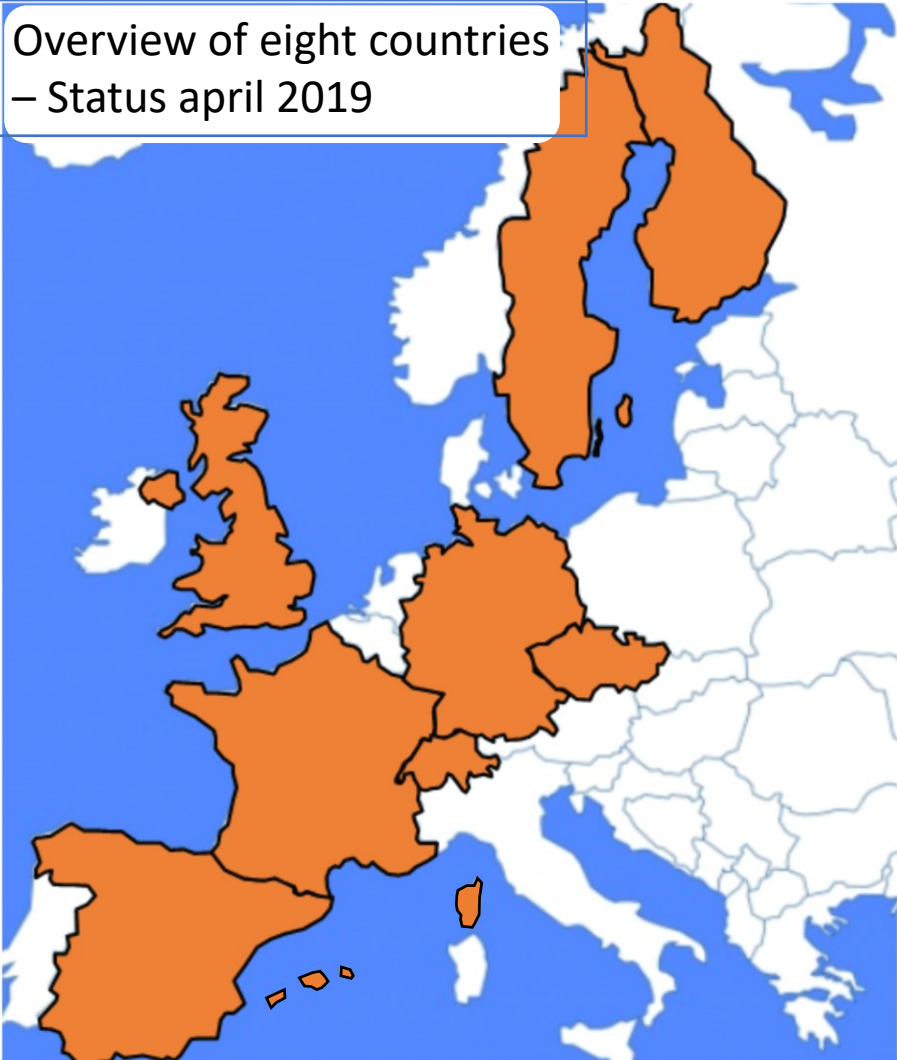


Overview of eight countries  
– Status april 2019



# Overview of eight countries – status April 2019

*Report 2019:1*

*The Swedish National Council  
for Nuclear Waste*

*Stockholm 2019*



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SWEDISH GOVERNMENT  
INQUIRIES

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**The Swedish National Council  
for Nuclear Waste**  
(M 1992:A)

Swedish National Council for Nuclear Waste  
SE-103 33 Stockholm, Sweden

This report can be downloaded from:  
[www.karnavfallsradet.se](http://www.karnavfallsradet.se)

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# Foreword

As per its directive (2018:18), the Swedish National Council for Nuclear Waste keeps track of other countries' programmes for management of nuclear waste and spent nuclear fuel. One element of this monitoring is the annual study trip the Council undertakes to meet with relevant organisations in other countries. This report contains simple overviews of the countries the Swedish National Council for Nuclear Waste has visited on study trips in recent years, as well as of the situation in Sweden. The text focuses on nuclear waste generated at nuclear power plants and other nuclear facilities. The overview covers the following eight countries: Sweden, Finland, Germany, Switzerland, Spain, the Czech Republic, France and the United Kingdom.

The overview does not provide a general image of the global situation. The Swedish National Council for Nuclear Waste has chosen to visit countries with relatively comprehensive programmes for the management of nuclear waste and spent nuclear fuel. Furthermore, this overview does not provide a general picture of the situation in Europe, even though the countries in Europe are often forerunners due to the EU nuclear waste directive (2011/70/Euratom), which is a European framework for the management of nuclear waste.<sup>1</sup>

The information in this text is based largely on the countries' reports submitted to the seventh review meeting of the Joint Convention<sup>2</sup>, held in spring 2018. These reports are updated every three years. These reports contain more information than is covered in this overview, as the objective here is to forego comprehensiveness in favour of providing an overview.

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<sup>1</sup> <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32011L0070&qid=1397211079180>

<sup>2</sup> [www.iaea.org/topics/nuclear-safety-conventions/joint-convention-safety-spent-fuel-management-and-safety-radioactive-waste](http://www.iaea.org/topics/nuclear-safety-conventions/joint-convention-safety-spent-fuel-management-and-safety-radioactive-waste)

We would like to give a big thank you to the people from the different countries who gave input and more recent information to this text.

This overview was written in April 2019 and the situation may change rapidly, therefore suggestions for further reading on websites and in reports are provided.

*As there are many countries facing similar challenges in terms of the management of nuclear waste, it is important that we learn from other countries' experiences and that they can learn from us, both now and for many years to come. This is particularly pertinent in terms of future research and development throughout the long timeframes, often exceeding a century, that design, construction, operation and sealing of repositories can entail.*

*Carl Reinhold Bråkenhielm, Chairperson  
Johanna Swedin, Scientific secretary, Author*

Please feel free to contact us with further information, perspectives and comments: <a href="mailto:karnavfallsradet@gov.se">karnavfallsradet@gov.se</a>
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# 1 Introduction and background

Around the world there is a great deal of nuclear waste and spent nuclear fuel generated by the operations and decommissioning of nuclear facilities, such as nuclear power plants and interim storage facilities for waste. Radioactive waste is a broader concept that also includes waste from hospitals, industry and research. Radioactive waste emits ionising radiation, which is harmful, and such waste must be managed correctly to avoid harm to people and the environment. Previously, it was not unusual for countries to dump waste in the sea (Sweden also partook in such practices), but since the London Convention came into force in 1972 this has been prohibited. There are differences in the ways different countries manage radioactive waste and who is responsible for the management. The countries can also classify their waste differently.

The countries selected for this overview are those the Swedish National Council for Nuclear Waste has carried out study visits to in recent years (Finland, Germany, Switzerland, Spain, the Czech Republic, France, and the United Kingdom), as well as Sweden. The report is a summary of the background of the situations in these countries, including links to facilitate access to more in-depth and current information. The text focuses on nuclear waste generated at nuclear power plants and other nuclear facilities. Radioactive waste from medicine, industry and research is not covered. This first chapter provides a more general background picture of the management of radioactive waste, followed by a chapter describing the situation in each of the eight countries. The final chapter provides a summary and highlights the similarities and differences between the countries.

### *Regulators and implementers*

Whilst these countries take different approaches to managing the waste in question, there are a number of common underlying elements. Each country has a piece of legislation to ensure that spent nuclear fuel and radioactive waste is managed safely. This legislation covers elements such as the setting up of a supervisory authority (a regulator), and in many cases the setting up of a national radioactive waste management organization (implementer) too.

Governmental *regulators* regulate and govern the work of the implementers. The regulator may have a number of different duties in terms of radiation safety, including drawing up regulations and reviewing licenses for operations involving radiation, as well as carrying out supervision regarding physical protection, nuclear material safeguards, interim storage, and transportation. More information on the regulators is available on their own websites.

In this context, *the implementer* refers to the organisation responsible for designing, building and operating repositories for nuclear waste. More often than not, the implementers are governmental organisations of some sort, however in some cases, such as in Sweden and Finland, they are a company owned by the nuclear power companies. In this overview, all implementers have one element in common; they are all responsible for disposal of spent nuclear fuel and/or high level waste in a repository, however not all are responsible for interim storage, for example.

### *Classification*

The different countries classify their waste in different ways, but most are based on the IAEA<sup>1</sup> classification. The classification is based on factors such as the level of radioactivity and the half-life of the waste. The method used for the management of waste depends on the type of waste in question. In this context we cover the classification in brief, focusing on low and intermediate level waste, as well as high level waste (and spent nuclear fuel). The IAEA

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<sup>1</sup> The International Atomic Energy Agency (IAEA).

recommends a classification scheme based on the following waste types<sup>2</sup>:

- High level waste (HLW), for example what is left after the reprocessing of spent nuclear fuel, will need to be disposed of in deep geological repositories, several hundred metres below the surface.
- Intermediate level waste (ILW), such as waste generated by dismantling activities, requires a repository between tens of metres and a few hundred metres below the surface.
- Low level waste (LLW), such as operational waste (for example filters, tools and protective clothing) can be placed in a repository close to the surface (near-surface).

A nuclear reactor is powered by nuclear fuel, and after approximately five years of usage, this fuel becomes so-called spent nuclear fuel. Some countries do not consider spent nuclear fuel to be waste, as it may be reprocessed and reused. If it is declared waste, it is classified as high level waste.

### *Reprocessing – open or closed fuel cycle*

In a so-called *open fuel cycle*, new nuclear fuel is used, whilst spent fuel is placed in interim storage prior to being placed in a repository. Some countries instead choose to reprocess and reuse this spent nuclear fuel as part of a so-called *closed fuel cycle*.

Some countries previously reprocessed their spent nuclear fuel, but for a range of reasons have since stopped doing so and instead plan to place the spent nuclear fuel into repositories without reuse – an open fuel cycle. The reasoning behind such decisions may be that the industry does not consider the process profitable or it has been prohibited. The countries that reprocess, or have reprocessed spent nuclear fuel, have high level waste products as a result. High level waste must be managed in a similar way to spent nuclear fuel. Where countries have both spent nuclear fuel and high level waste, disposal is planned in the same repositories.

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<sup>2</sup> IAEA, 2009, *General Safety Guide No. GSG-1: Classification of Radioactive Waste for protecting people and the environment*:

[www-pub.iaea.org/MTCD/Publications/PDF/Pub1419\\_web.pdf](http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1419_web.pdf)

The IAEA Guide also covers very low level waste (VLLW) and very short lived waste (VSLW). These classifications are not examined in this overview, with the exception of VLLW, which is mentioned in the summary in chapter 3.

*Interim storage and emplacement in a repository*

A great deal of the short lived low and intermediate level waste can, after appropriate conditioning and packaging, either be placed in interim storage or sent to a repository. Today, a number of countries have repositories for short lived low and sometimes also intermediate level waste, and have had such repositories for many years.

There are different strategies for the interim storage of spent nuclear fuel and high level waste. Spent nuclear fuel can either be stored in pools, with the water providing radiation protection, or in dry storage. The spent fuel is always cooled in pools close to the reactors before it can be moved elsewhere. High level waste is stored in dry storage. Some countries have one or several central interim storage facilities, whilst in many other countries interim storage is decentralised at the reactors (some countries have both). Responsibility for interim storage may lie with either the implementer or the nuclear power companies.

Progress in terms of disposal (emplacement in a repository) of spent nuclear fuel and/or high level waste is different in different countries. None of the countries in the world currently have a repository for spent nuclear fuel and/or high level waste, which is a long-term project, regardless of the method to be used.

Globally, there are only three countries with sites set aside for spent nuclear fuel and/or high level waste: *Finland* is the only country that has recently started constructing a repository, *Sweden* is currently in the licensing process, and the implementer in *France* intends to submit licensing applications shortly. The process to find a site is underway in several countries, whilst many countries have yet to start the process, or are at the planning stage. The method to be used is still an open question for most countries around the world.

*Deep geological disposal*

According to IAEA, the term ‘geological disposal’ refers to the disposal of solid radioactive waste in a disposal facility (emplacement in a repository) located underground in a stable geological formation. The waste must be isolated from the biosphere. Disposal means that there is no intention to retrieve the waste, even if the possibility has not been ruled out. Geological disposal is a method intended primarily for the more hazardous types of radioactive waste, which pose a significant radiological hazard over long time periods.<sup>3</sup>

The countries with programmes for disposal of spent nuclear fuel and/or high level waste in repositories are researching different kinds of geological formations, or host rocks (salt, granite, claystone). This may depend on what is available in the country. Often, the waste must first be enclosed in a container made of some form of metal to be able to endure the long timespan (at least 100 000 years) required for the radioactive materials in the repository to decay.

*Funding*

The Polluter Pays Principle applies to the countries covered in this text, i.e. it is the nuclear power companies, who must pay for the management of the waste they create. They often make these payments into a special fund.

