Ds 2024:17

Sweden's Eighth National Report under the

Joint Convention on the safety of spent fuel management and on the safety of radioactive waste management

Sweden's implementation of the obligations of the Joint Convention

Government Offices of Sweden
Ministry of Climate and Enterprise

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Upper left: Ms. Romina Pourmokhtari, Minister for Climate and the Environment, visiting SKB's Äspö Hard Rock Laboratory outside Oskarshamn in February 2024.
Upper right: Illustration of the repository for spent nuclear fuel, including facilities above ground, the underground disposal area as well as connecting ramp and shafts.
Lower left: Disassembly of Co-60 source holder at Cyclife Sweden AB, Non-Nuclear Department.
Lower right: M/S Sigrid, built for transporting spent nuclear fuel and radioactive waste between the nuclear power plants, the central interim storage facility and the final repositories.

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Foreword

The requirements of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management have for a long time been incorporated in the Swedish framework. The Swedish Government judged at the time of signing the Joint Convention in 1997 that the national policy and legislation, as well as the safety work conducted by the licensees and the authorities, complied with the obligations of the Convention.

The Swedish nuclear programme is in a phase of change. Massive expansion of nuclear power production is anticipated to meet the climate objective of net-zero emissions by 2045. At the same time, full-scale dismantling and decommissioning of several reactors is underway. The Swedish Government is currently taking a full range of measures to facilitate the commissioning and establishment of new reactors while ensuring the high level of safety, security, and safeguards. An intensive work has started. The Government has appointed a committee of inquiry that will propose changes to the legal framework, aiming at making the process of licensing new nuclear activities and facilities more efficient. In addition, the committee of inquiry will establish fair and effective licensing fees, and analyse the need for adaptation and development of the existing waste management programme to ensure safe final disposal of spent nuclear fuel and radioactive waste from new reactors.

A system for the final disposal of spent fuel from nuclear reactors is now underway. Since Sweden's Seventh National Report under the Joint Convention, the Swedish Government has granted licensing decisions for a deep geological repository for spent nuclear fuel from the current fleet of reactors, for a fuel encapsulation plant, as well as for an extension of the existing repository for low- and intermediate level waste to include reactor decommissioning waste.

Sweden continues to fulfil the requirements on nuclear safety, radiation protection and safe waste management. A second full scope IAEA IRRS mission to Sweden was performed in November 2022, followed by a back-to-back ARTEMIS mission in April 2023. Both missions provided valuable feedback that enables further development and improvement of nuclear safety, radiation protection and safe waste management. The Swedish programme for spent nuclear fuel disposal was recognised as Good Practice as it is based on a mature concept that has gained wide acceptance through a successful siting process involving all stakeholders. The Swedish Government has initiated measures to address the identified challenges concerning safe and sustainable management of radioactive waste from outside the nuclear fuel cycle, and measures concerning long term national competence provision.

This report was produced by representatives from the Swedish Radiation Safety Authority with the support of the Swedish Nuclear Fuel and Waste Management Company, see section L3. Information has also been provided by other fuel cycle facilities and waste management organisations.

Pursuant to the requirements of the Joint Convention, Sweden submits its Eighth National Report on the fulfilment of obligations under the Convention and accounts for developments since the Seventh Review Meeting. Sweden reaffirms its commitment and continues to comply with the Joint Convention.

Stockholm, 20 June 2024

Romina Pourmokhtari

Minister for Climate and the Environment

Section A – Introduction

A.1 Purpose and structure of this report

Sweden signed the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (hereinafter "Joint Convention") on 29 September 1997. Sweden ratified the Joint Convention approximately two years later and has been a Contracting Party to the Joint Convention since 29 July 1999. The Joint Convention entered into force on 18 June 2001.

Each Member State that has ratified the Joint Convention (Contracting Party) is obligated to prepare a national report covering the scope of the Joint Convention and to subject the report to review by other Contracting Parties at review meetings held in Vienna, Austria. Sweden has participated in all review meetings since the First Review Meeting was held in November 2003. The present report is the Eighth Swedish National Report under the Joint Convention.

This report meets the requirements of the Joint Convention for reporting on the status of safety at spent fuel and radioactive waste management facilities within Sweden's borders. It constitutes an updated document with the same basic structure as the previous national reports under the terms of the Joint Convention, and reflects developments in Sweden up to 1 April 2024, unless stated otherwise. The report will be subject to review in March 2025 at the Eighth Review Meeting of the Contracting Parties in Vienna.

The report's format and content follow the guidelines for National Reports, as agreed at the Second Review Meeting of Contracting Parties to the Joint Convention, held in May 2005 (including subsequent revisions). The sections in this report have the same titles as in these guidelines, thus facilitating review by other Contracting Parties. Table A1 provides a cross reference between the sections in this report and the specific reporting provisions of the Joint Convention.

Table A1 Joint Convention Reporting Provisions.

National Report Section	Joint Convention Section
A. Introduction	_
B. Policies and Practices	Article 32, Paragraph 1
C. Scope of Application	Article 3
D. Inventories and Lists	Article 32, Paragraph 2
E. Legislative and Regulatory Systems	Articles 18–20
F. General Safety Provisions	Articles 4–9, 11–16 and 21–26
G. Safety of Spent Fuel Management	Articles 4–10
H. Safety of Radioactive Waste Management	Articles 11–17
I. Transboundary Movement	Article 27
J. Disused Sealed Sources	Article 28
K. General Measures to Improve Safety	Multiple Articles
L. Annexes	Multiple Articles

Section A provides a broad overview of the Swedish waste management system, including a brief account of important developments since the last national report. Section A also includes a summary of highlights and issues raised with regard to the Swedish report and presentation during the Seventh Review Meeting, held 27 June to 8 July 2022, as well as a list of issues Sweden was asked to report on in its Eighth National Report.

At the Seventh Review Meeting it was agreed to address four topics in the National Reports for the next Review Meeting. These topics are discussed as follows in the current report.

- Competence and staffing linked to timetable for spent fuel and radioactive waste management programmes, see sections K.1.2 and K.3.1.2.
- Inclusive public engagement on radioactive waste management and spent fuel management programmes, see section K.5.
- Ageing management of packages and facilities for radioactive waste and spent fuel, considering extended storage periods, see section K.2.2.
- Long term management of disused sealed sources, including sustainable options for regional as well as multinational solutions, see sections J, K.1.1 and K.3.2.1.

A.2 Overview matrix

The rapporteur's overview matrix has been revised and supplemented with references to explanatory sections of the report to provide continuity from the Second Review Meeting, see Table A2.

Table A2 Revised overview of the Swedish programme for management and disposal of spent nuclear fuel and radioactive waste.

Type of liability	Long-term management policy	Funding of liabilities	Current practice/ facilities	Planned facilities
Spent fuel	NPP licensees responsible. Shared obligations for cost calculations and development of disposal solutions.	Funded by fees on nuclear energy production, accumulated in segregated funds (the Nuclear Waste Fund).	Stored on site initially, then transferred to the central interim storage facility (Clab) pending disposal. Reviews of the adequacy of funding every three years.	Government licence granted for construction of an encapsulation plant and a spent nuclear fuel repository. Pending conditions by the Land and Environment Court and approval of PSAR by SSM. All licences in place for extension of storage capacity in Clab.
Nuclear fuel cycle waste	NPP licensees responsible. Shared obligations for cost calculations and development of disposal solutions. Strategy in place for disposal.	Mainly funded by fees on nuclear energy production, accumulated in the Nuclear Waste Fund. Disposal of short-lived operational LILW (SFR) from NPPs, paid for directly by owners.	Short-lived LILW disposal at existing repository (SFR); shallow land burial for short-lived VLLW are present at NPP sites. Reviews of the adequacy of funding every three years.	Government licence granted for extension of the SFR repository for short-lived LILW. Pending approval of PSAR by SSM. Long-lived LILW to be disposed of in the planned repository for long-lived LILW (SFL).
Non-power waste	Disposal at fuel cycle waste facilities when appropriate.	Financed by producers/ owners of waste. Government funding available for legacy waste.	Disposal at fuel cycle waste repository (SFR) or interim storage pending disposal in the planned repository for long-lived LILW and nuclear fuel cycle waste (SFL).	Government licence granted for extension of the SFR repository for short-lived LILW. Pending approval of PSAR by SSM. Long-lived LILW to be disposed of in the planned repository for long-lived LILW (SFL).
Decommissioning	Licensees are responsible.	Mainly funded by fees on nuclear energy production (NPPs) or other fees, accumulated in the Nuclear Waste Fund.	Preliminary plans for decommissioning exist for all nuclear facilities, with more detailed plans for those approaching or undergoing decommissioning. Reviews of the adequacy of funding every three years.	Government licence granted for extension of the SFR repository for short-lived LILW. Pending approval of PSAR by SSM. Long-lived LILW to be disposed of in the planned repository for long-lived LILW (SFL).
Disused sealed sources	Returned to manufacturer or disposed of in SFR or in interim storage pending disposal in the planned repository for long-lived LILW (SFL).	Financed by producers/ owners of waste. Government funding available for orphan sources.	Returned to manufacturer or disposed of in SFR or in interim storage pending disposal in the planned repository for long-lived LILW (SFL).	To be disposed of in repositories for nuclear fuel cycle waste, SFR or SFL (if not returned to the manufacturer).

A.3 Summary of results from the previous review

In the period prior to the Seventh Review Meeting, Sweden received 140 questions on the report from 19 countries. The questions touched upon most of the articles of the Joint Convention. All the questions were answered on the Joint Convention website and commented on during the Review Meeting.

The Country Group identified a Good Practice related to Sweden's spent nuclear fuel programme: *High ability to tackle very challenging issues submitting and obtaining a licence for KBS-3 disposal system (encapsulation plant and geological disposal)*.

The review further acknowledged two Areas of Good Performance related to:

- commitment to implement solutions for spent nuclear fuel and radioactive waste management as planned, and
- modernisation of radioactive waste and spent nuclear fuel legislation.

The Challenges identified by the Country Group pertain to the following areas:

- the management system for radioactive waste generated from outside of the nuclear fuel (in particular plans for disposal),
- reinforcing a sustainable management of human resources and knowledge, and
- retrieval, characterisation and handling of non-conformities at the SFR facility (related to the identified waste being non-compliant with waste acceptance criteria).

The rapporteur's report also included a specific Suggestion (similar to the first Challenge above), namely to *Establish a strategy for the management of all non-fuel cycle waste arising in Sweden provision.*

The measures taken to address the Challenges and Suggestion are discussed in section K.1 of this report.

A.4 Summary of developments since the previous report

This section briefly summarises key developments in Sweden's waste management programme since the Seventh Review Meeting under the Joint Convention.

New nuclear energy policy

One of the Swedish Government's six priorities is the pursuit of an ambitious and effective climate policy to achieve the climate objective of net-zero emissions by 2045. The Government is overhauling its energy and climate policy, investing in new nuclear energy and taking a holistic approach to promote the industrial sector's green transition, improve the business sector's conditions in the long term and enhance competitiveness. The Swedish Government has proposed an energy policy orientation bill for the parliament to decide. In the proposed energy policy Sweden plans to meet a demand for electricity of at least 300 TWh until 2045, and the Government estimates that new nuclear with installed electrical capacity equal to two large scale reactors should be in operation by 2035 and capacity approximately equal to 10 new large-scale reactors in operation by 2045.

Governmental inquiry on preparation for new nuclear power

The Government has initiated an inquiry to propose the necessary changes to the legal framework to: (i) make the process of licensing new nuclear more efficient, (ii) establish fair and effective fees for the licensing of new nuclear, (iii) to adapt and develop the existing nuclear waste programme for the management of waste from new reactors, and (iv) adapt emergency preparedness requirements.

The investigation of tasks (i) and (ii) will be reported 30 December 2024, task (iii) 29 August 2025 and task (iv) 27 February 2026. Numerous designs, for both conventional large-scale reactors and small modular reactors (SMRs), are being developed. Therefore SSM needs to take a broad approach to be ready if an application is submitted. The challenge to safely manage spent nuclear fuel and radioactive waste from new nuclear power plants is discussed more in detail in section K.3.2.2.

