project from some regional authorities.

3.3.2 *Disposal in a deep geological repository (DGR)*

Since the approval of the 1st GRWP in 1987, Spain considers the deep geological repository as the most suitable final solution for the management of HLW (SF included) and SW, in line with the dispositions of Council Directive 2011/70/Euratom, of 19 July 2011, establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste. The following works have been performed on that direction since then:

- The completion of a plan for geological screening and selection of sites, developed during the 1980s and 1990s, provided sufficient information to conclude the existence in the Spanish sub-soil of abundant granitic and clay formations, and to a lesser extent, saline, capable of housing a final disposal installation.
- The elaboration of non-site specific conceptual designs for a final disposal facility in each of the aforementioned lithology, as well as the development of safety assessment methodologies and exercises. Successive R&D Plans have evolved and have allowed the acquisition of technical knowledge in the development of the final disposal option, both at the national and international level.

At present, a draft program for the development of a DGR considers its availability by 2068, according to the following stages:

- Report on the existing stock of knowledge and capabilities (2017-2022)
- Evaluation of the submitted report (2022-2025)
- Elaboration and implementation of a process for site selection (2025-2029)
- Analysis of candidate sites (2030-2037)
- Site characterization and verification of its suitability (2038-2050)
- Licensing and construction of the DGR (2051-2063)

- Initial operation (2064-2064)
- Normal operation (2069 onwards)

3.4 Research and Development

3.4.1 Research infrastructure

Spanish legislation states that the GRWP shall include the RD&D activities needed to apply solutions for the management of spent nuclear fuel and radioactive waste, as well as to carry out the dismantling and decommissioning of nuclear facilities. In connection to that, Enresa is entrusted with the establishment of the training and RD&D plans needed, within the framework of the Scientific and Technical Research and Innovation State Plan, to cover the needs of the GRWP and to acquire, maintain and further develop the necessary knowledge and skills. There is also an initiative led by the CSN and arranged around the Research and Development Plan.

As a summary, the main RD&D initiatives and plans are the following:

- 7th R&D Plan of Enresa (2014-2018)

This Plan is the specific plan for R&D in radioactive waste management that focuses its efforts on RD&D in areas where there are potential for improvement and optimisation. In accordance with the 6th GRWP in force, the 7th Plan includes four technical areas of work (Waste technology and know-how, Technology for treatment, conditioning and dismantling processes, Confinement systems and materials, and Safety assessment and modelling). This plan covers four thematic areas and a cross-activity. The four areas relate to the precise knowledge of the waste, both of their intrinsic properties and their evolution over time; treatment and conditioning of waste and its relationship with the techniques of operation and decommissioning of radioactive and nuclear facilities; the study of materials used for their confinement and their interrelationships with RW; their impact to the environment considering current and future scenarios, and related to radiation protection of human and environmental studies.

Enresa is the drafter of the Plan as well as the leader for its implementation.

- R&D Plan of CSN

The Spanish Nuclear Safety Council develops R&D plans to respond to new challenges in knowledge brought to light by the CSN's own and international experience and technological changes requiring new approaches.

CSN's R&D plans define strategic priorities (areas of knowledge in which new developments are needed) and leading lines of research (programmes) in those areas. Plans are developed with a five-year horizon in mind. For its development, the CSN promotes several projects, which are executed under its supervision by domestic and international organisations of a recognized prestige.

- CEIDEN (Technological Platform for Nuclear Fission Energy)

The CEIDEN technology platform, established in 2007, is an entity in charge of the coordination of the needs and efforts of R&D in the field of nuclear fission technology, nationwide. Nearly 100 public and private entities participate in CEIDEN, which represents the majority of the players in this field in Spain. CEIDEN develops 8 lines of specific work, with 25 entities involved, including MITECO, CSN, Universities, research centres and utilities.