**1.1.1 Further information**

Further information is available on the organisations’ websites. Regularly updated information is also available in the ‘Country Profiles’ on the website of the World Nuclear Association.<sup>4</sup>

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<sup>3</sup> IAEA Safety Standards: *Geological Disposal Facilities for Radioactive Waste for protecting people and the environment* No. SSG-14:

[www-pub.iaea.org/MTCD/Publications/PDF/Pub1483\\_web.pdf](http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)

<sup>4</sup> [www.world-nuclear.org/information-library.aspx](http://www.world-nuclear.org/information-library.aspx); see also The Implementing Geological Disposal of Radioactive Waste Technology Platform (IGD-TP): <https://igdtp.eu/>

The report *Status and Trends in Spent Fuel and Radioactive Waste Management* in IAEA's Nuclear Energy Series (2018)<sup>5</sup> summarizes the global situation in terms of amounts of waste and programmes for the management of spent nuclear fuel and radioactive waste. IAEA also has Country Nuclear Power Profiles with information.<sup>6</sup>

There is a report from 2014 with the countries in the EU: *Radioactive Waste Management Stakeholders Map in the European Union*.<sup>7</sup>

More information on different countries' programmes for management of spent nuclear fuel and high level waste can be found in the report *Survey of National Programs for Managing High-Level Radioactive Waste and Spent Nuclear Fuel: Update (2016)* published by the USA-based advisory organisation The U.S. Nuclear Waste Technical Review Board (NWSTRB). The report was published in 2016, so the information is not all up-to-date, especially concerning Germany.<sup>8</sup>

More information on the site selection processes in different countries is available in a report released by the UK-based implementer Radioactive Waste Management (RWM), *Geological Disposal Overview of International Siting Processes (2017)*.<sup>9</sup>

All links in this document are downloaded 2019-05-28.

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<sup>5</sup> IAEA Nuclear Energy Series (No NW-T-1.14): [www-pub.iaea.org/MTCD/Publications/PDF/P1799\\_web.pdf](http://www-pub.iaea.org/MTCD/Publications/PDF/P1799_web.pdf)

<sup>6</sup> <https://cnpp.iaea.org/pages/index.htm>

<sup>7</sup> [http://publications.jrc.ec.europa.eu/repository/bitstream/JRC90331/90331\\_final.pdf](http://publications.jrc.ec.europa.eu/repository/bitstream/JRC90331/90331_final.pdf)

<sup>8</sup> [www.nwtrb.gov/our-work/reports/survey-of-national-programs-for-managing-high-level-radioactive-waste-and-spent-nuclear-fuel-update-\(2016\)](http://www.nwtrb.gov/our-work/reports/survey-of-national-programs-for-managing-high-level-radioactive-waste-and-spent-nuclear-fuel-update-(2016))

<sup>9</sup> <https://rwm.nda.gov.uk/publication/geological-disposal-overview-of-international-siting-processes-2017/>

*Joint convention on the safety of spent fuel management and on the safety of radioactive waste management (Joint Convention)*

The Joint Convention came into effect in 2001 with the objective of strengthening global nuclear safety. The countries that have ratified the convention (78 as of 2018) are required to produce a national report every three years. The report must set out the safety measures the country is taking to fulfil the convention's requirements regarding management of radioactive waste and spent nuclear fuel.

The reports are then submitted to the UN's International Atomic Energy Committee, which hosts a secretariat for the Joint Convention. The countries can read each other's reports and ask questions about them. After this, the results of the reviews are processed during review meetings. The information in this text is based largely on the countries' reports from the seventh review meeting, held 21 May–1 June 2018.<sup>10</sup>

The national Joint Convention reports contain more information than is included in this text, and are worth consulting for more detail on the management of radioactive waste, including that from hospitals, industry and research. The reports also cover the countries' regulatory framework, transportation provisions, conditioning of waste, and decommissioning and dismantling activities, etc.

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<sup>10</sup> Link to the reports of all the countries:  
[www.iaea.org/topics/nuclear-safety-conventions/joint-convention-safety-spent-fuel-management-and-safety-radioactive-waste/documents?page=3](http://www.iaea.org/topics/nuclear-safety-conventions/joint-convention-safety-spent-fuel-management-and-safety-radioactive-waste/documents?page=3)



## 2 Overview of eight countries – status April 2019

### 2.1 Sweden

#### Nuclear power programme

In Sweden, eight reactors account for approximately 35% of the country's electricity generation. The plan is for two of these reactors to be closed by 2020, with the remaining six to run for a total of 60 years. This will result in the last of the reactors being closed in 2045.<sup>1</sup>

#### 2.1.1 Organisations

*Implementer SKB (jointly owned by the nuclear power companies)*

The companies that own nuclear power plants, the nuclear power companies, formed SKB (The Swedish Nuclear Fuel and Waste Management Company)<sup>2</sup> in 1972. SKB's assignment is to manage nuclear waste and spent nuclear fuel in Sweden. SKB is responsible for designing and operating both interim storage facilities and repositories for all forms of radioactive waste. However, it is the nuclear power companies who are responsible for decommissioning and dismantling nuclear facilities, with SKB taking on a coordinating role. SKB is also responsible for the Äspö Hard Rock Laboratory, which focuses on granite-related research.

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<sup>1</sup> [www.world-nuclear.org/information-library/country-profiles/countries-o-s/sweden.aspx](http://www.world-nuclear.org/information-library/country-profiles/countries-o-s/sweden.aspx)

<sup>2</sup> [www.skb.com/](http://www.skb.com/)

### *Regulator SSM*

In Sweden, SSM (the Swedish Radiation Safety Authority)<sup>3</sup> has served as the regulator since 2008, when the Swedish Nuclear Power Inspectorate's (SKI) and the Swedish Radiation Protection Authority's (SSI) was merged.

### *Advisory organisation – the Swedish National Council for Nuclear Waste*

The Swedish National Council for Nuclear Waste<sup>4</sup> is an interdisciplinary committee providing guidance to the Swedish Government on the disposal of nuclear waste and spent nuclear fuel in repositories, as well as on the closure and dismantling of nuclear facilities. Key target groups, in addition to the government, are concerned public authorities, the nuclear power industry, municipalities, NGOs, interested members of the public and the mass media.

The council draws on expertise from a broad range of fields, including ethics, natural sciences, and social sciences, in order to be able to highlight the different challenges nuclear waste poses.

## **2.1.2 Management of nuclear waste**

### *Classification*

Currently, there is no legally defined waste classification system for radioactive waste in Sweden. SKB has developed a classification system for the nuclear power industry, based on how the waste is handled:

- high level waste
- long lived low and intermediate level waste
- short lived intermediate level waste
- short lived low level waste

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<sup>3</sup> [www.stralsakerhetsmyndigheten.se/en/](http://www.stralsakerhetsmyndigheten.se/en/)

<sup>4</sup> [www.karnavfallsradet.se/en](http://www.karnavfallsradet.se/en)

Spent nuclear fuel is currently managed as waste. As per the Swedish Act on Nuclear Activities (1984:3), however, it is only classified as waste once it is placed in a repository.

### *Open fuel cycle*

Since 1982, Swedish policy has been aimed at direct disposal of spent nuclear fuel in a repository and an open fuel cycle with no reprocessing. According to current plans, this means that high level waste<sup>5</sup> will primarily comprise of spent nuclear fuel, when it is placed in a repository. However, there is no prohibition on reprocessing.

### *Repositories for short lived low and intermediate level waste – SKB responsible*

SKB is responsible for managing all types of nuclear waste. Since 1988, the repository for short lived radioactive waste (SFR) has been located in Forsmark, where waste from operations of nuclear facilities is disposed of.

SKB has submitted licensing applications to construct ‘a new’ repository for short lived waste in Forsmark, SFR 2, directly connected to the existing repository, SFR. The main hearing is currently scheduled for autumn 2019. The plan is for there to be room for low and intermediate level waste from Sweden’s nuclear power plants when they are decommissioned.

### *Management of long lived low and intermediate level waste – SKB responsible*

Interim storage of long lived waste is carried out at the nuclear power plants, in Studsvik<sup>6</sup> and at the central interim storage facility for spent nuclear fuel (see Clab below). SKB plans to create a separate repository for long lived low and intermediate level waste (SFL), which will not be ready for operation before 2045. Neither the location nor the method have yet been determined for SFL. According to SKB, a safety

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<sup>5</sup> On page 4 of SKB’s application ‘Toppdokument’ (‘Top document’), you can find out more about the waste types intended for the repository for spent nuclear fuel.

<sup>6</sup> [www.studsvik.com/](http://www.studsvik.com/)

evaluation has been carried out and more information is likely to be provided in SKB's research programme (RD&D Programme 2019), due for publication in late September 2019.

*Interim storage of spent nuclear fuel – SKB responsible*

Since 1985, Clab (Central Interim Storage Facility for Spent Nuclear Fuel) has been in operation in Oskarshamn. SKB is responsible for Clab, which currently houses approximately 6,700 tonnes of spent nuclear fuel in pools. At present, SKB has a license for the interim storage of a total of 8,000 tonnes. In early 2015, SKB applied for a license to store up to 11,000 tonnes in connection with an application for a repository for spent nuclear fuel.

*Planned repository for spent nuclear fuel – SKB responsible*

In terms of disposal of spent nuclear fuel in a repository, SKB submitted an application in 2011 and the licensing process is still underway, see below.

*Site selection and method selection for a repository for spent nuclear fuel*

The selection of Forsmark for the site was made by SKB in 2009 following a long site selection process.<sup>7</sup> In the 1980s, SKB carried out geological studies involving measures such as test drilling. The studies were suspended because of a number of protests. Local acceptance became a key principle when a new process was launched in 1992, with so-called feasibility studies. These were based on existing data, with no drilling taking place at this stage. Site Investigations were launched in 2002, taking over five years in Forsmark, in the municipality of Östhammar, as well as in Laxemar/Simpevarp, in the municipality of Oskarshamn.

SKB has been working with the proposed KBS-3 method since the 1980s.<sup>8</sup> The method involves encapsulating the nuclear fuel in

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<sup>7</sup> For more information see Göran Sundqvist, 2002, *The Bedrock of Opinion Science, Technology and Society in the Siting of High-Level Nuclear Waste*.

<sup>8</sup> Further information is available at: [www.skb.com/](http://www.skb.com/)

copper canisters to be placed at a depth of approximately 500 metres in the bedrock, embedded in bentonite clay. The canister has to be protected for at least 100,000 years from earthquakes, ice ages and human intrusion (intentional or unintentional).

### *Licensing process situation (April 2019)*

In January 2018, following a licensing process lasting almost seven years, the Land and Environment Court provided the government with a pronouncement regarding the Swedish Environmental Code (1998:808) and the Swedish Radiation Safety Authority's (SSM) pronouncement regarding the Swedish Act on Nuclear Activities (1984:3). It is now in the hands of the government to issue a decision on permissibility in accordance with the Swedish Environmental Code and licensing under the Swedish Act on Nuclear Activities.

In its pronouncement, the court stated, amongst other elements, that there are still significant uncertainties regarding the canister and certain forms of corrosion. The court also stated that it must be clarified that the state has the ultimate responsibility after the closure of the repository.

In its pronouncement, SSM stated that it supports SKB's applications. At the same time, SSM emphasised that there is still a great deal of research SKB needs to carry out, including certain forms of corrosion, as highlighted by the court.

One reason for the court and SSM reaching different conclusions is that the licensing processes are different under the two different laws. If SKB were to be granted a license, stepwise licensing in accordance with the Swedish Act on Nuclear Activities would follow, whereby the regulator SSM issues gradual approvals, giving it the opportunity to reassess its support. However, the court does not have the same opportunity to carry out ongoing stepwise licensing.

It will take at least 70 years to construct, operate and seal a repository for spent nuclear fuel, which entails a number of challenges, both technical and societal in nature. The Swedish National Council for Nuclear Waste's duties include paying attention to, and clarifying, these challenges.

### 2.1.3 Further information

SSM, 2017, Ds 2017:51 *Sweden's sixth national report under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management* (Ministry Publication Series)<sup>9</sup>

SSM, 2018 *Sweden's second National Report on Implementation of Council Directive 2011/70/Euratom*<sup>10</sup>

Implementer: [www.skb.com/](http://www.skb.com/)

Regulator: [www.stralsakerhetsmyndigheten.se/en](http://www.stralsakerhetsmyndigheten.se/en)

## 2.2 Finland

### Nuclear power programme

Finland has four reactors, providing almost 30% of the country's electricity. The nuclear power company TVO (Teollisuuden Voima Oyj) has two reactors at Olkiluoto in Eurajoki, whilst Fortum (Fortum Power & Heat Oy) has two reactors on the island of Hättholmen in Loviisa. Finland is in the process of expanding its programme. A fifth reactor, Olkiluoto 3, is currently being built.<sup>11</sup>

A new energy company, Fennovoima Oy, plans to build a nuclear power plant in the town of Pyhäjoki. It is a possibility that Finland will have two repositories for spent nuclear fuel.<sup>12</sup>

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<sup>9</sup> [www-ns.iaea.org/conventions/results-meetings.asp?s=6&l=40](http://www-ns.iaea.org/conventions/results-meetings.asp?s=6&l=40)

<sup>10</sup> Reference number: SSM2018-2869 Document No: 2018-2869-5; [www.stralsakerhetsmyndigheten.se/en/press/news/2018/swedens-implementation-of-nuclear-waste-directive-reported-to-european-commission/](http://www.stralsakerhetsmyndigheten.se/en/press/news/2018/swedens-implementation-of-nuclear-waste-directive-reported-to-european-commission/)

<sup>11</sup> [www.tvo.fi/OL3-](http://www.tvo.fi/OL3-)

<sup>12</sup> The implementer Posiva claims that it will not have space in its planned repository for spent nuclear fuel from Fennovoima. Consequently, Fennovoima may need to build its own repository.