Strengthening of the regulatory authority and long-term national competence

SSM has received increased funding from the Government to review and develop the regulatory framework and licensing processes for existing and new nuclear power, and to strengthen the Authority's competence and national competence provisions in the field of nuclear safety, radiation protection, physical protection and nuclear non-proliferation. The additional SSM budget allocation for the period 2023 to 2025 amounts to SEK 125 million. As of 2024, SSM has also received substantially increased funding to strengthen its support to national research (an increase of SEK 20 million in

2024 and an estimated increase of SEK 40 million in the following years). The objective is to meet the long-term national competence demand that follows from the development of new nuclear power. For more information on continued reinforcement of sustainable management of human resources and knowledge, see section K.1.2.

Investigation on possible Technical Support Organisation
The Government has decided to give the Swedish Agency for Public Management the task of investigating the possible creation of an expedient and efficient technical support organisation for nuclear safety and radiation protection that meets their needs. See further section K.1.2.3.

Reactor decommissioning
At the Ringhals nuclear power plant, reactor Unit 2 was permanently shut down in December 2019 and Unit 1 in December 2020. In March 2024 SSM approved Ringhals' safety related documentation to commence dismantling and decommissioning.

At Barsebäck 1 and 2 the segmentation of the reactor pressure vessel, the internal components of the reactor pressure vessel as well as the biological shield have been completed. Dismantling in various buildings and systems, such as in the turbine and the reactor buildings, is currently ongoing. Site release in accordance with regulatory requirements is planned for the mid-2030s.

At Oskarshamn Units 1 and 2 there is ongoing dismantling and demolition work. At Unit 1 segmentation of the reactor vessel is ongoing. At Unit 2 segmentation of the reactor vessel is completed. Further, at both units dismantling and demolition of systems in the reactor building and preparation for segmentation of the biological shield are ongoing. See also sections D.1.5 and F.6.

Licence applications for spent nuclear fuel facilities
In January 2022, under the Act on Nuclear Activities, the Government formally approved the KBS-3 system for final management of spent nuclear fuel, including an encapsulation facility adjacent to the existing interim storage facility, Clab near Oskarshamn, and the planned geological disposal facility at Forsmark. SKB intends to submit a PSAR for the geological disposal facility for SSM's approval in late 2024, in accordance with the Government's licence conditions. SSM's approval is necessary for starting the construction of the facility. A corresponding application by SKB to SSM for the encapsulation plant is expected somewhat later.

Following the Government's decision in August 2021 to approve an increase in the authorised storage capacity of the interim storage facility for spent fuel, Clab, SSM approved SKB's updated safety report for the facility, including a description of planned safety-enhancing measures related to control in the event of major incidents, in February 2024. This enables SKB to increase the quantity of spent nuclear fuel in Clab storage pools beyond the previous threshold of 8,000 tonnes. The current licence allows storage of up to 11,000 tonnes of spent fuel.

Licence application for an extension of the SFR disposal facility
In December 2021 the Government issued a new licence, under the Act on Nuclear Activities, covering the increase in capacity of the existing disposal facility for short-lived low- and intermediate-level waste (from 63,000 m^3 to 180,000 m^3). The primary purpose of the extension is to accommodate short-lived waste from the decommissioning of nuclear power reactors. Subsequently, in March 2023, SKB submitted to SSM the preliminary safety report (PSAR) for the facility, approval of which is a condition for starting construction. SSM's decision to approve the start of the construction works is expected by the summer of 2024.

Decommissioning of the Äspö Hard Rock Laboratory
The original goals of the Äspö Hard Rock Laboratory at Äspö have been fulfilled after three decades of research and development and SKB is currently finalising the last experiments and preparing to decommission the underground part of the facility, see section A.7.1.2.

Review of SKB's thirteenth programme for Research, Development and Demonstration
In September 2022, SKB, on behalf of the nuclear power plant licence holders, submitted its thirteenth tri-annual research, development and demonstration (RD&D) programme for the management of spent nuclear fuel and nuclear waste to SSM for evaluation. SSM concluded that the RD&D programme 2022 fulfils the statutory requirements, based on its review, including a public consultation process. In its statement of March 2023, the Authority recommended the Government's approval, with certain proposed conditions that SKB takes into account SSM's review comments in the continued development of the programme. See sections A.7.1.1, G.1.2.1, G.1.3.1, H.1.2.1 and H.1.3.1.

European Spallation Source
The European Spallation Source ERIC (ESS) has in October 2023 handed in an application for the trial operation of the superconducting part of the linear accelerator at the ESS facility. The Swedish Radiation Safety Authority (SSM) is currently reviewing this application. In addition, ESS is also engaged in discussions with different industry stakeholders concerning the challenge of intermediate storage, handling and disposal of radioactive waste emerging from future operation and decommissioning of this facility, see section A.5.1.

Responsibilities for legacy waste
In April 2021, SSM received an assignment from the Government to investigate the issue of responsibility for the legacy waste and to submit proposals for measures to be taken by the Government. SSM reported to the Government in February 2022. In its assessment, SSM concluded that the responsibility of the larger part of the nuclear and non-nuclear legacy waste rested on AB Svafo, a company formed by the NPP licence holders.

However, according to SSM, financial support by the State was motivated for the treatment and disposal for parts of the legacy waste. SSM suggested that conditions for such a financial support system to be further investigated by the National Debt Office (NDO) and also proposed that the NDO assessed whether a larger part of the long-lived waste at the Studsvik Tech Park site should be included in the Financing Act. The National Debt Office handed in their assessment to the Government in January 2024. See also sections K.1.3 and K.3.2.1.

Major revision of SSM regulations
SSM is now in a final phase of revising its Code of Statutes relating to nuclear activities and activities involving radiation, in a process that started in late 2013. Experience demonstrated the need to clarify and broaden the regulations to create more predictability for the licensees and to improve regulatory support. The objectives were to establish an improved, more transparent and consistent set of requirements, give a more logical structure, and to improve the preconditions for more integrated regulatory supervision.

To achieve these objectives, it was decided to define a collective term that encompasses "nuclear safety", including "security" (in accordance with the Act on Nuclear Activities) and "radiation protection". The term "radiation safety" was considered to cover these aspects and was therefore defined accordingly. This new terminology supports the regulations of radiation safety at nuclear facilities and other activities involving radiation for different phases of a facility's lifetime and for main types of different substantive issues. The first of the new regulations in the established structure entered into force in June 2018 and key regulations governing nuclear power plants, together with new regulations for pre-disposal management of radioactive waste from nuclear facilities waste, came into force in March 2022 (see below). Two regulations are still under development, namely the revised regulations on geological disposal facilities and regulations on nuclear facilities except nuclear power plants. The regulations are planned to be completed and enter into force in 2026. See section K.2.1.

New regulations on pre-disposal management of radioactive waste from nuclear facilities
The regulations on the management of radioactive waste, including spent nuclear fuel, from nuclear facilities (entered into force March 2022) must be applied by those who conduct nuclear activities and handle radioactive waste, e.g. at shallow land burials. The regulations specify requirements for documented plans for the radioactive waste managed at each facility. The plans must be based on an evaluation of alternative management options and derivation of acceptance criteria that specify the characteristics of spent nuclear fuel and radioactive waste that can be accepted for storage, disposal or other treatment. The regulations also contain requirements for control measures for waste items to ensure that they meet the acceptance criteria. Furthermore, description of waste types must be documented and waste items verified. In addition, an updated inventory must be carried out of all used fuel and radioactive waste at each facility (see also section L.1.2).

The Swedish National Council for Nuclear Waste
The advisory body, the Swedish National Council for Nuclear Waste was closed by the Government in 2022/2023. The Council was an independent body under the previous Ministry of Environment since 1992. The Council's mandate was to study issues relating to nuclear waste and to advise the Government and authorities on these issues. According to the Government, the Council was no longer needed because a licence was granted in 2022 for the spent nuclear fuel disposal facility.

IRRS mission
Sweden's second full scope IRRS mission took place during November 2022; the previous one took place in 2012 with a follow up in 2016. The IRRS team identified one Good Practice in the area of supervision and optimisation of patient dosimetry, but also 19 Suggestions and 33 Recommendations. The IRRS team considered that Sweden's main challenge was the lack of a sufficient qualified SSM staff in certain key functional areas, which could be a challenge for the authority's regulatory activities. These areas included review and assessment, authorisation of facilities and activities, and regulatory oversight of radioactive waste disposal. The policy discussion held during the mission had the theme Challenges of the regulatory body in the context of possible new builds (and new technologies) since a new nuclear programme was being considered in Sweden.

An overall conclusion from the IRRS mission was that Sweden has a comprehensive regulatory infrastructure for nuclear and radiation safety covering the full range of facilities, activities, and exposure situations, and that SSM is a competent, independent regulator. Sweden will use the feedback from the IRRS mission to further improve the Swedish regulatory system and the effectiveness of the regulatory functions in line with IAEA safety standards.

ARTEMIS mission
In the second half of April 2023 an Integrated Review Service for Radioactive Waste and Spent Fuel Management (ARTEMIS) mission took place in Sweden, the first of this kind for Sweden. It was performed as a back-to-back mission with the 2022 IRRS mission. SSM was the National Counterpart for the ARTEMIS mission. The ARTEMIS review focused on the evaluation of the current Swedish national programme and national framework for executing the country's obligations for safe and sustainable radioactive waste and spent fuel management as well as decommissioning of facilities. In total, the ARTEMIS team identified three Recommendations, four Suggestions and one Good Practice. One of the Suggestions was directed at SSM, all others were directed at the Government. The Good Practice noted that "Sweden has designed the KBS-3 for spent nuclear fuel disposal concept and developed it to a mature concept, carried out a successful siting process and interacted with all stakeholders for achieving wide acceptance and a governmental licence for the proposed disposal project".

The ARTEMIS mission advised that Sweden should improve its national policies and strategies to ensure that safe and sustainable final management routes are available for all non-nuclear radioactive waste that originates, for example, from industrial uses, research, or medical applications. The Sweden self-assessment report and the ARTEMIS mission's final report are available on the SSM's website.

Challenges, Areas of Good Performance and Good Practices
Section A of the National reports should include a summary of Challenges, Areas of Good Performance and Good Practices, as decided at the Fifth Extraordinary Meeting. This report summarises results from the Seventh Review Meeting in section A.3. Section K.1 gives an account of measures taken to address Challenges identified at the Seventh Review Meeting. Section K.3 reports current Challenges related to management of radioactive waste generated outside the nuclear fuel cycle and radioactive waste from new nuclear power. Section K.3 also proposes Areas of Good Performance related to stakeholder involvement in the construction phase of the spent nuclear fuel disposal facility and measures taken to strengthen the national competence in the nuclear area.

A.5 Overall context of Sweden's programme for nuclear and radioactive waste management

A.5.1 Overview of main activities and facilities related to management of spent fuel, nuclear and radioactive waste

The nuclear power program
Figure A1 shows the location of nuclear power plants and other nuclear facilities in Sweden. Spent nuclear fuel and nuclear waste emanate mainly from the 12 electricity-producing nuclear power reactors located at four sites in southern Sweden: Barsebäck, Forsmark, Oskarshamn and Ringhals. Nine of these reactors are of BWR type (ASEA-ATOM design) and three are of PWR type (Westinghouse design). All reactors were taken into commercial operation between 1972 and 1985. The two BWR Units B1 and B2 at the Barsebäck site were shut down permanently in 1999 and 2005, respectively. The two oldest BWR Units O1 and O2 at the Oskarshamn site were permanently shut down in 2015 and 2016. The two oldest Units at the Ringhals site, R1 (BWR) and R2 (PWR), were permanently shut down in 2019 and 2020.

Spent fuel from the nuclear power reactors is shipped to the centralised storage facility, Clab, close to the Oskarshamn nuclear power plant, operational since 1985.

Short-lived low- and intermediate-level waste, predominantly consisting of operational waste from nuclear facilities, is disposed of in the repository for low- and intermediate-level short-lived waste, SFR, in Forsmark, Östhammar municipality. SFR was commissioned in 1988 and is situated close to the Forsmark nuclear power plant.

Long-lived low- and intermediate-level waste is stored at the nuclear power plants, in Clab or at facilities controlled by different licensees at the Studsvik Tech Park, awaiting the development and planned implementation of a geological repository for such waste.

Very low-level waste is disposed of in shallow land burials on the sites of the Forsmark, Ringhals and Oskarshamn nuclear power plants as well as at the Studsvik Tech Park.