3.4.2 Contents of R&D plans

Enresa's RD&D commitment is set out in the 7th R&D Plan, a five-year plan (2014-2018), with a budget of 27 million euros. The Plan is structured across four separate thematic areas and a fifth cross-cutting area. These refer to:

- Technology and knowledge of the waste. It includes activities related to the knowledge of the physical and chemical properties of radioactive waste components, as well as their time evolution and the influence of their irradiation history.
- Process technology for treatment, conditioning and dismantling. This area of the Plan includes all the actions that can be performed on radioactive waste whose purpose is the conditioning prior to disposal, the reduction of its volume and radiotoxicity, or those other actions applicable to the dismantling of nuclear or radioactive facilities.
- Confinement materials and systems. This area aims to acquire and expand the knowledge and technologies related to the materials used in storage facilities, such as cement, clays, metals, etc., considered both individually and in conjunction.
- Safety assessment and modelling. The purpose is to improve the numerical models used in safety assessments of disposal facilities in the short, medium and long term.
- The cross-cutting area activity comprises the management of knowledge and scientific-technology assets generated and coordination between the different parties involved.

3.5 Financing of Radioactive Waste Management

3.5.1 Framework and responsibilities

The Spanish financing system for RW management is based upon the following premises:

- Those who generate radioactive waste are responsible for paying the costs of their management from "cradle to grave".
- The financing system will secure that no financial undue burden is imposed on future generations.
- The money to pay for the cost of the activities for radioactive waste management will be taken from a Fund, external to the waste producers, fed by them and managed by Enresa with the supervision of the Government, as stated in the sixth additional provision of Law 54/1997, of November 27th, of the electricity sector, declared in force by Law 24/2013.
- The licensees of the nuclear facilities, as most significant waste generators, are the main contributors to the Fund. They are obliged to feed the Fund paying fees during the operational lifetime of their facilities. These payments are advanced revenues that cover present and future costs, i.e. they include the management of the waste generated during the operation of the facility as well as the costs of the decommissioning and dismantling activities and management of the waste originated during dismantling.
- On the conclusion of the period for radioactive waste management and dismantling of facilities set out in the General Radioactive Waste Plan (GRWP), the total amount paid into the Fund via the different financing channels should cover the costs incurred, resulting in a closing balance of zero.

- The revenues obtained in the Fund are invested in the financial market, and those investments also generate revenues that, by turn, feed the fund. The law stipulates that such investment operations may only be done following the principles of security, profitability and liquidity.

According to the Spanish legislation the GRWP must set out the economic and financial forecasts and the measures and procedures necessary to implement the detected strategies and technical solutions for RW management and decommissioning of nuclear facilities. To this end, the Plan includes an estimation of all costs during the lifecycle of the waste and the corresponding facilities. This estimation is the basis to set the fees paid by the different producers and is reviewed every time that the Plan is.

Additionally, Enresa sends annually to MITECO, the following documents:

1. A report including technical and economic aspects related to the activities of the previous financial year.
2. An updated economic-financial study of the cost of the activities under the GRWP.

3.5.2 Status of financing schemes

Scope of expenses

The last economic-financial study carried out in mid-2017 estimates that the sum of the future expenses and those already accrued on waste management since 1985 is 19.8 billion € (2016). As for the remaining expenses since 2017 this amount is 18.5 billion €. The main assumptions behind this estimation are:

- Current nuclear power plant fleet with seven operational reactors located in five sites. The commissioning of new reactors is not considered.
- 40 years of service of operation of NPP with an operating performance similar to the current one.

(k€2016)	Accumulated 31/12/2016	2017-2020	2021-2090	TOTAL
1. LILW/VLLW Management	262.8	178.2	2651.3	3092.3
2. SF/HLW/SW Management	621.7	671.6	8371.6	9664.9
3. Dismantling	230.7	113.0	4147.3	4491.0
4. Other activities	4.1	1.2	48.6	53.9
5. R&D	25.8	23.3	391.9	441.0
6. Overheads	184.0	111.3	1757.7	2.053.0
	1329.1	1.098.6	17368.4	19796.1

Table 2. Total estimated management costs

- Open fuel cycle. Reprocessing is not considered.
- Immediate and complete dismantling strategy of light water nuclear power plants to be commenced three years after their final shutdown.