## 2.2.1 Organisations

*Two nuclear power companies and the implementer Posiva  
(owned jointly by the nuclear power companies)*

The nuclear power companies TVO and Fortum are responsible for managing operational waste and decommissioning waste. They also manage interim storage of spent nuclear fuel. However, the companies have transferred research and management concerning a repository for spent nuclear fuel to Posiva Oy (Posiva).<sup>13</sup> TVO and Fortum have jointly owned Posiva since 1995.

*Regulator STUK*

STUK (the Radiation and Nuclear Safety Authority)<sup>14</sup> has been the regulator in Finland since 1958.

## 2.2.2 Management of nuclear waste

*Classification*

In Finland, the waste is divided as follows:

- high level waste (includes spent nuclear fuel)
- intermediate level waste
- low level waste

In Finland, the low and intermediate level waste is also divided into short lived and long lived waste (high level waste is always long lived).

In Finland, spent nuclear fuel is classified as high level waste. Finland does not reprocess its spent nuclear fuel and has no plans to do so.

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<sup>13</sup> [www.posiva.fi/en](http://www.posiva.fi/en)

<sup>14</sup> [www.stuk.fi/web/en/frontpage](http://www.stuk.fi/web/en/frontpage)

*Management of low and intermediate level waste  
– nuclear power companies responsible*

The nuclear power companies are responsible for the management and disposal of Finland's low and intermediate short and long lived operational waste (low and intermediate level waste). TVO has an underground repository for operational waste, which has been in use in Olkiluoto, Eurajoki, since 1992. Fortum has a similar facility on Hästholmen, Loviisa, and this was opened in 1997.

TVO and Fortum both have plans underway to expand their repositories in order to be able to dispose of decommissioning waste as well. (Both repositories are located in the vicinity of nuclear power plants).

*Interim storage of spent nuclear fuel  
– nuclear power companies responsible*

The nuclear power companies are responsible for interim storage of spent nuclear fuel, which is stored in decentralised pools, located at the nuclear power plants.

*Repository for spent nuclear fuel – Posiva responsible*

Currently, Finland has made the most progress of any country in terms of disposal of spent nuclear fuel in a geological repository, and Posiva is the only implementer in the world that has recently started construction of such a repository. Posiva is building this repository on the Olkiluoto island in the municipality of Eurajoki.

In 2004 Posiva began construction of the Onkalo research facility at the site. First, Onkalo's purpose was to house underground research in a site suitable for a repository for spent nuclear fuel, and to provide Posiva with knowledge on the bedrock in Olkiluoto. From the beginning, the Onkalo was supposed to become a part of the repository facility. In future, parts of the operating repository areas will still have the same research service obligations as the former research facility did have.

Posiva has selected the same method as SKB, the KBS-3 method. The method involves encapsulating the nuclear fuel in copper containers to be placed at a depth of more than 400 metres in the bedrock, embedded in bentonite clay. Posiva and the Swedish Nuclear Fuel and Waste Management Company (SKB) are cooperating on research into this method.

### *The licensing process for a repository for spent nuclear fuel*

The Finnish decision-making process for the construction of a repository comprises four decisions the Finnish Government must make: the decision in principle, the decision on construction licensing, the decision on operating licensing, and the decision of decommissioning and closure licensing.

The first decision in the licensing process was made in 2001, when the Finnish Government issued a decision in principle approving the site selection of a KBS-3 type repository facility for spent nuclear fuel on Olkiluoto.

In late 2015 the government issued Posiva with a second license, concerning the construction of an encapsulation plant and a repository facility for spent nuclear fuel, as well as issuing several conditions for the construction license.

Posiva must also apply for a third license from the government before it may begin operations at the repository (a grant might be available by 2024). If Posiva is granted this license, it will be allowed to begin operations at the spent nuclear fuel encapsulation plant and to start placing the canisters in the underground repository.

The current plans are for the repository to be sealed in 2120, but this will also depend on whether the repository contains waste from reactors built after Olkiluoto 3, and if so for how long they operate.

### **2.2.3 Further information**

*Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management  
6th Finnish National Report as referred to in Article 32 of the Convention 2017<sup>15</sup>*

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<sup>15</sup> [www-ns.iaea.org/conventions/results-meetings.asp?s=6&l=40](http://www-ns.iaea.org/conventions/results-meetings.asp?s=6&l=40)

*Posiva's annual report 2018*<sup>16</sup>

*Finnish Research Programme on Nuclear Waste Management KYT2022 Framework Programme for the Research Period 2019–2022*<sup>17</sup>

*Implementer: [www.posiva.fi/en](http://www.posiva.fi/en)*

*Regulator: [www.stuk.fi/web/en/frontpage](http://www.stuk.fi/web/en/frontpage)*

## 2.3 Germany

### Nuclear power programme

Prior to 2011, Germany had 17 reactors in operation, currently this number stands at seven, which collectively account for approximately 12% of the country's electricity generation. All remaining reactors are due to be phased out by the end of 2022. Of all the countries reviewed, Germany has seen the most changes in recent years. This is partly due to the state having assumed some responsibility from the nuclear power companies, partly due to the state having reorganised responsibility concerning the regulator and implementer, and partly due to a new site selection process being developed.

#### 2.3.1 Organisations

Germany has made the decision to phase out nuclear power by 2022, and in 2016 passed a law regarding the reorganisation of the management of nuclear waste. This led to a number of measures, including the state assuming responsibility from the nuclear power industry for financing<sup>18</sup> and interim storage, and a reorganisation being carried out in terms of the implementer.

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<sup>16</sup> [www.posiva.fi/files/5019/POSIVA\\_Annual\\_Report\\_2018.pdf](http://www.posiva.fi/files/5019/POSIVA_Annual_Report_2018.pdf)

<sup>17</sup> <http://kyt2018.vtt.fi/hankehaku2019/Framework%20programme%20KYT2022.pdf>

<sup>18</sup> The nuclear power companies have made payments into a fund managed by the state.

*Implementer BGE (governmental)*

BGE (The federal company for radioactive waste disposal)<sup>19</sup> was established in 2017 and is a governmental implementer for disposal of nuclear waste and spent nuclear fuel in geological repositories. The former implementer, BfS<sup>20</sup>, was also a governmental implementer, but there is now a clearer division between the implementer and regulator (BfE see below). BGE's responsibilities include:

- existing repositories and repository projects for low and intermediate level waste (termed waste with negligible heat generation in Germany)
- implementing the site selection process for spent nuclear fuel and high level waste (termed heat-generating waste in Germany)
- siting, designing, building and operating a repository for spent nuclear fuel and high level waste (heat-generating waste)

*Interim storage BGZ (governmental)*

Until 2017, the nuclear power companies had responsibility for interim storage.<sup>21</sup> At this point, the state began to gradually assume responsibility through the newly-formed organisation BGZ (Company for radioactive waste storage).<sup>22</sup> From 2020 BGZ will take care of the interim storage of all forms of nuclear waste and spent nuclear fuel (both waste with negligible heat generation and heat-generating waste).

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<sup>19</sup> Bundesgesellschaft für Endlagerung mbH: [www.bge.de/en/](http://www.bge.de/en/)

<sup>20</sup> Das Bundesamt für Strahlenschutz: [www.bfs.de](http://www.bfs.de). BfS is no longer the implementer; however, it still works to protect people and the environment from harm arising from ionising and non-ionising radiation.

<sup>21</sup> Prior to this, responsibility lay with the industry organisation GNS (Gesellschaft für Nuklear-Service mbH): [www.gns.de/](http://www.gns.de/); the industry organisation continues to carry out measures such as creating containers for spent nuclear fuel, intermediate level waste and high level waste, and these containers are also exported.

<sup>22</sup> Gesellschaft für Zwischenlagerung: <https://bgz.de/>

### *Regulator BfE*

BfE (The Federal Office for the Safety of Nuclear Waste Management)<sup>23</sup> was established in 2014 and is the regulator. BfE is the federal regulatory and supervisory authority when it comes to disposal of radioactive waste in repositories and the handling and transport of radioactive wastes. In addition, BfE is also responsible for assessing the site selection process of a repository for spent nuclear fuel and high level waste (heat-generating waste), and for the public participation in the process. (The final decision is with the Federal Parliament.)

### *Advisory organization – ESK*

ESK (Nuclear Waste Management Commission)<sup>24</sup> advises the BMU (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety/ Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit) regarding the management of nuclear waste, including conditioning, storage and transportation of radioactive materials and waste, decommissioning and dismantling of nuclear facilities, and geological disposal. ESK is a commission focused on technical matters.

## **2.3.2 Management of nuclear waste**

### *Classification: heat-generating or negligible heat generation*

All radioactive waste in Germany must be disposed of in deep geological repositories, so it is not necessary to differentiate between long lived and short lived waste in the same way as when also depositing the waste in repositories closer to the surface. The waste is generally divided into two categories:

- waste with negligible heat generation  
(c/f low and intermediate level waste)
- heat-generating waste  
(c/f high level waste and partially intermediate level waste)

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<sup>23</sup> Bundesamt für kerntechnische Entsorgungssicherheit: [www.bfe.bund.de/EN/](http://www.bfe.bund.de/EN/)

<sup>24</sup> Entsorgungskommission: [www.entsorgungskommission.de/](http://www.entsorgungskommission.de/)

However, in the text below the categories low and intermediate level waste and high level waste and spent nuclear fuel will be used. Spent nuclear fuel is managed as waste as reprocessing is prohibited.

### *Reprocessing*

Up until 1994 there were reprocessing requirements in force, after this it became optional for several years, and in 2005 it was prohibited. Reprocessing has taken place in the UK and in France, and the high level waste that has not yet been returned is due to be returned no later than 2022.

### *Interim storage for low and intermediate level waste*

– *BGZ responsible (waste with negligible heat generation)*

The nuclear power companies previously had all responsibility for interim storage. In January 2019 BGZ took over the responsibility for interim storage of spent nuclear fuel and waste from reprocessing. In 2020 BGZ will also take over the responsibility for storage facilities for low and intermediate level waste. BGZ will then have taken over all the responsibility for interim storage.

### *Repositories for low and intermediate level waste*

– *BGE responsible (waste with negligible heat generation)*

The implementer BGE is responsible for repositories concerning low and intermediate level waste. The following repositories/mines either exist already or are under construction:

- Konrad: an iron ore mine that has been undergoing conversion into a repository since 2007. Operations will commence at the site in 2027 at the earliest.<sup>25</sup>
- Asse: an old salt mine; the waste stored here must now be removed, because the mine is not sufficiently safe. (There will not be room for this waste at Konrad.)
- Morsleben: an old repository in a salt mine, due to be sealed

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<sup>25</sup> Second report on the implementation of Directive 2011/70/Euratom, p. 57 (2018).

*Interim storage of spent nuclear fuel and high level waste  
– BGZ responsible (heat-generating waste)*

Since 2017 BGZ has been responsible for the centralised interim storage facilities in Ahaus and Gorleben for spent nuclear fuel and high level waste, that have been in use since the 1980s.<sup>26</sup> From 2019, BGZ has also assumed responsibility from the nuclear power companies for the 12 decentralised interim storage facilities for spent nuclear fuel and high level waste that are located at nuclear power plants. Both the centralised and decentralised facilities use dry storage.

*Planned repository for spent nuclear fuel, high level waste  
and partially intermediate level waste – BGE responsible  
(heat-generating waste)*

The implementer BGE is responsible for implementing the site selection process for a repository for spent nuclear fuel, high level waste (and partially intermediate level waste), and is to designate locations and criteria. BGE is also responsible for designing, constructing and operating the repository. There is not yet a determined method, but a great deal of preparatory work has been carried out for a site selection process.

*Site selection process*

Since 1979 research was carried out at a salt dome in Gorleben.<sup>27</sup> For a long time, the plans were to construct a repository for spent nuclear fuel and high level waste there, however in 2012 these plans changed. An agreement was reached to restart a site selection process based on a ‘spotless map’ approach, concerning both location and method. Gorleben is still an option, but is just one site amongst several being considered. Whether the repository will be in salt, granite or claystone has yet to be decided. The material of a container is also undecided.

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<sup>26</sup> Since 1999, Zwischenlager Nord (ZLN) in Rubenow has also been in operation, where waste is stored from locations such as Greifswald, where there are currently five reactors being de-commissioned – the EWN is responsible: [www.ewn-gmbh.de/projekte/zln-abfalllager/](http://www.ewn-gmbh.de/projekte/zln-abfalllager/)

<sup>27</sup> [www.bge.de/standortsuche/bergwerk-gorleben/](http://www.bge.de/standortsuche/bergwerk-gorleben/)

In 2013, a law (StandAG 2013) came into force regarding a new site selection process for a repository for spent nuclear fuel and high level waste. The law was updated in 2017 with some changes that had been proposed by a commission featuring a wide range of stakeholders.<sup>28</sup> Some of the criteria included in the law are:

- the safest location must be used
- a repository must be safe for at least a million years
- public participation is required
- retrieval must be possible for a long time (500 years)
- reversibility of decisions must be possible
- the process to find a site must be carried out in several stages

The process began in 2017 and the implementer BGE will develop proposals for regions and locations, as well as site selection criteria, and it shall also carry out the work. The regulator BfE is responsible for supervising the site selection process and reviews BGE's proposals, organises public participation, and conveys the results to the Federal Ministry for the Environment, BMU.

The different stages of the site selection process are:

- Stage 1 – selection of potential site regions (from a 'spot-less map')
- Stage 2 – surface exploration
- Stage 3 – underground exploration
- Stage 4 – site proposal and decision planned to have been achieved by 2031

The search areas will be reduced in size throughout the stages. The proposals from BGE will be reviewed by BfE at the end of each stage. Based on BfE's advice, BMU will then inform the Federal Parliament and the Federal Council<sup>29</sup> of proposals for further measures. The stages will conclude with a federal law. Operations at a repository

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<sup>28</sup> It comprised representatives from the likes of the parliament, academia, civil society organisations, industry, environmental organisations, and unions.