Westinghouse Electric Sweden AB (formerly Asea, Asea Atom, and ABB Atom), operates a nuclear fuel fabrication plant in Västerås, approximately 100 km west of Stockholm. The plant has been manufacturing fuel since the mid-1960s. Its annual production is approximately 500 to 600 tonnes of UO2 fuel for PWRs and BWRs, mainly for customers abroad. The manufacturing process generates some slightly uranium-contaminated waste in the form of CaF2, metal, construction waste, electronics, combustible waste, sludge, filters, protective clothing, etc. Westinghouse disposes of waste with very low uranium content, typically CaF2, metal and construction waste at municipal landfills as permitted by the Swedish Radiation Safety Authority. Prior to disposal, however, most of the uranium in the waste is extracted through special recovery processes in the Västerås plant. In addition, a new facility for waste processing (pyrolysis) at Cyclife Sweden AB has been established, and currently processes combustible waste from Westinghouse. A minor proportion of the remaining waste may be considered for disposal in a future disposal facility for long-lived waste.

The Studsvik Tech Park

Studsvik has been the site of the national centre for nuclear research activities and now (renamed the Studsvik Tech Park) hosts facilities for nuclear fuel and materials testing as well as facilities for waste treatment and storage.

Past practices

Spent fuel and nuclear waste was generated from the operation of three research reactors (all now decommissioned and dismantled) and from Sweden's first prototype nuclear power reactor (PHWR-type) in Ågesta, operational between 1964 and 1974, and mainly used for district heating in a suburb of Stockholm. The oldest research reactor R1, situated on the campus of the Royal Institute of Technology in Stockholm, was in operation between 1954 and 1970. Two additional research reactors R2 and R2-0, situated at Studsvik, were in operation between 1960 and 2005.

The former uranium mining and milling facility in Ranstad was constructed and operated in the 1960s. The uranium open-cast mine and the mill tailing deposits were restored and covered in the 1990s. The industrial facility has been released from regulatory requirements since 2019.

Chalmers University of Technology in Gothenburg

Chalmers University of Technology in Gothenburg is not explicitly shown in Figure A1, which is subject to licensing under the Act on Nuclear Activities, as the quantity of nuclear material it holds in connection with its research activities exceeds the threshold defined in the Act.

Non-nuclear fuel cycle activities

There are thousands of activities outside the nuclear fuel cycle where ionising radiation is used for different purposes: at hospitals, educational and research facilities, non-nuclear industries and so forth. These activities generate relatively small volumes of radioactive waste compared to the volumes generated within the nuclear fuel cycle. Arrangements have been set up to allow for such radioactive waste to be conditioned at the Studsvik Tech Park. After conditioning, such waste may, as appropriate, be managed within the management solutions developed for nuclear fuel cycle waste. However, there are challenges with the management of radioactive waste from outside of the nuclear fuel cycle, see section K.3.2.1.

European Spallation Source (ESS)

Radioactive waste will also arise from the European Spallation Source (ESS) accelerator facility in southern Sweden. The facility is planned to become operational in 2028 and be in operation for about 40 years. The ESS facility is not a nuclear facility, but it will house considerable quantities of radioactive material and generate significant volumes of radioactive waste.

Thus, one of the main challenges faced by ESS in the continuing licensing process is to clarify and verify that the waste management can be conducted in a way that is safe in terms of radiation safety and radiation protection, and that ESS can perform in compliance with applicable regulatory requirements, see section K.3.2.1. An agreement has been signed by the ESS consortium and SKB whereby SKB will provide services as regard to the future management of the radioactive waste from the facility.

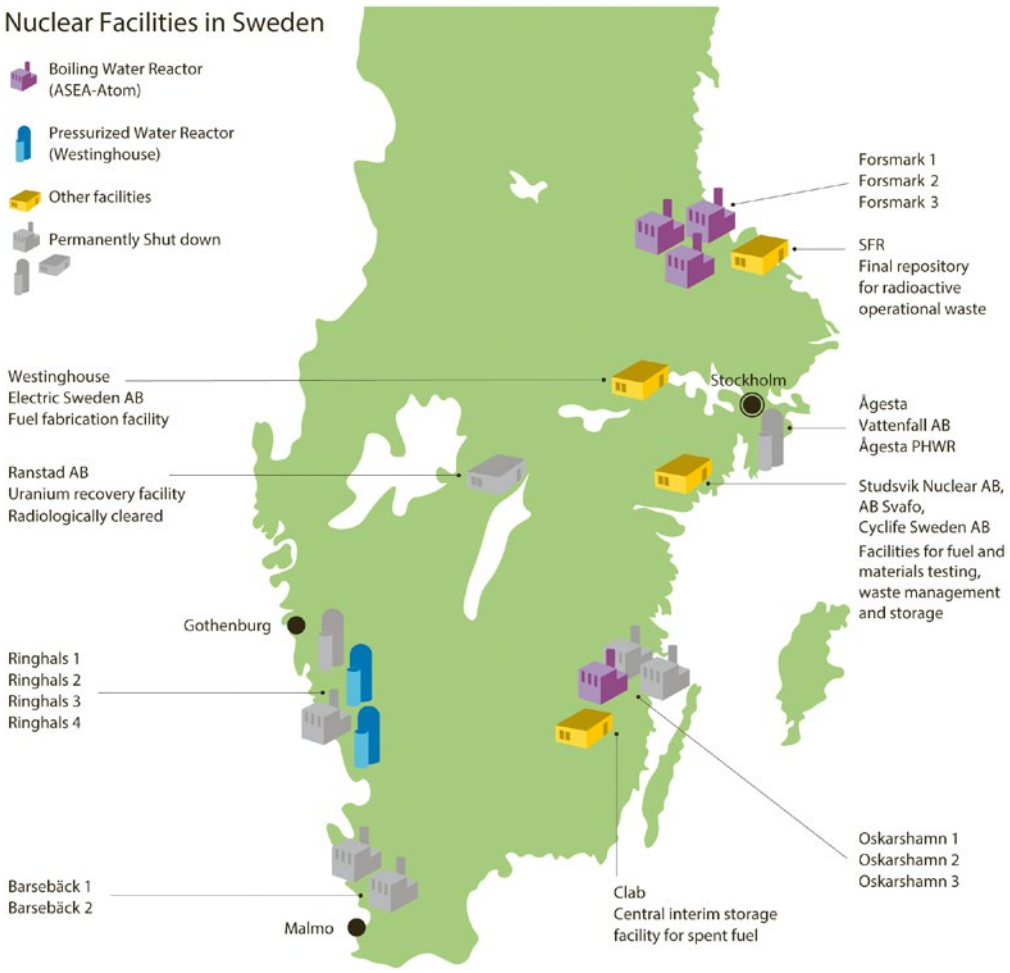

Figure A1 Nuclear facilities in Sweden.

A.5.2 National policy and fundamental principles

The fundamental principles for the management of spent fuel and radioactive waste have evolved in stages since the 1970s through public debate and policy decisions taken by both the Government and Parliament. These principles are reflected in the Swedish legislation, further described in sections B.1.1 and E.2.1.

The most important fundamental principles of the national policy are as follows.

- Costs for the management and disposal of spent fuel and radioactive waste from nuclear activities are covered by fees that licensees are required to pay.
- The licensees are to safely dispose of spent nuclear fuel and radioactive waste from nuclear activities.
- The state has the ultimate responsibility for final management of spent nuclear fuel and radioactive waste from nuclear activities.
- Sweden is responsible for the spent nuclear fuel and radioactive waste generated by its nuclear activities.

The implementation of these principles in Swedish legislation in practice constitutes the implementation of the polluter pays principle.

A.5.3 Basic preconditions

A.5.3.1 Management of spent nuclear fuel and nuclear waste

The responsibility for managing spent fuel and nuclear or radioactive operational and decommissioning waste that arises from any activity rests with the respective licence holder (see sections A.6.2 and E.2.1.1). The four utilities operating nuclear power reactors in Sweden have formed a special company, the Swedish Nuclear Fuel and Waste Management Co. (SKB), to assist them in executing their responsibilities regarding all handling, transportation and storage of spent fuel and radioactive waste outside the nuclear power plants. SKB is also responsible for the planning and construction of facilities required for the management of spent nuclear fuel and radioactive waste, and for the research and development work required to provide such facilities (RD&D programmes). Thus, the management of solutions for spent fuel and nuclear fuel cycle waste is developed and implemented by the nuclear reactor utilities in cooperation, through SKB.

Figure A6 provides an overview of the existing and planned facilities associated with waste streams in the overall system to manage spent nuclear fuel and nuclear waste, with a more detailed description found in section A.7.

A.5.3.2 Management of non-nuclear fuel cycle waste

As described above, arrangements have been set up to allow for radioactive waste from non-nuclear fuel cycle applications, i.e. medical use, industry, research activities and consumer products, to be managed within the management solutions developed for nuclear fuel cycle waste. More information is provided in sections K.1.1 and K.3.2.1.

A.6 The legislative and regulatory framework

A.6.1 Implementation of national policy in legislation

The legal framework provides a consistent system with clear allocations of responsibilities, licensing, prohibitions, institutional control, regulatory inspections, documentation and reporting. The framework also enables the enforcement of applicable regulations and conditions of the licences. The competent regulatory body (SSM) has the mandate, qualified staff and financial resources necessary for its activities. The legislation clearly designates the operator as being primarily responsible for the safety of spent fuel and radioactive waste management. The State, however, has the ultimate responsibility for the safety aspects of spent fuel and radioactive waste.

The legal framework reflects well the objectives of the Joint Convention.

The following main legislative instruments regulate the management of spent fuel and nuclear waste:

- The Act on Nuclear Activities;
- The Radiation Protection Act;
- The Environmental Code; and
- The Act on Financing of Management of Residual Products from Nuclear Activities.

Under the Act on Nuclear Activities, the licence holder for nuclear activities is primarily responsible for the safe handling and disposal of spent fuel and radioactive waste produced. In addition, under the Radiation Protection Act, the licensee must take all the necessary measures and precautions to prevent or counteract harmful effects to human health and the environment due to radiation.

The Environmental Code specifies basic environmental principles such as: the precautionary principle, the principle of best available technology, the polluter pays principle, the principle of conservation of natural resources, and the principle of selecting the most appropriate location where the purpose of the activity can be achieved with minimum damage and detriment to human health and the environment. The Code also contains provisions relating to the conduct of environmental impact assessments.

The Act on Financing of Management of Residual Products from Nuclear Activities lays down the principles for the financing of expenses for decommissioning and the management and disposal of spent fuel and decommissioning waste.

Sweden has implemented the European Union's radioactive waste and spent fuel management Directive (2011/70/Euratom) in its legislative framework. The Directive requires that EU countries:

– have a national policy for spent fuel and radioactive waste management;
– draw up and implement national programmes for the management and disposal of all spent nuclear fuel and radioactive waste generated on their territory;
– have in place a comprehensive and robust framework, a competent and independent regulatory body as well as financing mechanisms to ensure that adequate funds are available; and
– provide public information on radioactive waste and spent fuel and ensure that opportunities for public participation are available.

A.6.2 Licence holder responsibilities

A.6.2.1 General obligations on licensees for nuclear activities

The licence holder for nuclear activities and other activities involving radiation has the primary responsibility for maintaining safety, ensuring the safe handling and disposal of spent fuel and radioactive waste, and the safe decommissioning and dismantling of facilities when activities will cease.

As illustrated in Figure A2, the utilities operating nuclear power reactors cooperate in the implementation of their general obligations. The most important elements in this cooperation are:

– to establish and carry out a research development and demonstration (RD&D) programme for the safe handling and disposal of spent fuel and nuclear waste; and
– to estimate costs for the management and disposal of spent fuel and nuclear waste as a basis for payments to be made to the Swedish Nuclear Waste Fund.