The Fund for the financing of activities of the GRWP is fed with revenues including the financial yield generated by them. All the costs relating to the technical activities and supporting services required to undertake the activities contemplated in the GRWP, including those corresponding to structural costs and R&D activities and projects, are applied to the Fund. The activities to be paid from the Fund are the following:

- costs corresponding to the management of RW and SF generated by the operation and the dismantling and decommissioning of NPPs;
- the rendering of management services for RW arising from the manufacturing of fuel assemblies, including the decommissioning of the manufacturing facilities;
- costs for the rendering of services covering the management of RW generated at facilities out of the nuclear fuel cycle;
- those costs that, where appropriate, might arise as a result of the early shutdown of the facility for reasons not attributable to the licensee;
- the quantities set aside for the financing of the research activities determined by the MITECO to have been directly related to nuclear electricity generation;
- the dismantling and decommissioning operations to be performed as a result of the mining and production of uranium concentrates prior to the constitution of Enresa (1984);
- the costs arising from the reprocessing of SF sent abroad prior to the enactment of the Act on the Electricity Sector (1997);
- the assignments for municipalities affected by NPPs or SF or RW storage facilities, in the terms set out by the MITECO;
- the amounts corresponding to taxes levied in relation to RW and SF storage activities, regardless of the date of generation.

Management of the Fund

The fees are collected in a Fund, the Fund for the Activities in the General Radioactive Waste Management Plan. The Fund is an external fund, administered and managed by Enresa and controlled and supervised by the government. The monies in the fund can only pay those expenses attributable to activities included in the GWRP and can be only invested in financial assets that match the conditions of security, profitability and liquidity as stated in the legislation. There are several oversight organisations supervising the correct working of the Fund among which is relevant the Committee for Security and Control that reports to MITECO and is regulated by article 8 of Royal Decree 102/2014.

The Committee must elaborate the main criteria for Enresa's investments, must issue biannual reports covering the financial situation of the Fund, its investments, and a rating of its management, including appropriate observations. Said reports are delivered to MITECO, and other Ministries in charge of Economy and Finance.

4. DECOMMISSIONING STRATEGY AND CURRENT PRACTICE

4.1. Decommissioning policy and strategy

4.1.1 Responsibilities for decommissioning and dismantling

Responsibility for NPPs dismantling and decommissioning rests on Enresa. During the transition phase since the shut-down declaration to the start of decommissioning, the nuclear operator or licensee must discharge all spent fuel from the reactor and from the pools and place it in an ISF on site or send it to the CIS facility, if available. He must also condition all operational wastes and prepare the records for its transfer to Enresa. At this point Enresa is responsible for its dismantling and decommissioning after getting the corresponding approval of the decommissioning plan and the decommissioning license. Later on, when all the dismantling and decommissioning tasks are completed and after the CSN has issued the Closure Declaration, the site will be given back to its former owner.

In the case of Uranium concentrates mining and milling, the responsibility of dismantling and decommissioning is to the licensee, unless otherwise determined by the authorities account taken of its characteristics as “historic” facilities.

The responsibility for dismantling of the Juzbado fuel assembly manufacturing facility lies with Enresa, this being established in the corresponding technical specifications.

4.1.2 Decommissioning Strategy

The decommissioning policy and strategy are stated in the GRWP and, basically, have been the same since the first plan in 1987.

The general Spanish strategy for the NPPs is that of immediate decommissioning up to “green field” conditions. The strategy allows a deferred dismantling alternative only in those cases where the optimisation of doses or any technological particularity of the plant make it more advisable. In practice, immediate dismantling is a suitable strategy for all Spanish NPPs except Vandellós 1, this latter being a graphite-gas reactor.

Taking into account the need of transferring the licence from the operator of the NPP to Enresa, the GRWP assumes a 3 year transition period for the discharge of the spent fuel and conditioning of the waste and a 10 year period for completing the different decommissioning tasks.

4.2 Status of decommissioning projects

Enresa’s recent work in the dismantling and decommissioning of nuclear facilities includes the decommissioning of NPP José Cabrera, the latency of Vandellós I, the dismantling of obsolete installations of CIEMAT (so called “PIMIC project”), the monitoring and maintenance of the project restoration of Saelices el Chico (Salamanca), the preparation for the decommissioning of Santa María de Garoña and other minor actions.

4.2.1 Nuclear Power Reactors

José Cabrera NPP

José Cabrera NPP, located in Almonacid de Zorita (Guadalajara), was the first NPP connected to the grid in Spain (1968). After 38 years of operation it was shut down in April 2006 due to safety considerations by the CSN. Prior to the start of the decommissioning activities, the SF was evacuated from

the pool and transferred to a dry interim storage on site. The operational waste was conditioned. In February 2010, the nuclear license of the NPP was transferred to Enresa for the implementation of the Dismantling and Decommissioning Plan. The main tasks of the Plan are: the removal of conventional elements, the dismantling of radiological elements, the decontamination and demolition of buildings, and the materials management and environmental restoration of the site.