<sup>29</sup> Bundestag and Bundesrat.

for spent nuclear fuel and high level waste are intended to commence around 2050.<sup>30</sup>

At national level, the National Advisory Board (Nationales Begleitgremium) was formed in late 2016, as an independent public institution to monitor the site selection from the perspective of the public's best interests. Public participation is a key part of this process, and the parties involved (BfE and BGE) are obliged to provide transparency and dialogue. At regional level, participation will take place through so-called regional conferences.

### 2.3.3 Further information

*Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. Report of the Federal Republic of Germany for the Sixth Review Meeting in May 2018*<sup>31</sup>

*Second report on the implementation of Directive 2011/70/Euratom (Member State Report) (Report under Article 14(1) 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)*

*BfE Nuclear Regulatory Issues and Main Developments in Germany 14 November 2018*<sup>32</sup>

*Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) website:*  
*[www.bmu.de/service/benutzerhinweise/barrierefreiheit/gebaerdensprache/](http://www.bmu.de/service/benutzerhinweise/barrierefreiheit/gebaerdensprache/)*

*Implementer: [www.bge.de/en/](http://www.bge.de/en/)*

*Regulator: [www.bfe.bund.de/EN/](http://www.bfe.bund.de/EN/)*

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<sup>30</sup> For more information about the site selection process, see: [www.bge.de/en/sitesearch/](http://www.bge.de/en/sitesearch/) and [www.bfe.bund.de/EN/soa/siteselectionprocess/siteselectionprocess\\_node.html](http://www.bfe.bund.de/EN/soa/siteselectionprocess/siteselectionprocess_node.html) and p. 227f, 278f of the report to the Joint Convention.

<sup>31</sup> [www-ns.iaea.org/conventions/results-meetings.asp?s=6&l=40](http://www-ns.iaea.org/conventions/results-meetings.asp?s=6&l=40)

<sup>32</sup> Further information is available at: [www.bfe.bund.de/SharedDocs/Downloads/BfE/EN/reports/kt/germany-nuc-reg-issues.pdf?\\_\\_blob=publicationFile&v=7](http://www.bfe.bund.de/SharedDocs/Downloads/BfE/EN/reports/kt/germany-nuc-reg-issues.pdf?__blob=publicationFile&v=7)

## 2.4 Switzerland

### Nuclear power programme

Switzerland has five nuclear reactors, which account for up to 40% of the country's electricity generation. In June 2011 the Swiss parliament decided that several reactors would not be replaced, therefore gradually phasing out nuclear power, which was confirmed with a referendum on the Energy Strategy 2050 in 2017. The construction of new nuclear power plants is now prohibited.

#### 2.4.1 Organisations

*Implementer Nagra (cooperation between the nuclear power companies and the government)*

In Switzerland the nuclear power industry is responsible for spent nuclear fuel and radioactive waste from its nuclear facilities. The government is responsible for radioactive waste from medicine, industry and research (approx. 20% of the total waste volume). According to Swiss law all radioactive waste has to be disposed of in deep geological repositories.

In 1972 nuclear power companies and the government founded Nagra (the National Cooperative for the Disposal of Radioactive Waste).<sup>33</sup> Nagra is the technical organization in charge of the siting and implementation of deep geological repositories. This comprises the site investigations, the design and the general license application. At a later stage further licensing steps will lead to construction and operation of the geological repositories. Nagra also takes care of the national inventories of the different waste categories. Nagra is engaged in focused research and development including experiments in its own rock laboratory at Grimsel pass, at other rock labs and in international cooperations.<sup>34</sup>

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<sup>33</sup> Nationale Genossenschaft für die Lagerung radioaktiver Abfälle: [www.nagra.ch/en](http://www.nagra.ch/en)

<sup>34</sup> [www.nagra.ch/en/grimselrocklaboratory.htm](http://www.nagra.ch/en/grimselrocklaboratory.htm);  
[www.mont-terri.ch/en/homepage.html](http://www.mont-terri.ch/en/homepage.html)

*Zwilag (nuclear power companies responsible for interim storage)*

The four nuclear power companies are responsible for the interim storage of spent nuclear fuel and nuclear waste from their nuclear facilities through Zwilag, which operates ZZL (Zentrales Zwischenlager).<sup>35</sup>

*Regulator ENSI*

ENSI (The Swiss Federal Nuclear Safety Inspectorate)<sup>36</sup> is the national regulatory body with responsibility for the nuclear safety and security of Swiss nuclear facilities. ENSI bears overall responsibility for the safety assessment of geological siting regions and sites. It reviews and assesses safety aspects.

*Advisory organisation – KNS*

KNS/NSC (Nuclear Safety Commission)<sup>37</sup> advises the Federal Council<sup>38</sup>, DETEC,<sup>39</sup> and the regulator ENSI on matters regarding safety at nuclear facilities. This is a permanent commission comprising scientific expertise on nuclear safety.

## 2.4.2 Management of nuclear waste

*Classification*

According to the Swiss classification, waste is classified as follows:

- high level waste (spent nuclear fuel declared to be waste and vitrified waste from reprocessing of spent nuclear fuel)
- ‘alpha-toxic waste’<sup>40</sup>
- low and intermediate level waste

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<sup>35</sup> [www.zwilag.ch/en](http://www.zwilag.ch/en)

<sup>36</sup> Eidgenössisches Nuklearsicherheitsinspektorat: [www.ensi.ch/en/](http://www.ensi.ch/en/)

<sup>37</sup> Eidgenössische Kommission für nukleare Sicherheit: [www.bfe.admin.ch/bfe/en/home/swiss-federal-office-of-energy/swiss-federal-office-of-energy/federal-nuclear-safety-commission-nsc.html](http://www.bfe.admin.ch/bfe/en/home/swiss-federal-office-of-energy/swiss-federal-office-of-energy/federal-nuclear-safety-commission-nsc.html)

<sup>38</sup> Bundesrat

<sup>39</sup> DETEC, The Federal Department of the Environment, Transport, Energy and Communications.

<sup>40</sup> Alpha-toxic waste (ATA) is waste with a content of alpha-emitters exceeding 20,000 B/g.

Spent nuclear fuel is not high level waste until it is declared as such, and thus far none has been definitively declared as waste by its owners.

### *Reprocessing*

Up until 2003, spent nuclear fuel was sent to France and the UK for reprocessing. All reprocessed waste has been returned to Switzerland. Reprocessing was prohibited with a moratorium during the period 2006–2016. With the approval of the Energy Strategy 2050, reprocessing was prohibited permanently.

### *Interim storage of low and intermediate level waste – Zwiilag responsible*

In Switzerland, the waste is stored both at centralised interim storage facilities and decentralised at nuclear power plants. The centralised storage facility for nuclear waste is located in the nuclear industry's interim storage facility, ZZL, in Würenlingen.<sup>41</sup> Located at the Beznau nuclear power plant, Zwibez is a smaller interim storage facility for low and intermediate level waste, which has been in operation since 1993 (also featuring dry storage for spent nuclear fuel and high level waste).

### *Planned repository for low and intermediate level waste – Nagra responsible*

Nagra is responsible for designing, constructing and operating repositories for low and intermediate level waste. A site selection process, led by the Swiss Federal Office of Energy, for this is underway, see below.

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<sup>41</sup> Next to ZZL is the federal interim storage facility BZL for low and intermediate level waste at the Paul Scherrer Institute, where waste from medicine, industry and research is in interim storage (in operation since 1993): [www.psi.ch/media/the-swiss-federal-interim-storage-facility](http://www.psi.ch/media/the-swiss-federal-interim-storage-facility)

*Interim storage of spent nuclear fuel and high level waste  
– Zwiilag responsible*

Spent nuclear fuel and high level waste is stored both at the centralised interim storage facility ZZL (dry storage operated by Zwiilag) and decentralised at the nuclear power plants. Furthermore, at a couple of nuclear power plants there are extra storage facilities for spent nuclear fuel, Zwibez at the Beznau nuclear power plant has dry storage, and Gösigen nuclear power plant a wet storage.

*Planned repository for spent fuel and high level waste  
– Nagra responsible*

In terms of methods, Nagra submitted a feasibility report<sup>42</sup> to the Federal Council in 2002, to show that it is possible to dispose of spent nuclear fuel, high level waste and long lived intermediate level waste in a repository in Switzerland. The Federal Council approved the report in 2006, and stated that it considered Nagra to have shown that it is possible to design a deep geological repository. As early as the late 1980s, Nagra had already shown that it was possible to dispose of short lived low and intermediate level waste in a repository.

Two repositories are planned:

- one for high level waste, spent nuclear fuel (and maybe long lived intermediate level waste)<sup>43</sup>
- one for short lived low and intermediate level waste

A combined storage facility at the same site is possible. The storage locations would be different, but there would be just one joint facility on the surface.

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<sup>42</sup> Nagra, 2002, *TECHNICAL REPORT 02-05 Project Opalinus Clay – Safety Report – Demonstration of disposal feasibility for spent fuel, vitrified high level waste and long lived intermediate-level waste (Entsorgungsnachweis)*.

<sup>43</sup> The decision whether the long lived intermediate level waste will go into the repository for low and intermediate level waste or the repository for high level waste will be made later.

*The process for the site selection for deep geological repositories*

The site selection process and site selection criteria are defined in a so-called sectoral plan (The Sectoral Plan for Deep Geological Repositories). The process was approved by the Federal Council in 2008. The stages are:

- Stage 1 – selection of geological siting areas (carried out 2008–2011)
- Stage 2 – selection of at least two sites for each waste category (carried out 2011–2018, three siting areas remaining)
- Stage 3 – selection of site/sites (2019–)

Starting in stage 2, regional participation in so-called regional conferences was set up and is a vital part of the process. The second stage was concluded in November 2018 with three geological siting areas set to be further explored in stage 3, all claystone sites. For the third stage, the implementer Nagra intends to make a preliminary site selection around 2022.

In around 2029, the Federal Council is expected to make a decision on the final site selection and on licensing, which will conclude the third stage of the process. After this, the Federal Council's decision must be approved by the parliament. The parliamentary resolution is subject to an optional national referendum (around 2031).

The plan is for the repository for low and intermediate level waste to come into operation around 2050, and for the repository for high level waste/spent nuclear fuel/(long lived intermediate level waste) to come into operation around 2060.

### **2.4.3 Further information**

*Implementation of the obligations of the Joint Convention on the safety of spent fuel management and on the safety of radioactive waste management 6th national report of Switzerland in accordance with article 32 of the convention, October 2017<sup>44</sup>*

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<sup>44</sup> [www-ns.iaea.org/conventions/results-meetings.asp?s=6&l=40](http://www-ns.iaea.org/conventions/results-meetings.asp?s=6&l=40)

*Swiss Federal Office of Energy (SFOE) website:*  
*[www.bfe.admin.ch/bfe/en/home/supply/nuclear-energy/radioactive-waste.html](http://www.bfe.admin.ch/bfe/en/home/supply/nuclear-energy/radioactive-waste.html)*

*Implementer: [www.nagra.ch/en](http://www.nagra.ch/en)*

*Regulator: [www.ensi.ch/en/](http://www.ensi.ch/en/)*

## **2.5 Spain**

### **Nuclear power programme**

Spain has seven reactors in operation, which account for approximately 20% of the country's electricity generation.

During April 2019, following discussions with the Ministry for Ecological Transition, the Spanish utilities have signed a Protocol for stepwise closure of the existing nuclear power plants between 2025 and 2035.

#### **2.5.1 Organisations**

*Implementer Enresa (governmental)*

Enresa (the Spanish radioactive waste management agency)<sup>45</sup> was established in 1984 as a governmental company. Enresa's duties include designing, constructing and operating the centralised interim storage facilities and repository facilities. Enresa is also responsible for decommissioning and dismantling of nuclear facilities.

*Regulator CSN*

In 1980 CSN (Nuclear Safety Council)<sup>46</sup> was established to take on responsibility for the regulation and monitoring of nuclear facilities.

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<sup>45</sup> Empresa Nacional de Residuos Radiactivos SA: [www.enresa.es/eng/](http://www.enresa.es/eng/)

<sup>46</sup> Consejo de Seguridad Nuclear: [www.csn.es/en/home](http://www.csn.es/en/home)

## 2.5.2 Management of nuclear waste

### *Classification*

According to the Spanish system, waste is classified as follows:

- high level waste (primarily spent nuclear fuel, which is regarded as waste)<sup>47</sup>
- short lived, low and intermediate level waste

Furthermore, there is a grouping category termed called Special Waste (SW), which consists mainly of long lived intermediate level waste resulting from the cutting of the reactor vessel internals during the decommissioning of nuclear power plants. Due to its radiological properties (long lived, etc.), this waste is not adequate for disposal in the same facility as the rest of short lived low and intermediate level waste (El Cabril, see below). Therefore, SW must undergo interim storage and disposal in a similar way to high level waste.

### *Reprocessing*

An open fuel cycle without reprocessing has been used since 1983. There is a small proportion of reprocessed high level waste from the period prior to this.