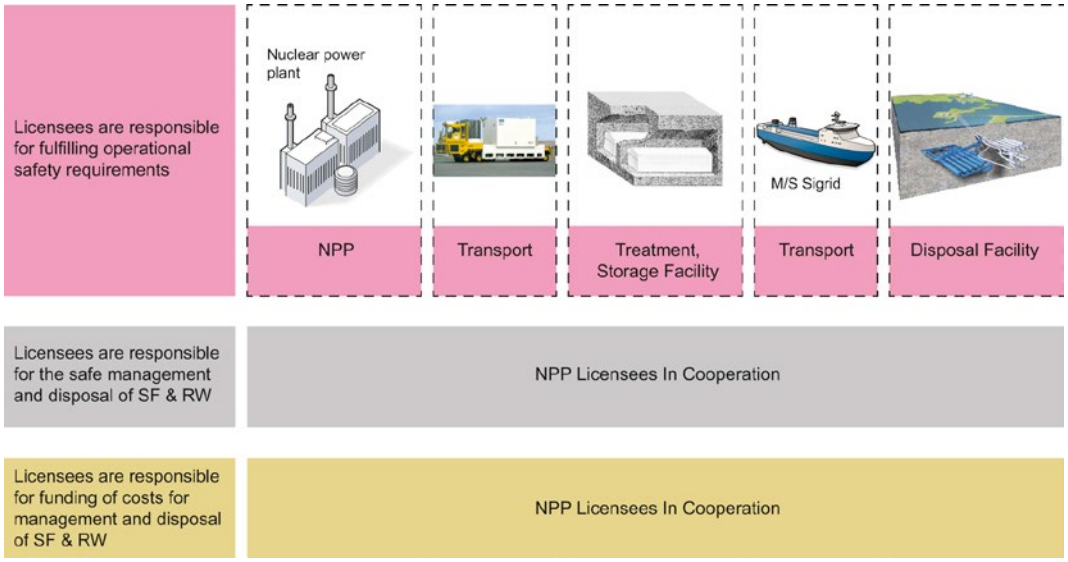

Figure A2 Basic requirements and general obligations of licensees.

The utilities operating nuclear power reactors have joint ownership of SKB that fulfils the utilities' shared obligations and assists them in executing their responsibilities, as previously mentioned.

SKB is tasked with the planning and construction of facilities required for the management of spent nuclear fuel and radioactive waste, and the research and development work associated with these facilities. SKB also calculates the costs associated with the management of spent fuel and radioactive waste as well as for future decommissioning of the nuclear power plants, including its own facilities.

Adequate financial resources for ensuring the fulfilment of these responsibilities and for maintaining qualified staff is provided through disbursements from the Nuclear Waste Fund and, in the case of operational radioactive waste, directly by the nuclear power plant utilities.

A.6.2.2 General obligations for licensees for non-nuclear activities

For non-nuclear activities, the Radiation Protection Act requires all parties that have produced radioactive waste to ensure the safe management and disposal of this waste, including securing of financial resources. This applies to all non-nuclear activities where radioactive material is used such as medicine, industry and research.

A.6.3 Financing arrangements

The waste generator has a financial responsibility for the management of the spent nuclear fuel and radioactive waste from each facility. This responsibility applies both to nuclear activities and to non-nuclear activities. This arrangement implements the polluter pays principle.

The Financial Act requires the licensees to pay fees and provide financial guarantees to minimise the risk to the State and future generations of bearing the costs from waste emerging from nuclear activities. This mainly applies to the costs for the safe management and disposal of spent nuclear fuel and decommissioning waste from nuclear operations. The fees are deposited in a nuclear waste fund. The funded assets are managed by a governmental authority, the Nuclear Waste Fund. The legislation on financing is presented in more detail in section E.2.1.4.

The licensees' cost estimates are reviewed by the National Debt Office every three years. Based on the review and statement from the Debt Office, the Government decides on the fees and financial guarantees for the nuclear power plants for the following three years. The financial guarantees constitute securities to cover fees that have not yet been paid and to cover costs in connection with unexpected events.

To date, the Nuclear Waste Fund has covered expenses for the central interim storage facility for spent nuclear fuel (Clab), for the transport system and for the research and development needed, including the siting and development for a spent fuel disposal system. Current and future expenses include the construction and operation of the encapsulation plant and repository for spent fuel, the decommissioning of nuclear power plants, repositories for low- and intermediate-level waste from the decommissioning of nuclear facilities and continued research and development work.

According to the Radiation Protection Act, all parties that have produced radioactive waste are required to ensure the safe management and disposal of the waste, including securing of financial resources. This applies to all non-nuclear activities where radioactive material is used such as medicine, industry and research. Institutional waste accepted by Cyclife Sweden AB is either disposed of in SFR or stored on site until SFL is in operation.

In 1984, the Government agreed to a one-off compensation payment to the predecessor of Cyclife Sweden AB, Studsvik Energiteknik AB, to cover future costs for disposal in SFR of all radioactive waste originating from non-nuclear activities. The fee paid by the producer to Cyclife Sweden AB includes the cost for this disposal where radioactive waste is to be disposed of in SFL.

There is also a state financing scheme administered by SSM for the recovery of orphan sources and clean-up of other non-nuclear legacy waste (see section J.1.2.2).

A.6.4 Environmental Objectives

The overall goal of the Swedish environmental policy is to hand over to the next generation a society in which the major environmental problems have been solved, without increasing environmental and health problems outside Sweden's borders.

To achieve this, the Swedish Government has defined a Swedish environmental objectives system that is divided into 16 national environmental goals. These goals incorporate the ecological dimension of the 2030 Agenda for Sustainable Development.

SSM is responsible for the goal *A Safe Radiation Environment*, which aims to protect human health and biodiversity against harmful effects of radiation. An important part of reaching this goal is to make sure that discharges of radioactive substances into the environment are kept within safe limits. To ensure this, radioactive waste needs to be managed safely and sustainably.

The environmental quality objective therefore plays an important role in the Swedish radioactive waste management system in targeting and evaluating non-nuclear radioactive waste. The national policy and the provisions for nuclear waste management are more comprehensively addressed in the nuclear legislation and the specific requirements on RD&D and cost estimates.

A.6.5 Regulatory control and supervision

Licensing

All nuclear facilities require a licence under both the Act on Nuclear Activities and the Environmental Code. The Government grants the licence based on the recommendations and reviews of its competent authority.

A key element of the regulatory framework is the clearly defined stepwise licensing process, see sections E.2.3 and E.2.9.1.

The most important licensing milestones that are common to all the planned facilities are as follows:

- Government approval of a licence under the Act on Nuclear Activities and decision on permissibility according to the Environmental Code to construct, own and operate a new nuclear facility.
- Formal licensing under the Environmental Code, with licence conditions established by the Land and Environment Court.
- Approval by SSM of a preliminary safety analysis report (PSAR) before starting construction.
- Approval of the safety analysis report (SAR) prior to the trial and routine operations.
- Approval of a final safety analysis report prior to the Government's decision regarding final closure of the disposal facilities.

Roles and responsibilities

The Swedish Radiation Safety Authority (SSM) is the competent authority that supervises licensees of nuclear activities in fulfilling their responsibilities for the safe operation of facilities, transport as well as in planning for decommissioning and disposal. SSM has the adequate levels of authority, competence, and financial and human resources to fulfil its assigned responsibilities, see sections E.3.

Independence of the regulatory authority

As a central administrative authority, SSM receives from the Swedish Government its budget and instructions on its general direction of operations. SSM is at the same time independent in its decision-making under the Swedish legislation, as evidenced by the Instrument of the Government (see also section E.3).

Regulatory inspections

SSM conducts regular inspections and assessments of nuclear and other facilities whose work involves radiation to ascertain compliance with regulations and licence conditions, in accordance with its legal authorisation and its mandate defined by the Government; see sections E.2.5.2 and E.3.2.6.

Documentation and reporting

Extensive reporting from licence holders is required. Annual reports are submitted to SSM on activities at facilities, including experience gained and conclusions drawn with regard to safety, and on the management of nuclear waste and high activity sealed sources (HASS). A deficiency detected during the construction or operation of a nuclear facility, that can lead to a deterioration in safety, in addition to what is assumed in the safety analysis report, must be reported to SSM without unnecessary delay, see section E.2.5.3.

The licensee of a nuclear facility must report to SSM on the discharge of radioactive substances into air and water, shown as discharge of activity, and doses to individuals in a reference group. In addition, the results of environmental monitoring must be reported, see section E.2.5.3.

Licensees are required to perform a periodic safety review (PSR), i.e. an integrated analysis and assessment of the safety of their facility, at least once every 10 years; see sections E.3.2.6.

Prohibition and enforcement

The Swedish authorities have extensive legal, regulatory and enforcement powers. As a supervisory authority, SSM may issue any injunctions or prohibitions and revoke activities if required to ensure compliance, see section E.2.4.

A.6.6 Provisions for public engagement and transparency

The legal framework for licensing of nuclear activities contains provisions governing transparency, openness and public participation. According to the Environmental Code, a prospective licensee is required to submit a plan for the formal process of consultation with stakeholders in order to develop an environmental impact assessment.

SSM supervises the development of management and disposal systems in the pre-licensing process through the mandatory review of RD&D programme reports. The review process includes opportunities for broad public participation in the development of the Swedish system for managing spent fuel and radioactive waste.

Host municipalities may receive financial support through the Nuclear Waste Fund to enable active participation in formal consultations during the licensing process.

Before the Government's licensing decision for a nuclear facility, the host municipality has a right to veto and is expected to formally declare its support or rejection of the decision. For more information on public engagement during the construction and operational phases of a spent fuel disposal facility, see section K.5.

A.7 Management of spent nuclear fuel and radioactive waste

A.7.1 Research and Development

A.7.1.1 RD&D programme for spent fuel and nuclear waste

The Act on Nuclear Activities obligates the utilities that are licensed to operate nuclear power reactors, in cooperation, to develop and implement an RD&D programme needed for the safe management and disposal of spent nuclear fuel and nuclear waste as well as the safe decommissioning and dismantling of nuclear power plants. Every three years, on the behalf of the operators, the Swedish Nuclear Fuel and Waste Management Company (SKB) submits a report on this programme to the regulatory authority for review.

The programme should contain an overview of all research and technical development needed to design, construct and operate facilities for managing spent nuclear fuel and radioactive waste, and should detail the measures that are intended to be taken within six years. Starting in 1986, SKB has submitted successively updated programmes every three years. Since 1992, this programme has been denoted as the programme for Research, Development and Demonstration (the "RD&D programme"). Over time, an overall system for handling and final disposal of the residual products from nuclear power production has been developed.

The structure and focus of the programme have varied over time. The 2022 RD&D programme includes the following parts:

- Part I, SKB's operations and action plan, which reports the operations and action plan for taking care of, and final disposal of, spent nuclear fuel and nuclear waste from the operation and decommissioning of the Swedish nuclear power reactors. There is also the reasoning for the research, development and demonstration programme needed to be able to build and put new facilities into operation.
- Part II, waste and final disposal, reports the need for continued RD&D during the reporting period, mainly in process understanding, knowledge and competence in the design and construction of barriers and components, and knowledge and competence in control and testing to verify that the requirements are fulfilled.
- Part III, decommissioning of nuclear facilities, reports the planning for the decommissioning of the Swedish nuclear power reactors and SKB's facilities.

A.7.1.2 Research and demonstration facilities

SKB operates several research and demonstration facilities to assist them in the development of remaining facilities. These include the underground Äspö Hard Rock Laboratory for the investigation of engineered and geological repository barriers, the Canister Laboratory for the development of sealing technology for copper canisters and the Multi-purpose Test Facilities for the testing of bentonite properties and development of methods for backfilling and plugging of repository tunnels. All facilities are situated in the Oskarshamn area.