Presently, the dismantling tasks are well advanced and the completion of all the D+D works is being expected by the end of 2019 or early 2020.

Latency of Vandellós I

Vandellós I is located in the town of Vandellos i L'Hospitalet de L'Infant, Tarragona. It started its commercial operation in 1972 and stop it after 17 years following an accident in its conventional part. Prior to the decommissioning activities, the plant's SF was transferred to France for reprocessing, the operational waste was conditioned and removed, and the facilities which were not required were dismantled. All these activities were conducted by the former operator of the plant.

In a second phase, already entrusted to Enresa, all facilities, installations and structures out of the reactor building were dismantled. This latter was sealed and confined. Then a latency period of 25 years began during which the reactor should remain confined for its radioactivity to decay before proceeding to full closure.

Santa María de Garoña NPP

Garoña NPP is a 500 MWe BWR located in the province of Burgos. The renewal of its operational license was denied by the Government in July 2017. Following this decision, the plant started to fulfil the regulatory conditions previous to the transfer of the license to Enresa for the implementation of the decommissioning plan.

Currently, the NPP is organizing the removal of the spent fuel to an ISF next to the plant, is conditioning the operational waste and is keeping the records for its passing to Enresa. This latter is preparing a study of decommissioning alternatives as part of the required Decommissioning Plan of Garoña NPP.

4.2.2. Other sites

Environmental restoration of uranium mines

There have been mining uranium activities in the past in Spain -specifically in Castilla y León, Extremadura and Andalusia-. These activities started in 1948 and culminated in 2000 with the closing of the last installation, located in Salamanca. From the year 1997 and progressively, Enresa has developed plans aimed at the environmental restoration of old abandoned mines basically through the filling of lands, the sealing of holes, the stabilization of soil, slopes and embankments, the recovery of the topography and plant regeneration.

Additionally, the Empresa Nacional del Uranio S.A. (ENUSA), license and owner of a large uranium mine in Saelices (Salamanca) has completed the environmental restoration of this large facility in close cooperation with Enresa.

Other facilities of the nuclear fuel cycle

In parallel with the disappearance of uranium mining, facilities dedicated to the processing of ore have also been closed. Currently there are no such facilities in operation and all of them have been dismantled and are on the way to be decommissioned. The main decommissioning and environmental restoration projects included the following facilities:

- The Factory of Uranium concentrates in Andujar (Jaen, Andalusia),
- Plant “La Haba” in Badajoz,
- Plant “Elefante” in Saelices el Chico (Salamanca, Castilla y León).

The dismantling of these sites is completed and currently the main tasks refer to the surveillance of the fulfilment of the radiological and environmental conditions set in the decommissioning licenses.

4.3 Decommissioning issues at national level

See 3.3.

ACRONYMS AND ABBREVIATIONS

- AEC: Building for the temporary storage of loaded casks
- BWR: Boiling Water Reactor
- CE: European Community
- CEIDEN: Technological platform for Nuclear Fission Energy
- CIEMAT: Centre for Energy-Related, Environmental and Technological Research
- CIS: Centralized Interim Storage Facility
- CSN: Consejo de Seguridad Nuclear, Nuclear Safety Council
- D+D: Dismantling and decommissioning
- DGR: Deep Geological Repository
- Enresa: Empresa Nacional de Residuos Radiactivos S.A.
- EURATOM: European Treaty on Atomic Energy
- GRWP: General Radioactive Waste Plan
- HLW: High Level Waste
- IAEA: International Agency for the Atomic Energy
- ISF: Independent Storage Facility (for SF, HLW or SW)
- LILW: Low and Intermediate Level Waste
- LWR: Light Water Reactor
- MITECO: Ministry for the Ecological Transition
- PIMIC: Integrated Plan for the Improvement of the installations of CIEMAT
- PWR: Pressurised Water Reactor
- RINR: Regulation on Nuclear and Radioactive Installations
- RW: radioactive waste
- SEPI: Sociedad Española de Participaciones Industriales
- SF: Spent fuel

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- SW: Special Waste
- VLLW: Very Low Level Waste