### *Repository for low and intermediate level waste – Enresa responsible*

Since 1992 there is a repository in operation for low and intermediate level waste at El Cabril, Córdoba. This repository is located on lands which had been used already in the decade of 1960 for the storage of institutional waste (coming from research activities). Following its creation in 1984, Enresa became the new owner of this land and undertook the construction and operation of the repository. The operation started in 1992. In 2008 an additional area in the site was devoted specifically for the disposal of very low level waste.

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<sup>47</sup> According to the report to the Joint Convention, p. 17.

*Interim storage of spent nuclear fuel, high level waste and long lived intermediate level waste – a planned Centralised Temporary Storage – Enresa responsible*

The spent nuclear fuel currently is stored at interim storage facilities provided by the nuclear power companies at the reactor sites. The intention is to build a centralised facility for interim storage, the so-called ATC/CTS (Almacén Temporal Centralizado/Centralised Temporary Storage), which would be under the responsibility of Enresa. In 2011 the council of ministers designated the municipality of Villar de Cañas as the site for the CTS. The regulator CSN has approved the design, which is similar to that of the Habog facility in the Netherlands (dry storage). The operating period is planned to be approximately 60 years, but the facility can remain for 100 years. Special Waste is also planned to be stored at the centralised interim storage facility. Furthermore, the interim storage facility will provide storage for small quantities of reprocessed waste shipped back to Spain from abroad, such as the vitrified high level waste from re-processing in France, which originated as spent nuclear fuel from the nuclear power plant Vandellós I.

The interim storage facility was intended to be completed by 2010, but the project has been delayed for a number of reasons.<sup>48</sup> The delays to CTS have led to a need for further dry storage capacity, decentralised to several nuclear power plants, so-called ITS (Individualised Temporary Storage) facilities. The nuclear power companies are the licensees for these decentralised storage facilities.

*Long-term management of spent nuclear fuel, high level waste and long lived intermediate level waste*

In Spain, the focus now is on building an interim storage facility, whilst the disposal of spent nuclear fuel, high level waste, and long lived intermediate level waste in a repository is a matter for further down the line.

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<sup>48</sup> Further information is available in the report to the Joint Convention, p. 105f.

### 2.5.3 Further information

*Joint Convention on the safety of spent fuel management and on the safety of radioactive waste management. Sixth Spanish National Report October 2017*<sup>49</sup>

*General Radioactive Waste Plan (GRWP)*

The GRWP sets out the strategies and activities to be implemented within the management of radioactive waste. The sixth General Radioactive Waste Plan, approved by the Spanish government in 2006, is the most recent plan. (The seventh plan has not yet been approved for a number of reasons, including the delay to CTS.)

*Enresa Annual report 2017*<sup>50</sup>

*Implementer: [www.enresa.es/eng/](http://www.enresa.es/eng/)*

*Regulator: [www.csn.es/en/home](http://www.csn.es/en/home)*

## 2.6 The Czech Republic

### Nuclear power programme

The Czech Republic has six reactors, which account for approximately 33% of the country's electricity generation. The plan here is to continue using nuclear power and potentially construct new reactors, but there are some financial uncertainties regarding new construction.<sup>51</sup>

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<sup>49</sup> [www-ns.iaea.org/conventions/results-meetings.asp?s=6&l=40](http://www-ns.iaea.org/conventions/results-meetings.asp?s=6&l=40)

<sup>50</sup> [www.enresa.es/eng/index/about-enresa/publications/category/9-institutional?download=105:annual-report-2017](http://www.enresa.es/eng/index/about-enresa/publications/category/9-institutional?download=105:annual-report-2017) (CTS delayed, p. 77f)

<sup>51</sup> [www.world-nuclear.org/information-library/country-profiles/countries-a-f/czech-republic.aspx](http://www.world-nuclear.org/information-library/country-profiles/countries-a-f/czech-republic.aspx)

## 2.6.1 Organisations

### *Implementer SÚRAO (governmental)*

SÚRAO (the Radioactive Waste Repository Authority)<sup>52</sup> is a governmental organisation that has been in operation since 1997. SÚRAO is responsible for the disposal of all radioactive waste in repositories and operates three repositories for short lived low and intermediate level waste. SÚRAO is also responsible for the Bukov underground research facility, which is a generic laboratory in the crystalline host rock.<sup>53</sup>

### *Regulator SÚJB*

SÚJB (The State Office for Nuclear Safety)<sup>54</sup> has been the regulator since 1993.

## 2.6.2 Management of nuclear waste

### *Classification*

According to the Czech classification, waste is classified as follows:

- high level waste
- intermediate level waste
- low level waste

Nuclear waste, so-called RAW (radioactive waste), that does not meet the acceptance criteria for existing repositories for low and intermediate level waste, will be disposed of in a future deep geological repository.

Spent nuclear fuel is considered nuclear waste only when it has been declared to be waste by its owner or the regulator SÚJB.

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<sup>52</sup> Správa úložišť radioaktivních odpadů, also known as RAWRA in English: [www.surao.cz/en](http://www.surao.cz/en)

<sup>53</sup> [www.pvpbukov.cz/en/home-page/](http://www.pvpbukov.cz/en/home-page/)

<sup>54</sup> Státního úřadu pro jadernou bezpečnost: [www.sujb.cz/en/](http://www.sujb.cz/en/)

### *Reprocessing*

Currently, waste is not reprocessed as it is not considered economically advantageous by the nuclear power company CEZ, but there is no prohibition on reprocessing.<sup>55</sup>

#### *Repositories for low and intermediate level waste – SÚRAO responsible*

The implementer SÚRAO assumed management of three repositories for low and intermediate level waste in 2000:

- Dukovany, operating since 1995, low level nuclear waste from Czech nuclear power plants, large enough to receive the waste from the existing reactors.
- Richard, operating since 1964, low and intermediate level waste from medicine, industry and research.
- Bratrství, waste with naturally occurring radionuclides since 1974.

#### *Interim storage of spent nuclear fuel – nuclear power company CEZ responsible*

The nuclear power company CEZ is responsible for interim storage of nuclear waste and spent nuclear fuel. Spent nuclear fuel is stored (dry storage) at the two nuclear power plants, Dukovany and Temelín.

#### *Site selection for a repository for spent nuclear fuel, high level waste and long lived intermediate level waste – SÚRAO responsible*

The Czech Republic is implementing a site selection process that has been ongoing for some time.

1990–1993: Based on a number of geological criteria, the Czech geological institute proposed that several sites should be investigated.

2003–2005: SÚRAO cut down the list of 27 sites to the six most suitable, all of which are in a crystalline host rock.

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<sup>55</sup> There is high level waste from research reactors that is being reprocessed in Mayak, Russia, and is due to be returned in 2024–2033.

2005–2009: Due to protests from the municipalities concerned, work at the six sites stopped until the end of 2009 following a governmental decision. One of the conditions for the process to be restarted was that the municipalities concerned would need to give their consent for the continuation of exploration activities.

2011: The financial contribution for the geological investigation were incorporated to the Atomic Act (this was a request from the municipalities).

For 2010–2012 the plan was for SÚRAO to begin geological exploration activities at the sites, with the municipalities voluntarily involved in the selection process.

As public opinion was negative, another site close to a former uranium mining facility was also explored in 2010. For the same reason the Government assigned SÚRAO in 2014 to search for potential sites in the close vicinity of the nuclear power plants. Temelín (Janoch) and Dukovany (Na Skalním) were added to the list of potential sites and in 2016–2017 they were geologically investigated.

There are currently nine potential sites. SÚRAO will face a number of additional challenges further along in the process.<sup>56</sup> However, the intention is for the selection of the site to take place in several stages:<sup>57</sup>

- 2019 – there are currently nine sites, this number must be reduced to four (exploration on the surface, no drilling holes)
- 2019(?)–2025 – the four sites will be subject to further exploration work and one shall be selected as the priority site, with the others as reserve sites (the intention is to use drilling and carry out comprehensive surveys)
- post-2025 – show that the site can be approved

Construction is planned to start after 2050, with operations planned to start in 2065.

The method has not yet been determined, but the plan is to create a deep geological repository in crystalline host rock, with metal canisters and bentonite as barriers.

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<sup>56</sup> [www.surao.cz/en/director-prachar/](http://www.surao.cz/en/director-prachar/)

<sup>57</sup> *Selection of a site for the deep geological repository*: [www.surao.cz/wp-content/uploads/2019/03/presskit\\_20190313\\_EN\\_3.pdf](http://www.surao.cz/wp-content/uploads/2019/03/presskit_20190313_EN_3.pdf)

In October 2016 SÚRAO signed a four-year service contract with Posiva Solutions from Finland<sup>58</sup> for guidance on the site selection process for a repository for spent nuclear fuel and high level waste, the repository concept, and the design of the repository.

### *Working group for dialogue on a deep geological repository 2010–2016*

The working group for dialogue on deep geological repository was an independent working group<sup>59</sup> formed in 2010 with the support of the Ministry of Industry and Trade (MIT) and in cooperation with the Ministry of the Environment. The group would aim at the public and the affected municipalities to become more involved in the process of finding a suitable location for a repository for spent nuclear fuel and high level waste.

Under 2014 the working group was incorporated in the Government Council for Raw Materials and Energy Strategy. However, the group had problems, among other things because several stakeholders resigned. Only two meetings were held in 2016. MIT has not nominated any new members since 2016 and the mandates are over, so Working Group does not exist. There is a plan in the MIT to set up new groups on 4 sites.

### **2.6.3 Further information**

*The Czech republic national report under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management Prague 2017*<sup>60</sup>

SÚRAO, 2017, *DGR development in the Czech republic. Action plan 2017–2025*. Technical Report No.: 112/2017<sup>61</sup>

*Deliberating Together on Geological Repository Siting: Expectations and Challenges in the Czech Republic. Synthesis and International*

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<sup>58</sup> A subsidiary of Posiva Oy: [www.posiva.fi/posiva\\_solutions#.XJjV\\_uTty70](http://www.posiva.fi/posiva_solutions#.XJjV_uTty70)

<sup>59</sup> With representatives of municipalities in the areas proposed as suitable for further research, representatives of the government (Ministry of Industry and Trade and Ministry of Environment) and parliament, SÚRAO, SÚJB, environmental organisations, academic institutions and other experts.

<sup>60</sup> [www-ns.iaea.org/conventions/results-meetings.asp?s=6&l=40](http://www-ns.iaea.org/conventions/results-meetings.asp?s=6&l=40)

<sup>61</sup> [https://inis.iaea.org/collection/NCLCollectionStore/\\_Public/49/081/49081721.pdf](https://inis.iaea.org/collection/NCLCollectionStore/_Public/49/081/49081721.pdf)

*Perspective of the 9<sup>th</sup> Community Visit and National Workshop of the OECD Nuclear Energy Agency Forum on Stakeholder Confidence (FSC) Czech Republic, 24-26 October 2012:*

[www.oecd-nea.org/rwm/docs/2014/rwm-r2014-1.pdf](http://www.oecd-nea.org/rwm/docs/2014/rwm-r2014-1.pdf)

*Implementer: [www.surao.cz/en](http://www.surao.cz/en)*

*Regulator: [www.sujb.cz/en/](http://www.sujb.cz/en/)*

## 2.7 France

### Nuclear power programme

France has 58 reactors in operation, which provide approximately 75% of the country's electricity. A new reactor, Flamanville 3, is currently under construction.<sup>62</sup> There are plans to reduce the proportion of electricity coming from nuclear power by approximately 25% by around 2035. France has been very active in the development of nuclear technology and is one of the world's largest net exporters of electricity. Reactors, fuel products and services are also significant exports.

#### 2.7.1 Organisations

France set its sights on nuclear power from an early stage, and there are a large number of reactors and other nuclear facilities and installations, such as reprocessing facilities and research facilities, in the country.

*Implementer Andra (governmental)*

Andra (the French National Radioactive Waste Management Agency)<sup>63</sup> was established in 1991 and is responsible for the disposal of all categories of radioactive waste in repositories. A piece of legislation passed in 2006 changed Andra's role from being solely focused on management of high level waste to all types of radioactive waste. The company is owned by the state. Some of its key duties include:

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<sup>62</sup> [www.edf.fr/en/groupe-edf/producteur-industriel/carte-des-implantations/centrale-nucleaire-de-flamanville-3/views-of-flamanville-3](http://www.edf.fr/en/groupe-edf/producteur-industriel/carte-des-implantations/centrale-nucleaire-de-flamanville-3/views-of-flamanville-3)

<sup>63</sup> L'Agence nationale pour la gestion des déchets radioactifs: <https://international.andra.fr/>

- being responsible for the existing repositories for short lived low and intermediate level waste
- studying and designing repositories for long lived low level waste as well as long lived intermediate level waste and high level waste
- ensuring all citizens are kept informed using documents, exhibitions, etc.
- preserving awareness of its repositories for future generations
- taking responsibility for the Underground Research Laboratory in claystone, located between Meuse and Haute-Marne

### *Regulator ASN*

In 2006 ASN (the French Nuclear Safety Authority)<sup>64</sup> became a regulator responsible for supervision of nuclear safety and radiological protection.

### *Advisory organisation – CNE<sup>2</sup>*

Since 1991, the Commission Nationale d'Evaluation (CNE) has been tasked with assessing research within three areas concerning high level and long lived intermediate level waste: disposal in a deep geological repository, separation and transmutation, and interim storage of such nuclear waste. In a revision of the law on waste management, carried out in 2006, CNE was replaced by CNE<sup>2</sup>,<sup>65</sup> and its duties expanded to encompass all forms of waste. CNE<sup>2</sup> reports annually on progress in research on French waste management (by the implementer Andra and other producers including the nuclear power company EDF France, CEA and the French National Centre for Scientific Research).