The Äspö Hard Rock Laboratory

The Äspö Hard Rock Laboratory (HRL), situated on the island of Äspö north of the Oskarshamn nuclear power plant, started regular operation in 1995 and has been an important part of SKB's work on design, construction and operation of final repositories. An illustration of the HRL and concluded and ongoing (2020) experiments are shown in Figure A3

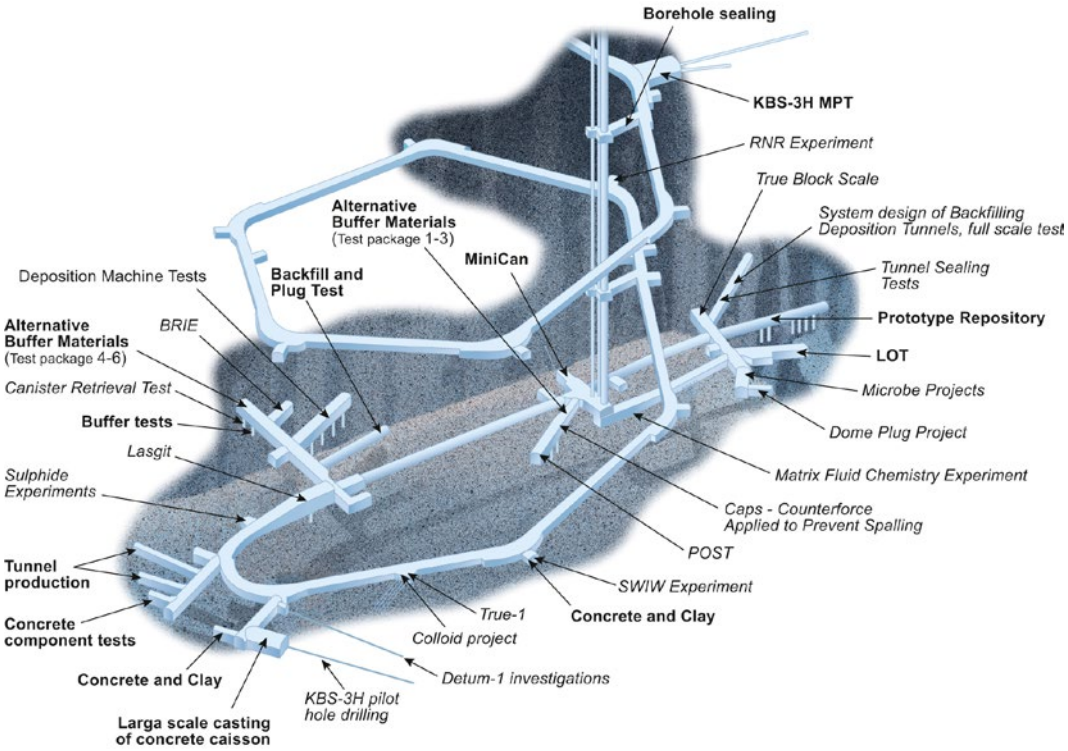

Figure A3 The Äspö HRL with ongoing (bold) and concluded (italics) experiments.

The Äspö HRL has provided opportunities for the development and testing of investigation methods, increased understanding of groundwater flows in a large rock domain and provided a site for geoscientific investigations and experiments. The HRL has been used to investigate the behaviour of the engineered barriers (canister, buffer, backfill) and their interaction with the bedrock as well as for the development and demonstration of equipment to be used in future facilities. After three decades of research and development, the original goals of the laboratory have been fulfilled and SKB is currently finalising the last experiments and preparing to decommission the facility.

The Canister Laboratory

The Canister Laboratory, situated in Oskarshamn, has been in operation since 1998. The laboratory is used for developing sealing and other technologies for the copper canisters, including welding and non-destructive testing techniques for the canister components. Figure A4 illustrates equipment for friction stir welding of copper lids.

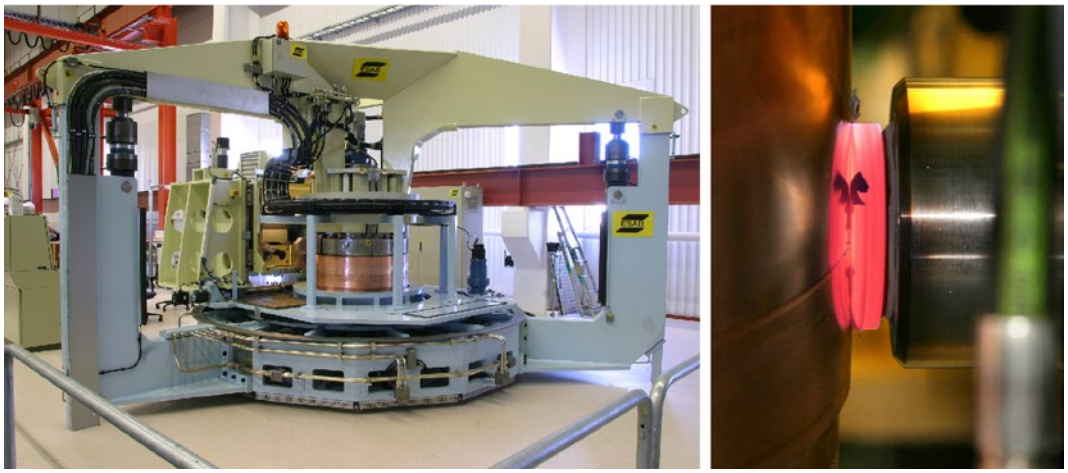

Figure A4 Friction stir welding of copper lids. The image to the left shows Canister Laboratory equipment for development, and the image to the right shows the rotating tool that is pressed into the joint between the parts that are to be combined.

The Multi-purpose Test Facilities

The Multi-purpose Test Facilities started operation in 2007. The facilities are situated adjacent to the Äspö HRL and supplement the experiments being conducted there, see Figure A5.

In the Multi-purpose Test Facilities, the properties of the bentonite are (for example) tested by simulating water conditions in a controlled manner. Here, SKB is also developing methods for backfilling repository tunnels and construction of plugs to seal deposition tunnels.

Figure A5 The Multi-purpose Test Facilities at Äspö. The photo shows the testing of a self-positioning robot for backfilling a deposition tunnel with bentonite blocks.

A.7.2 Overview of waste streams and management solutions

The following section gives an overview of waste streams and management solutions, as illustrated in Figure A6.

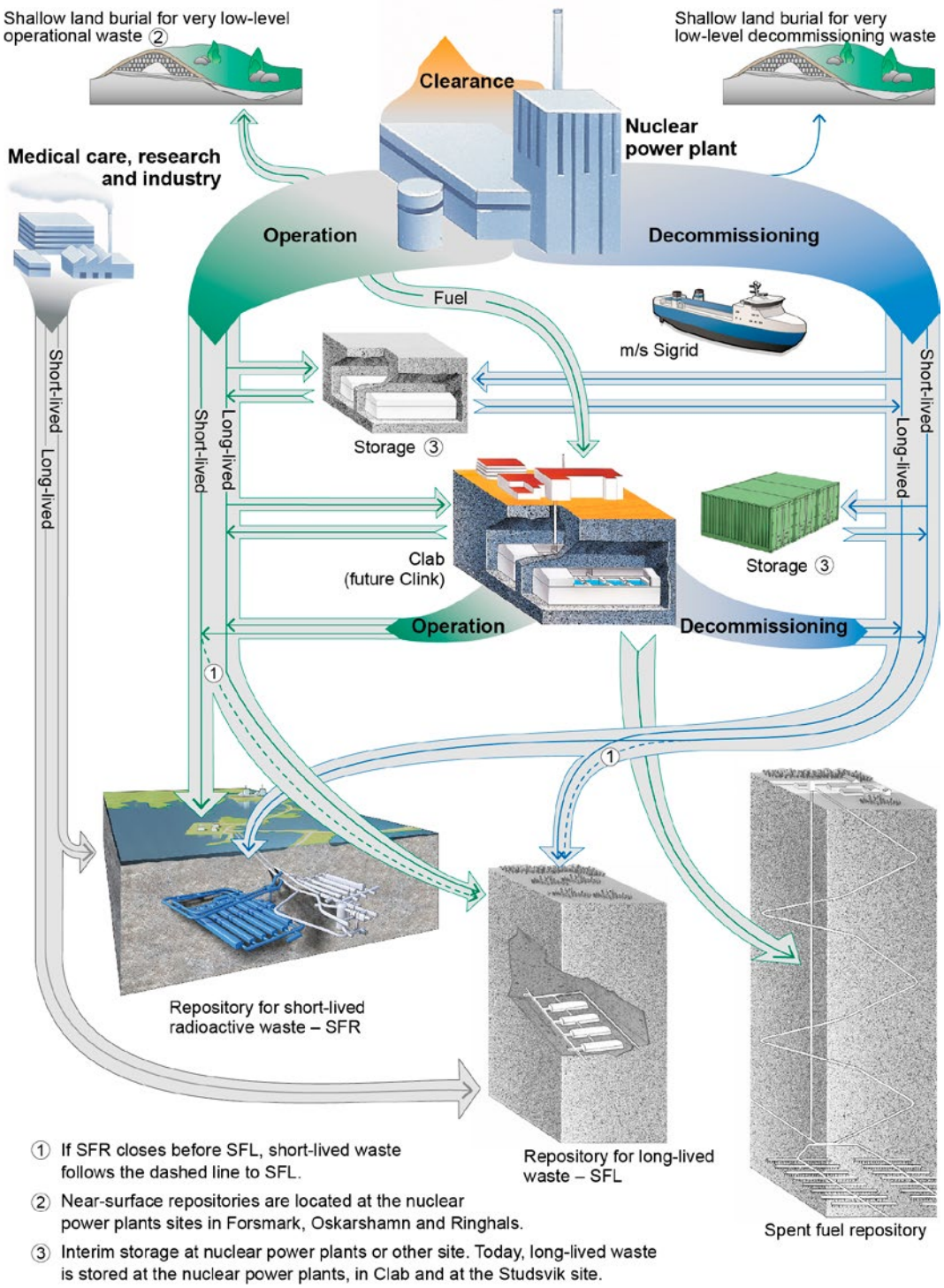

Figure A6 The system for managing spent nuclear fuel and radioactive waste

Management of spent nuclear fuel

After cooling at the reactor site, the spent fuel is transported by ship to the central interim storage facility, Clab, located next to the Oskarshamn nuclear power plant. Current practices foresee interim storage of the spent fuel for a period of at least 30 years before being disposed of in a deep geological disposal facility.

In addition to spent nuclear fuel from nuclear power reactors (including the Ågesta reactor), materials to be disposed of include fuel residues from testing programmes at Studsvik as well as MOX fuel (mixed oxide fuel). Approximately 20 tonnes of spent nuclear fuel from Ågesta and about two tonnes from Studsvik Nuclear AB's research activities are currently in interim storage in Clab. Clab is also used to store 23 tonnes of MOX fuel obtained from Germany in exchange for fuel that was sent to France (La Hague) for reprocessing at an early stage of the Swedish programme. A small amount of spent nuclear fuel from the first reactor at Oskarshamn was sent for reprocessing in Sellafield, England. No fuel or radioactive waste from that reprocessing have been returned to Sweden.

Management of long-lived low- and intermediate-level waste

Long-lived waste from the NPPs consists of used core components, reactor pressure vessels from Pressurised Water Reactors (PWRs) and control rods from boiling water reactors (BWRs). The waste is currently stored at the nuclear power plants, Clab and Studsvik Tech Park. The total volume of long-lived low- and intermediate-level waste is about 16,000 m^3, one third of which comes from the NPPs. The rest comes from facilities operated by Studsvik Nuclear AB, Cyclife Sweden AB, AB Svafo and, potentially, from ESS (see further sections A.7.4.1 and D). SKB plans to dispose of the long-lived waste in a geological facility for long-lived low- and intermediate-level waste at SFL.

Management of short-lived low- and intermediate-level waste

Short-lived low- and intermediate-level waste is disposed of in SFR, operated by SKB. Most of the short-lived waste originates from the nuclear power plants. Other waste originates from Clab, Cyclife Sweden AB, Studsvik Nuclear AB, AB Svafo and, potentially, from ESS (see sections A.7.4.1 and D). According to current projections, about 180,000 m^3, including nine segmented reactor pressure vessels from BWRs, will be disposed of in SFR.

Management of very low-level short-lived waste

Very low-level waste is disposed of in shallow land burials operated by the nuclear power plants. Under the current licences, a total of about 37,000 m^3 of short-lived very low-level operational waste may be disposed of in shallow land burials at the Forsmark, Oskarshamn and Ringhals nuclear power plants (see also sections A.7.4.1 and D.1.4.3).

Transportation system

Since the nuclear facilities are situated on the coast, transportation of spent nuclear fuel and radioactive waste from the sites to SKB's facilities is by sea. The transportation system has been in operation since 1982 and consists of a purpose-built INF class 3 vessel, transport casks and containers, and terminal vehicles for loading and unloading. Figure A6 provides a schematic illustration of the management system for spent nuclear fuel and radioactive waste.