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<sup>64</sup> Autorité de sûreté nucléaire: [www.french-nuclear-safety.fr/](http://www.french-nuclear-safety.fr/)

<sup>65</sup> [www.cne2.fr/index.php/en](http://www.cne2.fr/index.php/en)

### *Reprocessing and construction of reactors (formerly AREVA)*

France reprocesses most of the spent nuclear fuel and AREVA was one company working with the entire nuclear fuel cycle. In January 2018 it was announced<sup>66</sup> that AREVA was to be divided into two separate companies as part of a comprehensive restructuring process:

- Framatome – which now focuses primarily on development, design and construction of nuclear power reactors.
- Orano – which now focuses primarily on uranium mining and enrichment, management of spent fuel, and nuclear decommissioning.

### *Research organisation CEA*

CEA<sup>67</sup> (Atomic Energy Commission) was founded in 1945 and in 2010 became the Alternative Energies and Atomic Energy Commission. CEA is a governmental research company with both operational research reactors and research reactors currently being decommissioned.

CEA has expanded the scope of its research within physics, chemistry, and biology, and develops new knowledge within areas such as microelectronics and new energy technology. CEA's research is currently focused on four areas: defence and security, low-carbon energies (nuclear power and renewable energy), technological research for industry, and fundamental research in the physical sciences and life sciences.

## **2.7.2 Management of nuclear waste**

### *Classification*

In France, the waste is divided as follows:

- high level waste
- long lived intermediate level waste

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<sup>66</sup> [www.world-nuclear-news.org/C-New-Areva-changes-name-to-Orano-2301185.html](http://www.world-nuclear-news.org/C-New-Areva-changes-name-to-Orano-2301185.html)

<sup>67</sup> Commissariat à l'Energie Atomique: [www.cea.fr/english](http://www.cea.fr/english)

- long lived low level waste
- short lived low and intermediate level waste

The current plan is for all spent nuclear fuel to be reprocessed, see more below.

### *Reprocessing – closed fuel cycle*

France chose in an early stage to operate a closed fuel cycle, which involves reprocessing of spent nuclear fuel. Spent nuclear fuel from the French reactors (and from other countries) is sent to Orano's reprocessing facility in La Hague (Normandy).<sup>68</sup>

The present official policy of France is to reprocess all spent nuclear fuel, but all is not reprocessed today. It supposes the introduction of a GEN IV reactor system not foreseen before 2080.<sup>69</sup> Present planning for disposal does not include disposal of spent fuel, however, a repository for high level waste (Cigéo, see below) has to be flexible. If changes are made in the future, requiring it to also accept spent nuclear fuel, it should be able to do so.

### *Repositories for short lived low and intermediate level waste – Andra responsible*

Andra is responsible for the two existing repositories for short lived low and intermediate level waste:

- The Aube disposal facility (CSA), which has been in operation since 1992.
- Centre de stockage de la Manche in La Hague was in operations from 1969 to 1994, and is now sealed and monitored by Andra.

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<sup>68</sup> <https://orano.group/en/expertise/facilities/recycling-spent-fuel/la-hague/unique-expertise>

<sup>69</sup> Read more about the spent fuel management police in the report to Joint Convention p. 34f.

*Site selection for a repository for long lived low level waste  
– Andra responsible*

Long lived low level waste cannot be disposed of in existing repositories and instead requires special management. The waste is now in interim storage provided by the nuclear power companies.

A prior site selection process for a repository for long lived low level waste was met with opposition, so a new process was launched in 2012. The implementer, Andra, has submitted a preliminary situation report on the design of a repository in the Soulaines region<sup>70</sup>, and is set to continue geological surveys in the region and submit a report setting out technology and concept selection options in mid-2019. A report on an overarching industrial system for the management of long lived low level waste is also due for submission before the end of 2019. In the plans for a deep geological repository (Cigéo, see below), Andra will need to show that there is reserve capacity to potentially take certain types of long lived low level waste, if it cannot be stored in a repository closer to the surface.

*Interim storage of high level waste and long lived intermediate level waste – producers responsible*

Today, high level waste and long lived intermediate level waste are placed in interim storage where they were created, and the nuclear power company EDF France and other producers such as CEA and Orano are responsible (dry storage). Spent nuclear fuel is stored in pools at La Hague whilst awaiting reprocessing.

*Planned repository for high level waste and intermediate level waste  
– Cigéo – Andra responsible*

In the 1980s, an unsuccessful site selection process that did not involve the communities of the areas in question was carried out. Following this, the Bataille Act was introduced in 1991 concerning research into and development of nuclear waste management and requiring a decision-making process involving a 15-year research and development

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<sup>70</sup> In the proximity of the repository The Aube disposal facility for short lived low and intermediate level waste and the repository for very low level waste (VLLW).

project to be carried out before a decision could be reached on long-term management of high level waste and long lived intermediate level waste. This act also led to the establishment of the implementer Andra.

In December 1998, Andra was granted a license to develop an underground laboratory investigating claystone, in the village of Bure (on the border of Meuse and Haute Marne). After several years of research, in 2005 Andra reached the conclusion that building a deep geological repository within a space with an area of 250 km<sup>2</sup> on the border between Meuse and Haute Marne, in close proximity to the laboratory, would be possible. The next year, the 2006 Waste and Planning Act was passed. The 1991 law was revised and the government decided on a reversible (for at least 100 years) deep geological repository in Meuse/Haute Marne as the solution for the long-term management of high level waste and long lived intermediate level waste.

In 2011 Andra launched the industrial design stage for the project, now known as Cigéo (the Industrial Centre for Geological Disposal)<sup>71</sup>.

A public consultation on Cigéo was carried out between May and December 2013, with some debates held online or with invited participants only, due to protests. The consultation was a contributing factor in Andra making certain adjustments to the project. They have, for example, added the following elements:

- a pilot phase is to be carried out to test the repository’s capacity prior to being able to start operations
- a master plan has been developed for the design and operation of the Cigéo project, to be updated and reviewed regularly
- the plans regarding involvement of civil society in the project are to be improved
- reversibility must be possible. The concept of reversibility has been clarified and defined in a law in 2016

The planned method is for the waste to be vitrified and for the canisters to be deposited in long, horizontal holes drilled into claystone, at a depth of approximately 500 metres.

Andra will present the license application at the earliest 2020.<sup>72</sup>

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<sup>71</sup> Center Industriel de Stockage Géologique. Press release from Andra in French: [www.andra.fr/sites/default/files/2019-01/Andra-JOURNAL\\_N31\\_Meuse-Haute-Marne-BDissuHD.pdf](http://www.andra.fr/sites/default/files/2019-01/Andra-JOURNAL_N31_Meuse-Haute-Marne-BDissuHD.pdf)

<sup>72</sup> [www.cne2.fr/telechargements/RAPPORT\\_CNE2\\_12\\_2018\\_EN.pdf](http://www.cne2.fr/telechargements/RAPPORT_CNE2_12_2018_EN.pdf)

### *Cigéo Ethics and Society Committee*

An Ethics and Society Committee linked to Andra was established in late 2016.<sup>73</sup> The committee's role is to inform Andra, citizens and society about ethical issues relating to the management of radioactive waste. It is also intended to assess how Andra, in its operations and projects, manages dialogue and stakeholder involvement. The committee works to promote public participation and to ensure that Andra takes into account different perspectives.

### **2.7.3 Further information**

*The National Plan for the Management of Radioactive Materials and Wastes (PNGMDR) is updated every three years*

As per the 2006 Waste and Planning Act, the national plan (PNGMDR) shall provide an overview of the management of radioactive waste carried out in France. A fourth edition for the period 2016–2018 was submitted to parliament in early 2017.

The PNGMDR is based on the work of a multi-actor working group. A 'strategic environmental assessment' of the plan has been carried out, aiming to identify the probable environmental impact. A public consultation was organised in 2016. (In April 2019, the public debate on the 5th edition was launched).

The plan must feature an inventory of the technical solutions and planned measures for the period after the closure of a repository, as well as a summary of the results and research carried out in other countries.

It is important to ensure long-term dialogue with the population on the topic of repositories for radioactive waste. A summary of the plan is available and intended for the public, clarifying the main recommendations of the plan.

*Joint Convention on the safety of management spent fuel and on the safety of management of radioactive waste. France Sixth National Report on Compliance with the Joint Convention Obligations. October 2017<sup>74</sup>*

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<sup>73</sup> [www.andra.fr/gouvernance-de-cigeo-les-avis-du-comite-ethique-et-societe](http://www.andra.fr/gouvernance-de-cigeo-les-avis-du-comite-ethique-et-societe)

<sup>74</sup> [www-ns.iaea.org/conventions/results-meetings.asp?s=6&l=40](http://www-ns.iaea.org/conventions/results-meetings.asp?s=6&l=40)

*The National Plan for Radioactive Materials and Waste Management (PNGMDR) 2016–2018*<sup>75</sup>

*National assessment board (CNE2), For research and the studies into the management of radioactive waste and materials instituted by the law 2006-739 of June 28, assessment report no. 12 (2018)*<sup>76</sup>

*Implementer: <https://international.andra.fr/>*

*Regulator: [www.french-nuclear-safety.fr/](http://www.french-nuclear-safety.fr/)*

## 2.8 UK

### Nuclear power programme

In the UK there are 15 reactors, generating approximately 21% of the country's electricity, but almost half of this capacity will cease to exist by 2025. The intention is to establish new facilities instead. Two new nuclear reactors are currently being constructed at Hinkley Point C in Somerset.<sup>77</sup>

The UK was a pioneer in nuclear technology, opening the world's first commercial nuclear power plant in 1956, close to Sellafield. In addition to normal operational waste, there is also a great deal of radioactive waste from the earlier development of nuclear power, from reprocessing of spent fuel from the UK and overseas, and from military programmes.

#### 2.8.1 Organisations

*Implementer NDA and subsidiary RWM (governmental)*

The NDA (Nuclear Decommissioning Authority)<sup>78</sup> was formed as a result of the Energy Act 2004. The NDA has an overarching role in decommissioning and dismantling, as well as in management and disposal of nuclear waste in repositories (overseeing budgets, setting objectives, and monitoring progress). Under the NDA are so-called

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<sup>75</sup> [www.french-nuclear-safety.fr/Information/Publications/Others-ASN-reports/French-National-Plan-for-the-Management-of-Radioactive-Materials-and-Waste-for-2016-2018](http://www.french-nuclear-safety.fr/Information/Publications/Others-ASN-reports/French-National-Plan-for-the-Management-of-Radioactive-Materials-and-Waste-for-2016-2018)

<sup>76</sup> [www.cne2.fr/telechargements/RAPPORT\\_CNE2\\_12\\_2018\\_EN.pdf](http://www.cne2.fr/telechargements/RAPPORT_CNE2_12_2018_EN.pdf)

<sup>77</sup> [www.edfenergy.com/energy/nuclear-new-build-projects/hinkley-point-c](http://www.edfenergy.com/energy/nuclear-new-build-projects/hinkley-point-c)

<sup>78</sup> [www.gov.uk/government/organisations/nuclear-decommissioning-authority](http://www.gov.uk/government/organisations/nuclear-decommissioning-authority)

Site License Companies (SLCs) and subsidiaries, which are the licensees carrying out the work on behalf of the NDA.

The NDA is responsible for the decommissioning of 17 nuclear facilities spread throughout England, Wales and Scotland, some dating back to the 1940s. This includes the first-generation Magnox nuclear power plant, a range of research and fuel facilities, and the largest and most complex site – Sellafield which has been the site of spent fuel reprocessing facilities since the 1950s. In 2016 Sellafield was transferred from SLC to the subsidiary Sellafield Ltd.<sup>79</sup>

An example of a SLC is LLWR Ltd (Low Level Waste Repository Ltd)<sup>80</sup>, which holds a license to operate the repository for low level waste, located close to Sellafield in the village of Drigg. Whilst it is the NDA's responsibility, they have a contract with LLWR Ltd, which runs the repository.

The NDA is responsible for the disposal of all forms of nuclear waste in repositories, including the grouping Higher Activity Waste (HAW), which cannot be disposed of with short lived low level waste, see below. The NDA has established RWM (Radioactive Waste Management Ltd)<sup>81</sup>, a wholly-owned subsidiary, as implementer. RWM's role is to develop plans for a deep geological repository for HAW, in the UK called GDF (Geological Disposal Facility). The NDA also supports RWM (and BEIS – the Department for Business, Energy and Industrial Strategy) in work on the site selection process for a GDF, read more below.

### *Regulator ONR*

The ONR (the Office for Nuclear Regulation)<sup>82</sup> is the regulator and was created under the Energy Act 2013, replacing the earlier Nuclear Installations Inspectorate.

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<sup>79</sup> Sellafield is one of Europe's largest industrial complexes, with a large amount of radioactive waste (including historic waste). Some of the facilities have become obsolete, no longer fulfilling high level modern requirements.

<sup>80</sup> [www.gov.uk/government/organisations/low-level-waste-repository-ltd](http://www.gov.uk/government/organisations/low-level-waste-repository-ltd)

<sup>81</sup> [www.gov.uk/government/organisations/radioactive-waste-management](http://www.gov.uk/government/organisations/radioactive-waste-management)

<sup>82</sup> [www.onr.org.uk/](http://www.onr.org.uk/)

*Advisory organisation – CoRWM*

The role of the CoRWM (the Committee on Radioactive Waste Management)<sup>83</sup> is to carry out independent reviews and provide guidance to ministers in the UK on the long-term management of the UK's higher activity radioactive waste. CoRWM has 12 members who represent a range of scientific and social disciplines.

**2.8.2 Management of nuclear waste***Classification*

In the UK, the waste is divided as follows:

- high level waste
- intermediate level waste
- low level waste

In the UK there is also a grouping of classes under the HAW classification (higher activity radioactive waste). HAW includes high level waste, intermediate level waste and a small amount of low level waste that is not currently suitable for disposal in the existing LLW repository near Drigg (due to chemical, physical or radiological properties that do not meet existing criteria for acceptance of waste).

*Spent nuclear fuel and reprocessing*

Spent fuel that is not currently intended for reprocessing at Sellafield and certain nuclear materials (separated plutonium and uranium) are not currently classified as waste. However, reprocessing is scheduled to cease from 2020. The government does not expect to carry out reprocessing of spent nuclear fuel from the proposed new nuclear power plants in the UK. When reprocessing ceases, spent fuel is expected to be classified as HAW and placed in interim storage prior to disposal in the planned GDF.<sup>84</sup>

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<sup>83</sup> [www.gov.uk/government/organisations/committee-on-radioactive-waste-management](http://www.gov.uk/government/organisations/committee-on-radioactive-waste-management); [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/712149/corwm-work-programme-2018-21.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/712149/corwm-work-programme-2018-21.pdf)

<sup>84</sup> Report to Joint Convention p. 118.

*Chapter set to close for reprocessing*

In November 2018 reprocessing of spent nuclear fuel from countries around the globe, that had been underway at THORP (the Thermal Oxide Reprocessing Plant) at Sellafield since 1994, was stopped. THORP is planned to be used as an interim storage facility for spent nuclear fuel until the 2070s.<sup>85</sup>

The Magnox Reprocessing Plant will cease operations in 2020. These two closures will transform Sellafield Ltd, which manages the UK's largest and most complex site featuring nuclear facilities, from an operational company into an organisation focused entirely on decommissioning.<sup>86</sup>

*Repository for low level waste – LLWR Ltd responsible*

The UK has the Low Level Waste Repository (LLWR), a centralised repository in the village of Drigg (close to Sellafield), which has been in operation since 1959. The repository is operated by LLWR Ltd, which has the contract with the NDA, the government-owned organisation with overall responsibility.

A small proportion of the low level waste cannot be deposited at LLWR or other repositories as the waste does not meet their acceptance criteria. Some waste will require development of new processing techniques before it can meet these, or as a last resort it will be treated as HAW at a future repository for HAW.<sup>87</sup>

Since 2015 the Dounreay LLW Disposal Facility in northern Scotland has featured a vault for low level waste from operations and decommissioning at this site, which was previously a research centre.

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<sup>85</sup> <http://news.onr.org.uk/2018/11/end-of-reprocessing-of-spent-nuclear-fuel-at-thorp-plant/>

<sup>86</sup> [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/761322/NDA\\_Draft\\_Business\\_Plan\\_2019-2022\\_-\\_031218\\_\\_3\\_.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/761322/NDA_Draft_Business_Plan_2019-2022_-_031218__3_.pdf) (see p. 9)

<sup>87</sup> For more information see the 'UK Strategy for the Management of Solid Low Level Radioactive Waste from the Nuclear Industry': [www.gov.uk/government/publications/national-waste-programme/national-waste-programme](http://www.gov.uk/government/publications/national-waste-programme/national-waste-programme)

*Interim storage of HAW – higher activity waste*

The NDA is working with its SLCs and subsidiaries in order to ensure the safe interim storage of the waste. The power company EDF Energy UK is responsible for the interim storage of its waste in co-operation with NDA, and NDA is responsible for the historical waste.

The HAW that is not high level waste is generated by a number of different facilities and business activities in the UK, including re-processing of spent nuclear fuel, operations and maintenance of radioactive facilities, and decommissioning. There is also historical waste from the 1950s onwards, which requires retrieval and reconditioning prior to disposal. Currently, HAW is stored at Sellafield, awaiting a repository. (There are plans to build another new interim storage facility for decommissioning waste at Harwell, Oxfordshire.) HAW is also currently stored in specially-built containers at over 20 nuclear power plants.

HAW that is considered high level waste from reprocessing is also stored at Sellafield. The waste has been vitrified and packaged in stainless steel containers in silos. Spent nuclear fuel that will not be reprocessed and that originates from AGR reactors (advanced gas-cooled reactors) is also in interim storage there.

Since 2017, spent nuclear fuel has also been stored in dry containers at the nuclear power plant Sizewell B.

*The policy of disposal of HAW*

The policy when it comes to disposal of HAW differs between the different countries in the UK. The governments of England and Wales are of the view that HAW should be managed for the long-term in a geological repository. However, the Scottish government does not support this option, and instead takes the view that HAW should be stored in facilities close to the surface, and as close to the place in which it was produced as possible. It should be noted that this policy does not apply to spent nuclear fuel and high level waste, as there is currently no such waste in Scotland.<sup>88</sup>

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<sup>88</sup> [www2.gov.scot/Resource/0051/00511782.pdf](http://www2.gov.scot/Resource/0051/00511782.pdf)

*Site selection process for a repository for HAW*

A precursor to the current site selection process was the MRWS process – *Managing Radioactive Waste Safely*, published in 2008. This was based on the voluntary principle, and in 2009 two local councils in Cumbria, together with the overall County Council, agreed to form a partnership to explore the implications of participation. The partnership was supported and funded by the government. However, the plans were stopped early in 2013 when Cumbria County Council voted not to continue, although the two local councils had agreed to.

Following this and a period of public consultation, the government released a new White Paper *Implementing Geological Disposal of HAW*, in July 2014. This reiterated that the choice of site should be voluntary and partnership-based. The government made the NDA responsible for the planning and delivery of the GDF. In April 2014 the NDA established a wholly-owned subsidiary, Radioactive Waste Management Limited, RWM, which replaced the previous Radioactive Waste Management Directorate (RWMD) as implementer on behalf of the NDA.

In January 2018 the responsible government department, BEIS, began a public consultation on a new policy regarding a GDF. Following this, in December 2018 the new policy was launched to replace the 2014 White Paper. The new document, *Implementing geological disposal – working with communities: updated framework for the long term management of higher activity radioactive waste* brings together information on a range of different areas:

- the government’s political framework for the management of HAW by implementing geological disposal through a GDF
- site selection on a voluntary basis, by working together with local communities in order to find a suitable site for a GDF, based on the 2018 consultations
- how the site selection process will work in terms of planning and regulations

A news bulletin released on the government’s website in late 2018 stated that all preparatory work for the site selection process had

been completed and that the implementer RWM had commenced the search for a site for a geological disposal facility.<sup>89</sup>

Between January and March 2019, RWM undertook a series of public meetings to support interested stakeholders in their development of responses to a consultation on how RWM will screen potential communities in terms of a number of technical and environmental criteria.<sup>90</sup>

In mid-2018 the NDA released its integrated strategy for the management of radioactive waste: *The Integrated Waste Management Radioactive Waste Strategy*.<sup>91</sup> One project underway at the NDA is researching the potential for, in addition to a deep geological repository, creating another repository closer to the surface for some HAW, depending on its characteristics. After the NDA has completed the project, it will provide recommendations to the government.

The benefit of such a repository is that decommissioning and dismantling can take place earlier, if it can receive the dismantling waste.

### 2.8.3 Further information

*The United Kingdom's Sixth National Report on Compliance with the Obligations of the Joint Convention on the Safety of Spent Fuel and Radioactive Waste Management*, October 2017<sup>92</sup>

*NDA Business Plan 1 April 2019 to 31 March 2022*<sup>93</sup>

*Department for Business, Energy & Industrial Strategy (BEIS)*

*website:* [www.gov.uk/government/organisations/department-for-business-energy-and-industrial-strategy](http://www.gov.uk/government/organisations/department-for-business-energy-and-industrial-strategy)

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<sup>89</sup> [www.gov.uk/guidance/about-national-geological-screening-ngs](http://www.gov.uk/guidance/about-national-geological-screening-ngs); [www.gov.uk/government/news/government-launches-new-policy-to-deal-with-radioactive-waste](http://www.gov.uk/government/news/government-launches-new-policy-to-deal-with-radioactive-waste); [www.gov.uk/government/publications/implementing-geological-disposal-working-with-communities-long-term-management-of-higher-activity-radioactive-waste](http://www.gov.uk/government/publications/implementing-geological-disposal-working-with-communities-long-term-management-of-higher-activity-radioactive-waste)

<sup>90</sup> [www.gov.uk/guidance/site-evaluation-consultations-public-events](http://www.gov.uk/guidance/site-evaluation-consultations-public-events)

<sup>91</sup> [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/729845/Radioactive\\_Waste\\_Strategy\\_July\\_2018.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/729845/Radioactive_Waste_Strategy_July_2018.pdf)

<sup>92</sup> [www-ns.iaea.org/conventions/results-meetings.asp?s=6&l=40](http://www-ns.iaea.org/conventions/results-meetings.asp?s=6&l=40)

<sup>93</sup> [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/790526/NDABusinessPlan2019-2022.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/790526/NDABusinessPlan2019-2022.pdf)

*Implementers:*

*[www.gov.uk/government/organisations/nuclear-decommissioning-authority](http://www.gov.uk/government/organisations/nuclear-decommissioning-authority)*

*[www.gov.uk/government/organisations/radioactive-waste-management](http://www.gov.uk/government/organisations/radioactive-waste-management)*

*Regulator: [www.onr.org.uk/](http://www.onr.org.uk/)*

# 3 Comparison of the countries

Below is a brief overview of the similarities and differences between the countries presented in this document.

## Nuclear power programme

*France* and *the UK* are both large nuclear power countries. They invested in nuclear power from an early stage, including fission technology for military purposes, which has led to them having a great deal of historical waste to manage. The two countries have reprocessed spent nuclear fuel, both for themselves and for other countries. For this reason, they have a number of different kinds of nuclear facilities and other nuclear installations. The two countries each have multiple reactors, and currently have no intentions of ending their nuclear power programmes. In *Finland*, which has fewer reactors, the intention is also to continue using nuclear power. One new reactor is currently near commission, with another having site selected but not construction granted.

In *Switzerland* and *Sweden*, the current plan is to continue operating existing reactors but not build any new ones (even if the nuclear option is not legally closed in Sweden).

In *Spain* there are also no plans for new reactors, and a decision has been made in April 2019 for the scheduled closure of the existing nuclear power plants. In the *Czech Republic* no decisions have yet been reached. According to current plans in the countries featured in this text, *Germany* will be the first to phase out nuclear power, scheduled to end of 2022 at the latest.

*Current status of plans for nuclear power programmes<sup>1</sup>*

France – new construction underway

UK – new construction underway

Finland – new construction underway

Switzerland – no plans for new construction

Sweden – no plans for new construction

Czech Republic – no decision on new construction

Spain – decision to phase out nuclear power by 2035

Germany – decision to phase out nuclear power by 2022

**Implementers of repositories for spent nuclear fuel and/or high level waste**

The majority of the implementers are state-owned/governmental, although there are differences in how they are organised. However, in Sweden and Finland, the implementers are owned by the nuclear power companies, and in Switzerland the implementer is run in collaboration between the government and the nuclear power companies.

*Implementer (of repositories for spent nuclear fuel and/or high level waste)*

France – Andra – governmental

UK – NDA/RWM – governmental

Germany – BGE – governmental

Spain – Enresa – governmental

Czech Republic – SÚRAO – governmental

Sweden – SKB – jointly owned by the nuclear power companies

Finland – Posiva – jointly owned by two nuclear power companies

Switzerland – Nagra – cooperative of the government and nuclear power companies

The implementers have different duties in all eight countries, but one factor they all have in common is that they are tasked with disposing of spent nuclear fuel and/or high level waste in repositories.

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<sup>1</sup> For information on the rest of the world, see: *Plans For New Reactors Worldwide*: [www.world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors-worldwide.aspx](http://www.world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors-worldwide.aspx)

Finland is the only country with the implementer Posiva solely focused on the disposal of spent nuclear fuel in a repository.

It is common for the implementers to also be responsible for disposal of low and intermediate level waste in repositories. There are already repositories for short lived low level and potentially also intermediate level waste in many countries, see the box below. The repositories that are operational are all relatively close to the surface. Germany (BGE) and Switzerland (Nagra) have plans for deep geological repositories for low and intermediate level waste. In Germany, construction is underway at a mine that is to be repurposed as a repository for low and intermediate level waste (Konrad) and in Switzerland a site selection process is ongoing.

*Repositories in operation close to the surface (near surface) for short lived waste*

LLW – low level waste

LILW – low and intermediate level waste

**UK** – (LLW) LLW Repository – NDA

**Spain** – (LILW) El Cabril – Enresa

**France** – (LILW) Centre de l'Aube – Andra

**Sweden** – (LILW) SFR – SKB

**Finland**<sup>2</sup> – (LILW) Olkiluoto and Loviisa – TVO and Fortum

**Czech Republic**<sup>3</sup> – (LLW) Dukovany – SÚRAO

## Interim storage of spent nuclear fuel and high level waste

The nuclear power companies are often responsible for interim storage. In Sweden, the nuclear power companies are responsible for interim storage through their implementer, SKB. In Switzerland the nuclear power companies have formed Zwiilag, a company specifically responsible for interim storage. In Spain, the nuclear power companies are responsible for decentralised interim storage, whilst

<sup>2</sup> Short and long lived operational, and nuclear power plants decommissioning wastes are, and will be, disposed in the low and intermediate waste repositories nearby the currently operating nuclear power plants at Olkiluoto and Hättholmen.