Planned facilities

Facilities that remain to be commissioned are an encapsulation plant for spent fuel, repositories for spent fuel and long-lived low- and intermediate-level waste and an extension of SFR for decommissioning waste.

A.7.3 Spent nuclear fuel management

A.7.3.1 Existing spent nuclear fuel management practices and facilities

Management practices at the NPP sites

Spent nuclear fuel from the nuclear power reactors is temporarily stored on site in water-filled fuel pools for at least nine months before being transported to the central interim storage facility for spent nuclear fuel, Clab. Fulfilment of the requirements of SSM's general regulations are accomplished and verified through regulatory review and inspection activities at the nuclear power plants, as reported under the Convention on Nuclear Safety.

The central interim storage facility for spent fuel, Clab

Spent nuclear fuel from all Swedish nuclear power reactors is stored in Clab, situated adjacent to the Oskarshamn nuclear power plant. The facility has been in operation since 1985 and employs around 100 staff.

The facility consists of two parts: one building above ground for unloading spent fuel assemblies from transport casks, and one underground section for storage in water-filled pools with a rock cover of about 25 to 30 m. The spent fuel is stored for at least 30 years before being encapsulated and disposed of in a geological disposal facility.

The application for the spent fuel repository also included an application to increase the amount of the spent fuel stored in Clab from 8,000 to 11,000 tonnes. The Government separated the two applications and granted in 2021 SKB a licence to increase the storage capacity. In July 2022, a corresponding decision by the Land and Environment Court followed. In February 2024, SSM decided to approve the safety report (FSAR) for trial operation. Figure A7 shows one of the storage pools. Principal data as well as information on inventories are contained in section D.1.2.2.

Figure A7 Storage pool in Clab. The top edge of the spent fuel is 8 m below the water surface.

A.7.3.2 Planned spent nuclear fuel management practices and facilities

The KBS-3-concept

The concept for disposal of spent fuel, KBS-3, involves emplacement of fuel elements in copper canisters (corrosion resistance) with ductile iron inserts (mechanical strength), see Figure A8. The canisters will be embedded in bentonite clay (protection against corrosion, rock movements and prevention of water penetration and leakage of radioactive substances) in individual vertical deposition holes at a depth of about 500 m in the bedrock (maintains the technical barriers for a long time and isolates the spent fuel from human and the environment).

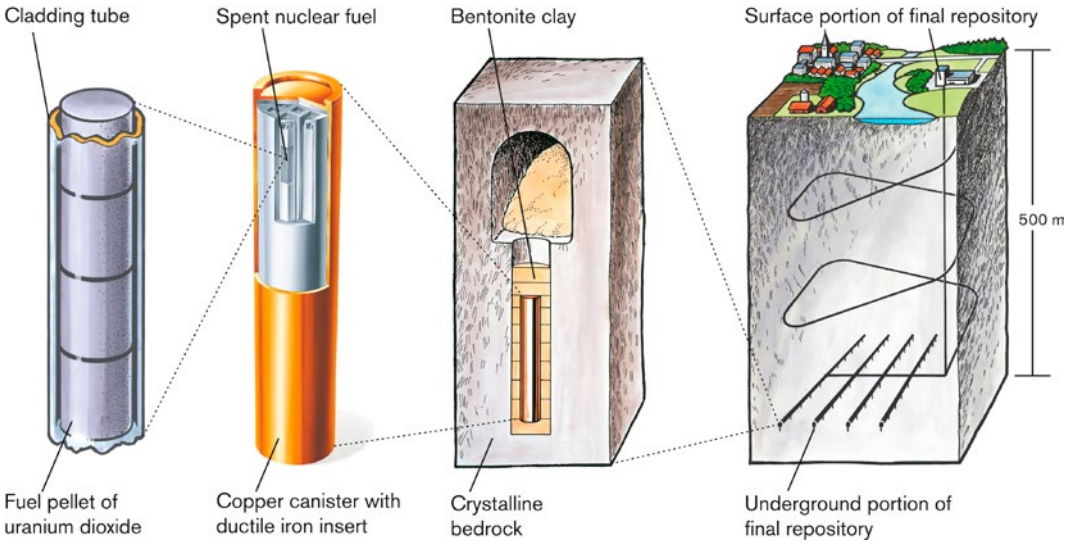

Figure A8 The KBS-3-method for disposal of spent nuclear fuel.

Licensing of an encapsulation plant and a spent fuel disposal facility

Figure A9 shows the timetable for establishing the facilities in the KBS-3 system for management of spent nuclear fuel. SKB's submitted parallel licence applications in March 2011, under the Act on Nuclear Activities and the Environmental Code, for an encapsulation plant in combination with the existing interim storage facility at Oskarshamn and a geological repository for spent fuel at Forsmark. These applications were subject to a thorough regulatory review by SSM and examination by the Land and Environment Court.

After an initial assessment of SKB's primary licensing documentation, SSM reviewed the quality and completeness of the two separate applications for nuclear facilities, including supporting technical material and references. Over a period of three years, SSM requested and obtained from SKB substantial supplementary information and clarification relating to both facilities, on the scope of SKB's assessment of alternative methods, locations and on detailed scientific and technical analyses relating to specific aspects of the disposal system design and its performance. By the end of 2015, SSM had completed the major part of its technical review of SKB's rationale for method and siting as well as SKB's preliminary safety analyses for the two facilities. In June 2016, SSM submitted a statement to the Land and Environment Court based on its review as part of the Court's consultation process.

The Land and Environment Court's role was, in the first instance, to prepare a recommendation to the Government relating to the permissibility of SKB's plans for final disposal in relation to the general principles established in the Environmental Code.

The role of SSM was to review SKB's licence applications for a Government's decision under the Act on Nuclear Activities. This also included a formal national consultation process involving a wide range of referral bodies such as local, regional and national authorities, higher education institutions and environmental organisations. SSM's review and assessment of the licence applications entailed judgment as to whether SKB made a credible case for the feasibility of its plans for the facilities and whether, when taken forward to detailed design and industrial implementation, they would be expected to comply with all relevant radiation safety requirements, including those after closure.

In January 2018, both SSM and the Court submitted their final review statements to the Government. SSM recommended the approval of SKB's licence applications to possess, construct and operate an encapsulation plant and a final repository under the nuclear activities act. The Court on the other hand stated that SKB would need to present further documentation clarifying the long-term protective function of copper canisters, for the repository to be considered permissible in accordance with the provisions of the Environmental Code. In addition, the Court highlighted the need for legal clarification regarding responsibility for the repository after its final closure.

In April 2019, SKB submitted supplementary information requested by the Government, including results from further experimental and theoretical studies relating to potential corrosion mechanisms identified by the Court. SSM, after a thorough technical review of the new material, reiterated its earlier statement that SKB's preferred site was suitable, the disposal concept being feasible and the safety case meeting strict regulatory requirements.

In January 2022, the Government granted separate licences under the Act on Nuclear Activities to construct and operate the encapsulation facility and the geological repository for spent nuclear fuel. At the same time, the Government also formally approved the KBS-3 system by declaring it permissible under the Environmental Code.

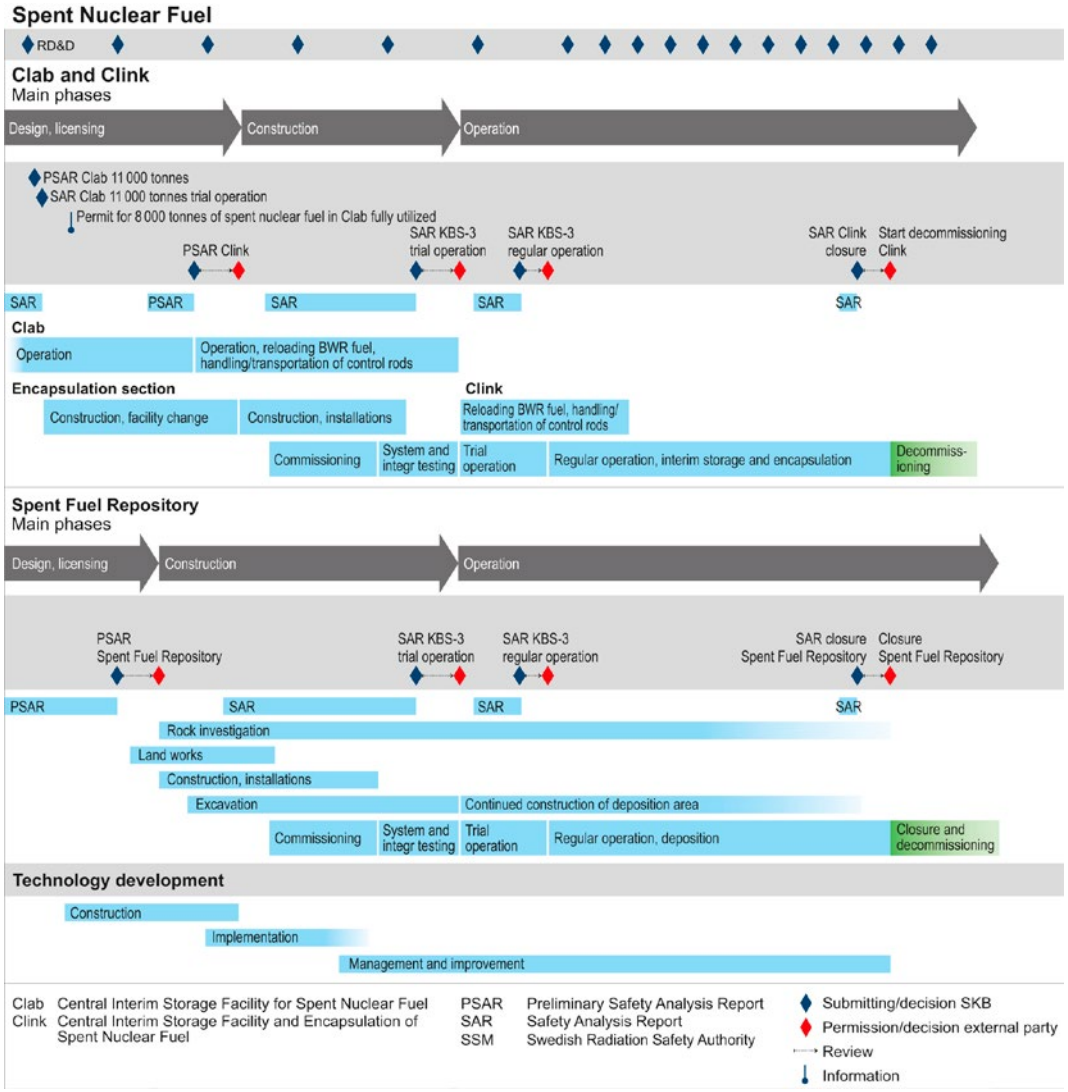

Figure A9 Estimated general timetable for the establishment of the spent fuel repository and Clink based on the current status of the licensing process for KBS-3.

A.7.4 Radioactive waste management

A.7.4.1 Existing radioactive waste management practices and facilities

Management practices at the nuclear power plant sites

Waste management at the NPP sites is fully integrated into the operations at each site. The requirements of SSM's general regulations are met and verified through regulatory review and inspection activities at the nuclear power plants, as reported under the Convention on Nuclear Safety. Most of the low- and intermediate-level waste (LILW) is conditioned (solidified, compacted, etc.) at the point of origin, i.e. at the reactor sites. Some waste is sent to facilities at the Studsvik Tech Park for incineration or melting. More details are found in section D.1.4.1.

Management practices at Studsvik Tech Park

Early nuclear research activities started in Stockholm in the 1950s and some nuclear laboratories were also established at the Studsvik Tech Park, located around 30 km from the town of Nyköping (see Figure A10). During the 1960s basically all nuclear research activities were moved to Studsvik, where research reactors operated until 2005. As of today, three companies operate facilities at the site under a nuclear licence, i.e. Studsvik Nuclear AB, Cyclife Sweden AB and AB Svafo.

Figure A10 The facilities at Studsvik Tech Park.

Studsvik Nuclear AB provides services in fuel and materials technologies to the nuclear power industry. Facilities operated by Studsvik Nuclear AB include the hot cell laboratory (HCL), the active metal laboratory (AML) and the storage facility (FA).

Cyclife Sweden AB, owned by the French EDF, manages Studsvik's waste treatment facilities. These include the incineration facility (HA), the melting facility (SMA) and treatment facilities for radioactive non-nuclear waste (FR0-A and R0-A).