<sup>3</sup> In Dukovany operational waste (low level waste) is stored based on the new Atomic Act (263/2016). There are also two repositories for low and intermediate level waste (Bratrství for naturally occurring radionuclides and Richard for medicine, industry and research).

the governmental implementer Enresa is responsible for designing, constructing and operating a planned centralised interim storage facility. In the UK the governmental implementer NDA is responsible for all legacy waste, whereas the nuclear power company is responsible for interim storage of its waste until a GDF/repository is available.

In Germany a governmental company (BGZ) began taking over responsibility for interim storage from the nuclear power companies in 2017.

*Responsibility for interim storage of spent nuclear fuel (SNF) and high level waste (HLW)*

Centralised interim storage facility and/or decentralised storage at the nuclear power plants

**Sweden** – SKB, (the nuclear power companies' implementer), centralised interim storage facility

**Switzerland** – Zwiilag (nuclear power companies' storage company), centralised and decentralised.

**Spain** – currently the nuclear power companies, decentralised. Enresa will be responsible for a planned centralised interim storage facility

**Finland** – the nuclear power companies, decentralised.

**Czech Republic** – the nuclear power companies, decentralised.

**France** – the nuclear company EDF and other producers responsible for SNF at La Hague by the reprocessing facility and HLW at La Hague.

**UK** – NDA (governmental implementer) responsible for SNF and HLW legacy/historical waste. The nuclear power companies in cooperation with NDA, responsible for its SNF and HLW in Sellafield and decentralised.

**Germany** – BGZ (separate governmental organisation), centralised and decentralised.

## Classification

The countries classify radioactive waste in different ways, and this may depend on how it needs to be managed or its level of radioactivity. It may also depend on other factors, such as in Germany, where the heat generation of the waste is a decisive factor.

The clearest differences are apparent in how the countries interpret *intermediate level waste* (ILW)<sup>4</sup>, which in turn influences how it is to be disposed of. Some countries classify short lived waste with a high radioactive content as ILW in their national systems, even though it could be managed in a way similar to that used for low level waste (LLW). Furthermore, there may be national requirements whereby waste that is partially long lived must be stored in a geological repository facility as high level waste, even if it could be classified as LLW or ILW under the IAEA's classification (GSG-1).

Another example is the classification *very low level waste* (VLLW)<sup>5</sup>, which has not been addressed in this text. There are a few countries that currently use this classification (incl. France, Spain and Sweden). In Spain and France, there are special repositories for VLLW.<sup>6</sup> In Sweden, VLLW is disposed of in surface repositories at some of the nuclear facilities. In the UK, in its 2018 strategy the NDA stated that it would be developing ways of disposing of VLLW.<sup>7</sup>

Some countries use VLLW as a sub-classification of short lived low level waste. In some countries VLLW is disposed of with other waste types (e.g. LLW). More repositories for VLLW will probably be built, as it is easier, and more economical than to dispose it with LLW. In the future, there will be large quantities of VLLW to dispose of as large numbers of nuclear facilities are to be decommissioned and dismantled.

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<sup>4</sup> See IAEA Status and trends: p. 17f: [www.iaea.org/publications/11173/status-and-trends-in-spent-fuel-and-radioactive-waste-management](http://www.iaea.org/publications/11173/status-and-trends-in-spent-fuel-and-radioactive-waste-management)

<sup>5</sup> Disposal in special landfill-type facilities.

<sup>6</sup> Inside the site of El Cabril, there is a specific place for very low level waste (VLLW) disposal, separate from low and intermediate level waste (LILW) disposal. In France in Morvilliers, there is the CIREs repository for VLLW.

<sup>7</sup> NDA strategy 2018 – the development of alternative paths for the disposal of VLLW is underway in the UK, for example.

## Reprocessing

In many countries spent nuclear fuel is regarded and handled as waste, whilst in others it is considered a potential future energy resource. If it is reprocessed, the system is called a 'closed fuel cycle'. If it is not reprocessed, the system is called an 'open fuel cycle'.

A few countries reprocess their spent nuclear fuel today, France does it partly. The UK reprocesses a part of its spent nuclear fuel, but intends to stop doing so in the near future.

The majority of countries around the world use an open fuel cycle and plan to dispose of spent fuel directly. Many of these countries still consider spent nuclear fuel a potential resource, which is why they have not yet declared it to be high level waste.

Several countries have changed their policy from a closed fuel cycle to an open fuel cycle with direct disposal of spent nuclear fuel. Some made the change in the early 2000s, such as Germany and Switzerland, whilst others made the switch earlier such as Sweden and Spain.

## Disposal of spent nuclear fuel/high level waste/long lived intermediate level waste

There are differences in terms of the kinds of waste the countries intend to dispose of in their planned geological repositories for spent nuclear fuel/high level waste/long lived intermediate level. Finland and Sweden now have spent nuclear fuel to dispose of. France's current plans are to dispose of high level waste and long lived intermediate level waste, as France operates a partly closed fuel cycle with reprocessing of spent nuclear fuel. The rest of the countries covered in this summary intend to dispose of spent nuclear fuel, high level waste (and long lived intermediate level waste) in the same repository.

In terms of site selection processes, Finland is the only country that has made a decision on a site location. France and Sweden, which do have planned sites today, were forced to restart their site selection processes following unsuccessful processes in the 1980s.

Currently, site selection processes are underway in both Switzerland, which has recently started the third and last stage of its

process, and the Czech Republic, which has faced a number of challenges.<sup>8</sup> Following unsuccessful prior attempts, Germany and the UK have recently restarted their site selection processes, applying new approaches.

One factor in common to all site selection processes is that participation and transparency are considered key.

In Spain, the plans for a repository for spent nuclear fuel and high level waste have been postponed. Instead, a process is ongoing to provide interim storage for the waste for at least 60 years, but even this process has encountered problems.

In the IAEA report *Status and Trends*, it is stated that if a repository site is selected and accepted by the public, a further challenge is then to maintain this public acceptance during the long construction period the project entails, as such processes take many decades, if not a century or more. This is a factor the Swedish National Council for Nuclear Waste has also taken into account (the producer of this report), as has the Swedish Land and Environment Court (time perspective in the pronouncement to the government about SKB's application for a repository for spent nuclear fuel).

*Plans for host rock/geological formation and container material (for a planned repository for spent nuclear fuel and/or high level waste)*

*Sweden:* KBS-3, i.e. granite and copper containers (canisters)

*Finland:* KBS-3, i.e. granite and copper containers (canisters)

*The Czech Republic:* crystalline host rock and metal containers (combination of stainless and carbon steel)

*France:* claystone and stainless steel containers

*Switzerland:* claystone and the current concept foresees steel containers (alternatives materials are further explored as well)

*Germany:* not determined

*UK:* not determined

*Spain:* not determined

<sup>8</sup> [www.surao.cz/en/director-prachar/](http://www.surao.cz/en/director-prachar/)

Many countries have also made plans to store long lived intermediate level waste in their repositories for spent nuclear fuel and/or high level waste. In Sweden on the other hand, the implementer SKB plans to create a specific repository for long lived waste.

## Decommissioning and dismantling

The NDA<sup>9</sup> in the UK and Enresa in Spain are the two implementers discussed in this summary who also have a responsibility for decommissioning and dismantling. Otherwise, it is common for the nuclear power companies to be responsible for this (including in Germany, where the state has assumed almost all responsibilities).

For reasons of brevity, this text has not covered the decommissioning and dismantling of nuclear facilities. This is an area of increasing importance as a growing number of reactors and other nuclear facilities have been closed permanently or are set to be closed in the near future. (More information on this is available in the countries' reports to the Joint Convention.)

An increase in decommissioning activities entails greater challenges regarding planning, disassembly, financing, and, above all, disposal of dismantling waste. In certain cases, there are delays to the decommissioning and dismantling due to a lack of options for disposal. Furthermore, much of the waste produced as a result of the decommissioning of a nuclear facility is different to standard operational waste: for example, it can contain a higher proportion of metals.

Efforts to minimise the amount of waste by, for example, sorting, decontaminating, recycling and reusing will grow in importance in order for the waste to be deposited in existing and future repositories. The availability of qualified personnel/expertise will also pose a challenge. As the reactors age, so do experienced personnel, and their expertise is often decisive in the safe decommissioning of facilities. It is of utmost importance that existing expertise is passed on to future generations.

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<sup>9</sup> NDA is responsible for legacy waste. The NDA also performs certain advisory functions for the Secretary of State, including reviewing decommissioning plans for the UK's nuclear new build programme and providing oversight of the decommissioning plans of the EDF energy fleet. See: <https://cnpp.iaea.org/countryprofiles/UnitedKingdom/UnitedKingdom.htm>

### 3.1.1 Conclusion

A great deal of work is currently underway on how nuclear waste and other radioactive waste can be managed in terms of factors such as conditioning, interim storage, disposal in repositories, decommissioning and dismantling. Currently no country in the world has a repository for spent nuclear fuel and/or high level waste. Research is being carried out in a number of countries around the world into how we can store this waste for hundreds of thousands of years in repositories.

The countries have different requirements regarding geological formations, political and legal frameworks, etc. so concepts can rarely be copied directly.

*The question is how the different countries around the world can best utilise each others' experiences, both good and bad, during the century/centuries the management of radioactive waste will take? There is currently cooperation, but how can it be further developed?*

One decisive issue is that expertise will need to be available in order to carry out the work – this is a challenge many countries are facing.

We have created waste that future generations will need to help us manage. What is the most ethical way of resolving this issue? In countries such as France, Switzerland and Germany, there are laws requiring the work to be reversible, given it will take multiple decades to carry out the work and we are unsure what the future holds.

During 2016 a law was passed in *France*, providing a more specific definition of reversible in regard to work on a deep geological repository. It must be possible for coming generations to either continue on with prior decisions, or reassess these decisions and change the solutions for waste management. This principle can be implemented via a stepwise licensing process, provision of the option to adapt the design, and provision of flexibility in operations in order to be able to integrate technical advances (and adapt to any changes in the waste inventory)<sup>10</sup>.

Reversibility also includes the opportunity to retrieve the packages of waste (waste retrievability) already placed in the repository. For example, in *Switzerland*, the implementer must demonstrate

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<sup>10</sup> In France potentially from high level waste to spent nuclear fuel if changes to energy policy occur.

through experiments that it is technically feasible to retrieve the waste, before the repository is ready for operation. In Switzerland there must also be a pilot facility close to the repository, where radioactive waste is emplaced and observed during the entire operational and monitoring phase.

In *Germany*, the waste must be retrievable for at least 500 years (due to factors including their bad experiences with the disposal of short lived low and intermediate level waste in salt mines).

These are examples of chances for self-reflection. The Swedish National Council for Nuclear Waste considers this important given we do not know the stances future generations, whom we will be leaving this waste to, will take. Nor do we know how technology and society will change over time while repositories are in operation, which could be a century or more in many countries.

Other examples of the opportunities for self-reflection and humility during the construction, operation, sealing and after, are:

- monitoring programmes
- the opportunity for openness and transparency by participation of other actors also in safety audits of safety cases etc. (in the host municipalities, NGOs and others)
- the opportunity for openness and transparency in the ongoing research programmes – which facilitates involvement from universities and colleges
- the opportunity for openness and transparency by international reviews
- and, not least, being aware of the progress and research underway in the world

A repository for spent nuclear fuel/high level waste must last at least for 100,000 years (up to one million years) from earthquakes, ice ages and human intrusion (intentional or unintentional). One big challenge for all countries will be to keep records, knowledge and memory of the waste and repositories for more generations to come, than we can even imagine.

### Further reading about countries in the world

This text has considered eight countries in Europe, you can read more about other countries in their reports to the Joint Convention.<sup>11</sup>

IAEA also has 'Country Nuclear Power Profiles' with information.<sup>12</sup>

Regularly updated information is available in the 'Country Profiles' on the website of the World Nuclear Association.<sup>13</sup>

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<sup>11</sup> [www.iaea.org/topics/nuclear-safety-conventions/joint-convention-safety-spent-fuel-management-and-safety-radioactive-waste/documents?page=3](http://www.iaea.org/topics/nuclear-safety-conventions/joint-convention-safety-spent-fuel-management-and-safety-radioactive-waste/documents?page=3)

<sup>12</sup> <https://cnpp.iaea.org/pages/index.htm>

<sup>13</sup> [www.world-nuclear.org/information-library.aspx](http://www.world-nuclear.org/information-library.aspx)

The Swedish National Council for Nuclear Waste keeps track of developments in other countries' programmes for management of nuclear waste and spent nuclear fuel. One element of this work is undertaking an annual study trip. This report provides an overview of the situation in Sweden, as well as in the countries the Council has visited in recent years: Finland, Germany, Switzerland, Spain the Czech Republic, France and the United Kingdom.

This overview briefly covers:

- who the implementers are for designing, building and (later) operating repositories for spent nuclear fuel and/or high level waste
- who the regulators (supervisory authorities) are
- if there is an advisory organisation
- how the country classifies its waste
- if the waste is reprocessed/has been reprocessed
- who is responsible for interim storage
- if there are repositories for low and intermediate level waste, or plans for such facilities
- what plans are underway for disposal of spent nuclear fuel and/or high level waste in deep geological repositories

Information is also provided on where further information for each country are available, as there is a constant stream of new information becoming available in the field. The last section provides a summary, highlighting the similarities and differences between countries.