AB Svafo, owned by the companies operating nuclear power reactors, treats and stores radioactive legacy waste from former research and development operations conducted in Sweden. Svafo also manages liquid radioactive waste from other Studsvik facilities. Svafo is also responsible for decommissioning the R2/R2-0 research and materials testing reactor at Studsvik that was shut down in 2005, see Figure A11. The decommissioning project started in 2015 and is now in its final phase with the buildings being cleared from regulatory control in 2023. Facilities operated by AB Svafo are the treatment facility for intermediate waste (HM) and the interim storage facility for low- and intermediate-level waste (AM).

The radioactive waste treatment and management facilities at the Studsvik Tech Park are described in more detail in section D.1.4.1.

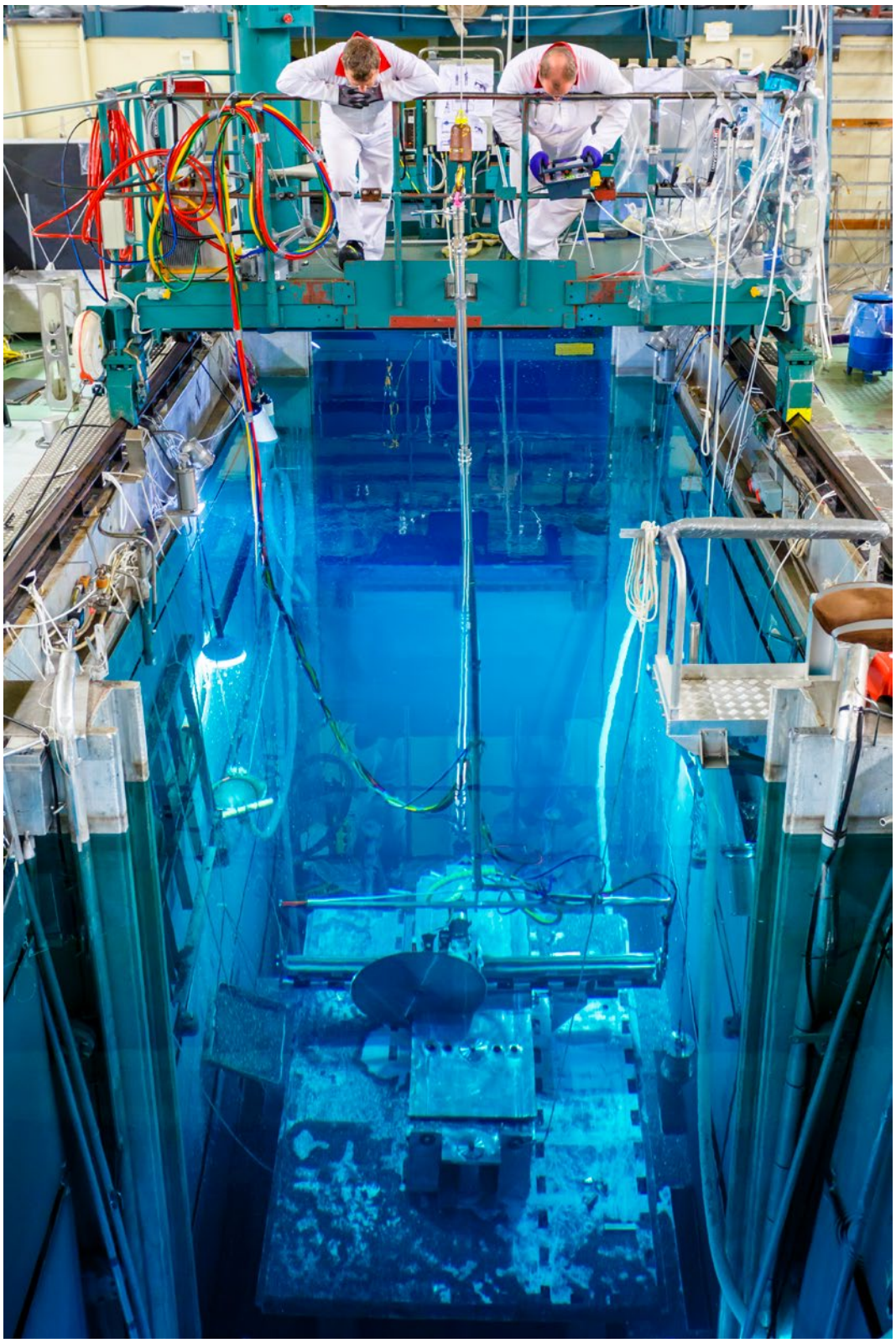

Photo: Fredrik Ekenborg

Figure A11 Decommissioning of the R2 research and materials testing reactor at Studsvik Tech Park.

Repository for radioactive operational waste, SFR
SFR is located approximately 140 km north of Stockholm, close to the Forsmark nuclear power plant. The facility is situated in crystalline bedrock beneath the Baltic Sea, covered by about 60 m of rock. It is designed for disposal of short-lived low- and intermediate-level radioactive waste from Swedish nuclear power plants, and Clab, and from other usage in industry, research and medicine.

SFR started operation in 1988 and consists of four 160 m long waste vaults, plus a 70 m high cavern housing a concrete silo. Its total capacity is roughly 63,000 m^3 and about 40,000 m^3 had been used by the end of 2022. The silo is shown in Figure A12. Principal data as well as information on inventories are described in section D.1.4.2.

Figure A12 Photo from the top of the silo in SFR and an illustration of the design. Waste packages are placed in shafts in the silo.

Shallow land burials
The nuclear power plants at Ringhals, Forsmark and Oskarshamn as well as the Studsvik Tech Park, have shallow land burials for solid short-lived low-level operational waste (< 300 kBq/kg). Each burial is licensed for a total activity of between 100 and 1100 GBq (the highest level permitted under the legislation is 10 TBq, of which a maximum of 10 GBq may consist of alpha-active substances).

Clearance
Material may be cleared for unrestricted use or for disposal as conventional non-radioactive waste (see also sections E.2.9.4 and F.6).

A.7.4.2 Planned radioactive waste management practices and facilities
The low- and intermediate-level waste programme comprises three main activities: the extension of the SFR facility to receive decommissioning waste; the development of a repository for long-lived low- and intermediate-level waste, SFL; and the interim storage of long-lived waste. The general timetable is illustrated in Figure A13 and described below.

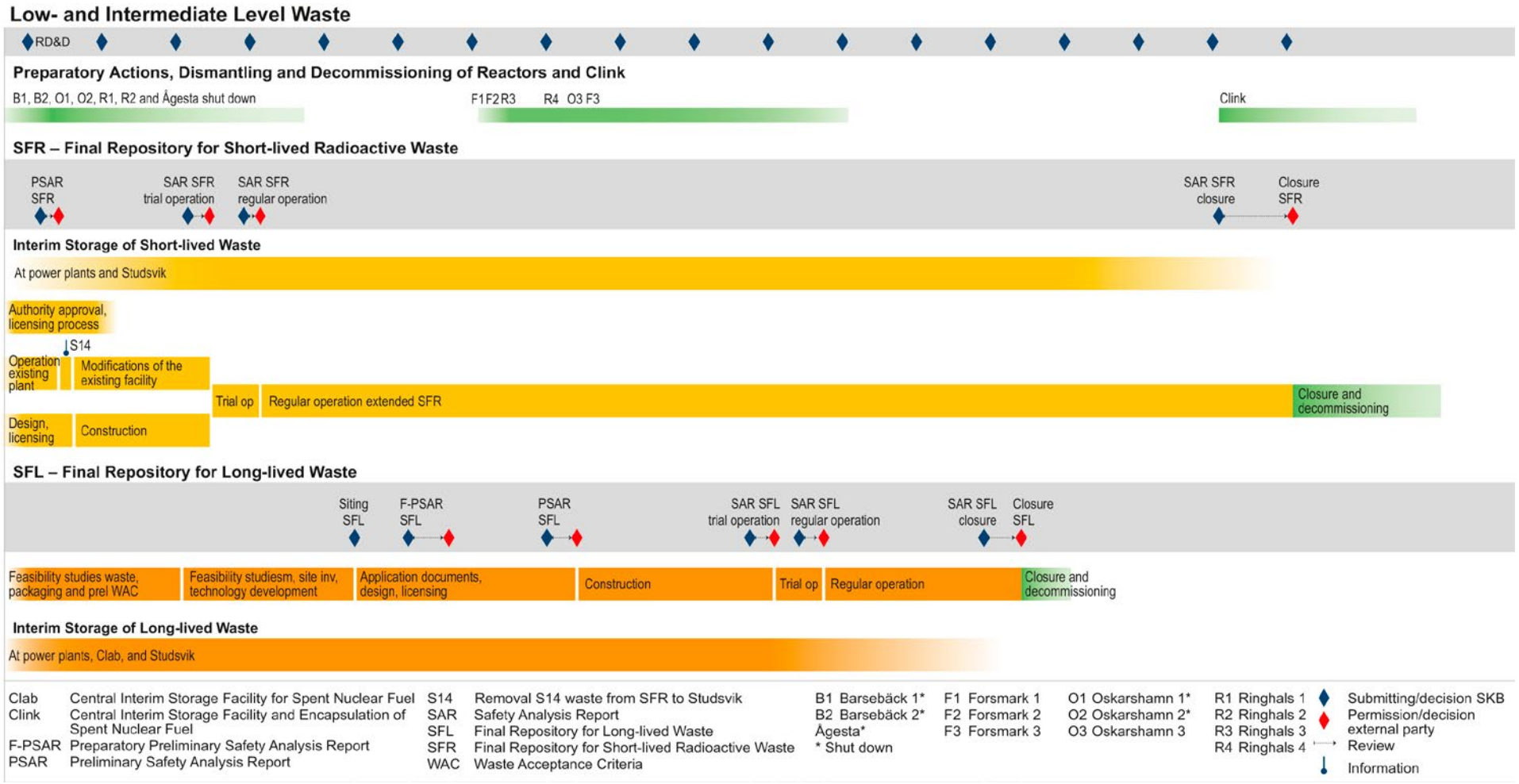

Figure A13 Timetable for low- and intermediate-level waste and decommissioning of the nuclear power plants.

Extension of the SFR facility

In December 2014, SKB applied for permission to extend the final repository for short-lived low- and intermediate-level waste at Forsmark (SFR) so that it can also accommodate decommissioning waste (see Figure A14). This is further described in the Seventh National Report. In December 2021, the Government issued a licence under the Act on Nuclear Activities covering both continued operation of the existing SFR and construction and operation of the planned extension. At the same time, the Government also formally determined that the extension of SFR was permissible under the provisions of the Environmental Code.

Implementation of the licensing and approvals process by SSM (according to the Act on Nuclear Activities) and the Land and Environment Court (according to the Environmental Code) is now continuing with a focus on detailed requirements and conditions for the construction and operation of the facilities. In March 2022, SKB submitted a formal request to the Court for a licence for the extension of SFR to be issued according to the Environmental Code, based on the Government's approval of the project.

Hearings were held in late November 2022, and the licence, with conditions relating to (e.g.) noise, transport and releases of non-radioactive substances to water during construction, was granted by the Court later the following month.

In March 2023, SKB submitted a PSAR to SSM which, according to the Government's licence conditions, must be approved before starting construction of the extension.

At the time of preparing this report, the PSAR is under review by SSM. Construction of the extension, estimated to take approximately six years. Waste disposal will be paused during the construction.

SSM's approval of updated safety analysis reports, plans and other related documentation is required prior to authorisation for the start of trial and routine operations (see also section E.2.9.1).

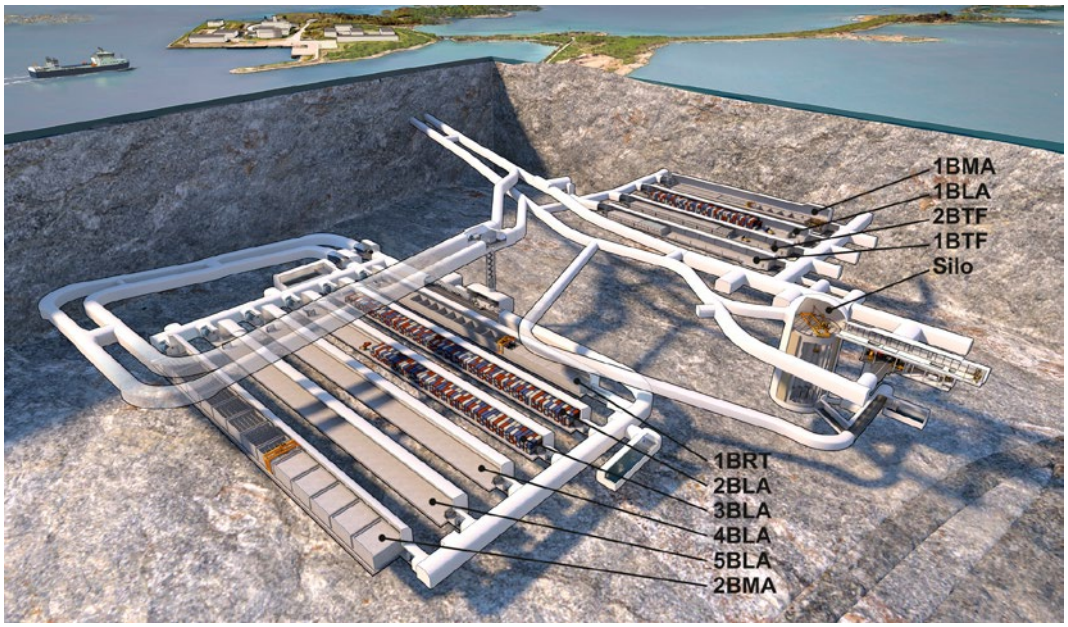

Figure A14 The existing facility in Forsmark for short-lived low- and intermediate-level operational radioactive waste, SFR (the silo and vaults in the upper right part of the figure) and the planned extension (lower left). The extended SFR will consist of four additional waste vaults for low-level waste (2–5 BLA), one additional waste vault for intermediate level waste (2BMA) and one waste vault for segmented reactor pressure vessels (1BRT).

Repository for long-lived low- and intermediate-level waste (SFL)

According to the current plans, SFL will be in operation for approximately 10 years before closure. The origin of this waste is legacy (primarily research), industry, medical applications, used reactor core components, reactor pressure vessels from PWRs and control rods from BWRs. The volume of SFL will be relatively small compared to SKB's other disposal facilities. According to the current concept, SFL is designed as a deep geological repository with two different sections, see Figure A15:

- one waste vault, designed with a concrete barrier, for metallic waste (core components and control rods) from the nuclear power plants; and
- one waste vault, designed with a bentonite barrier, mainly for legacy waste.

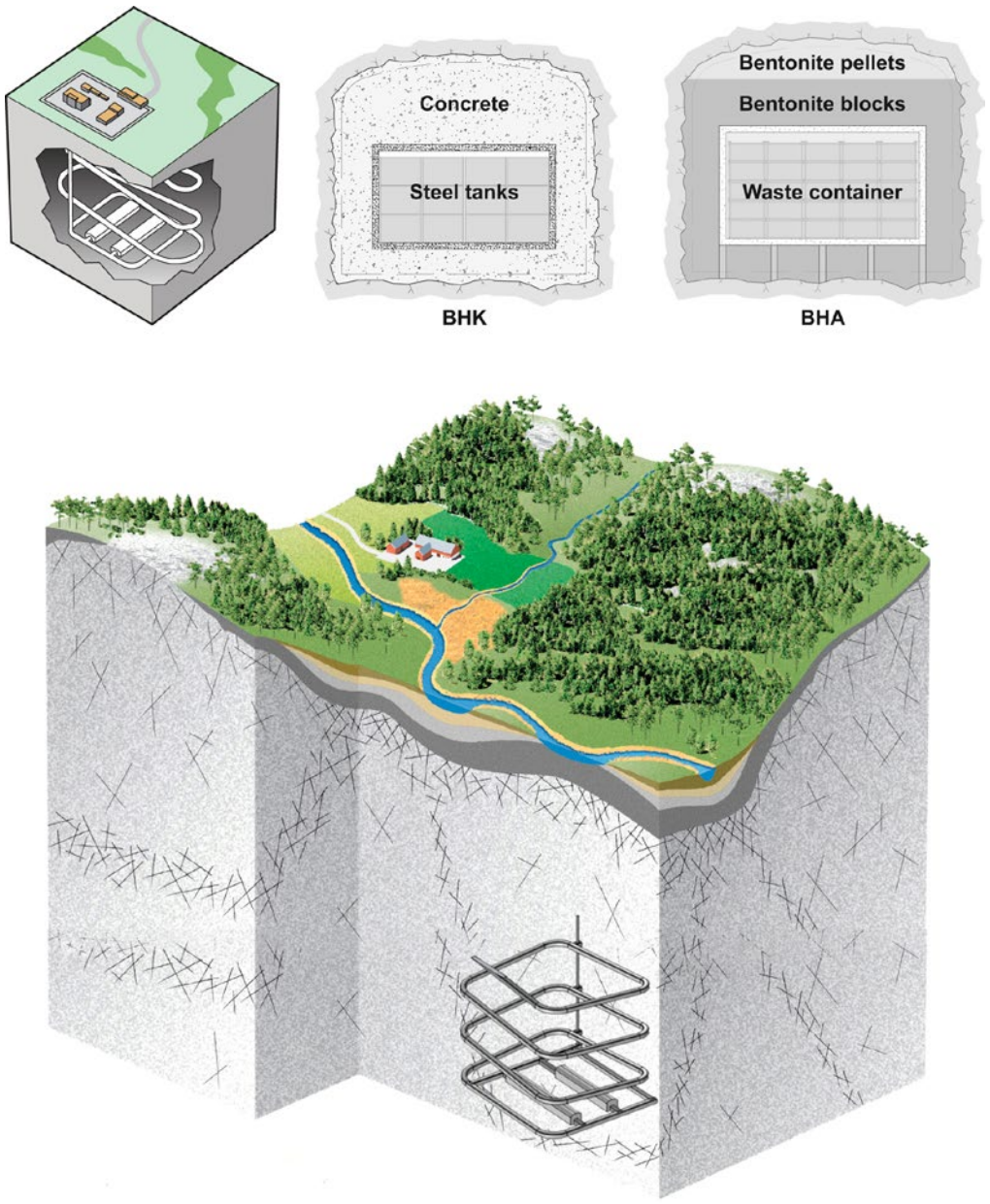

Figure A15 Illustration of the current concept for SFL as a geological repository with two different sections. Metallic waste from the nuclear power plants is placed in a waste vault (BHK) designed with a concrete barrier, and legacy waste is placed in a waste vault (BHA) designed with a bentonite barrier. An evaluation of the post-closure safety for this design was presented in 2019.

During the period 2015-2019, an evaluation of post-closure safety for the proposed repository concept was carried out to provide input to the subsequent, consecutive steps in the development of SFL. These consecutive steps include further development of the design of the engineered barriers, waste acceptance criteria and the site selection process for SFL. The evaluation was performed by analysing several cases that together indicate under what conditions the repository concept has the potential to fulfil regulatory requirements.

Acceptance criteria for the long-lived low- and intermediate-level waste will be established in conjunction with the submission of the SAR for SFL. Today, there is a need to clarify the planning prerequisites for management of the waste arising during operation and decommissioning of the nuclear facilities. The safety evaluation for SFL provides some guidance for future requirements on the waste. Requirements related to the construction, transportation and handling during operation will serve as a basis to further define acceptance criteria for the waste, in addition to requirements related to the post-closure safety of the repository. As the details of the repository design are progressively finalised, it will be possible to further define the set of requirements and eventually establish acceptance criteria. At the current stage, the regulations are very restrictive on irreversible conditioning of the waste.

Interim storage of long-lived waste
According to the current plan, several reactors will be decommissioned before the repository is finished. Therefore, the capacity for interim storage of the long-lived waste from decommissioning is needed and nuclear power plants will arrange for interim storage at their sites or elsewhere, e.g. the new storage building at Studsvik Tech Park for low- and intermediate-level decommissioning waste from the research reactor R2 that started operation in 2022.

The transportation system will be supplemented with a new type of transport container for shipping long-lived waste placed in steel tanks. The transport container is called ATB 1T. It is, due to its activity content, designed in accordance with the IAEA requirements type B(U), and delivery of the first container is expected in 2025.

A.8 Swedish participation in international activities to enhance safety and radiation protection

Sweden is a member of the IAEA and the OECD Nuclear Energy Agency (NEA), with permanent delegations to both organisations. Sweden has been a Member State of the European Union (EU) since 1995.

Sweden is party to the relevant conventions applicable to a country with nuclear power plants in operation, encompassing nuclear safety, emergency preparedness and response, nuclear liability, spent nuclear fuel, radioactive waste and physical protection. Sweden has also formally committed to implement the Code of Conduct on the Safety and Security of Radioactive Sources and the Supplementary Guidance on the Import and Export of Radiation Sources.

A.8.1 The regulatory authority

The Swedish Radiation Safety Authority (SSM) is a regulatory authority with its missions and tasks defined in the Ordinance (2008:452), see section E.3. The Ordinance declares that SSM (among other tasks) shall carry out Swedish obligations in accordance with conventions, EU ordinances/directives and other binding agreements (e.g. to provide points of contact, reporting, and act as the national competent authority), undertake international cooperation work with national and multinational organisations, and monitor and contribute to the progress of international standards and recommendations.

SSM's international liaison activities encompass many international groups, the majority of which are concerned with nuclear safety and radiation protection issues. Such cooperation takes place within the frameworks of the IAEA, NEA and EU, in connection with international conventions ratified by Sweden, and through networks such as the Western European Nuclear Regulators Association (WENRA), the European Nuclear Security Regulators Association (ENSRA), the Heads of European Radiation Control Authorities (HERCA), and the International Nuclear Regulators Association (INRA).

The IAEA safety standards form the main basis of SSM's regulatory requirements and guides. SSM is represented in the IAEA safety standards committees (CSS, NUSSC, WASSC, RASSC, EPReSC and TRANSSC) and Nuclear Security Guidance Committee (NSGC).

As a member of the European Union, Sweden is obligated to comply with the directives and legal requirements emanating from the Euratom Treaty. SSM has a key role in the transposition of Euratom Directives into Swedish legislation.

SSM is a member of the European Nuclear Safety Regulators Group (ENSREG), an independent, expert advisory group to the European Commission. It is composed of senior officials from national regulatory or nuclear safety authorities from all EU Member States. SSM has been active in developing implementation and reporting guidelines for the Directive on establishing a community framework for the responsible and safe management of spent fuel and radioactive waste (2011/70/Euratom).

SSM has contributed significantly to WENRA's work on harmonising safety approaches between European member countries with regard to the development of common safety reference levels for decommissioning, storage of waste and spent fuel and geological disposal and waste processing.

SSM also contributes to the work performed within the Convention on Nuclear Safety (CNS) as well as the Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR) and the Helsinki Commission (HELCOM) conventions for the reduction of radioactive substances releases from nuclear facilities.

In addition, SSM has bilateral agreements with twelve countries relating to liaison and exchange of information on agreed issues (e.g. nuclear safety, emergency preparedness, occupational exposure, environmental radiological protection, and radioactive waste management). Additionally, Sweden has special agreements with the Nordic countries (Denmark, Finland, Iceland and Norway) regarding emergency preparedness and information exchange on the technical design of nuclear facilities. A Memorandum of Understanding on liaison and information exchange has also been signed between the Nordic regulatory bodies (the Norwegian Radiation and Nuclear Safety Authority, the Finnish Radiation and Nuclear Safety Authority and the Swedish Radiation Safety Authority) and the Ministry for Emergency Situations of the Republic of Belarus.

Due to plans for new nuclear power, SSM has expanded its international collaborations both within international organisations and through new or renewed bi- and multi-lateral agreements with other countries authorities on specific reactor concepts. These collaborations aim to increase international harmonisation and standardisation of new reactor technology, to develop conditions for carrying out national licence reviews in an efficient manner and to reduce the risk of fundamental issues or obstacles to granting licences being identified late in the design work. SSM recently entered into a cooperation agreement with the French NUWARD SMR Joint Early Review and participated in the British ONR's Generic Design Assessment of the Rolls Royce SMR design. In May 2024, an agreement was also concluded with the Polish Authority (PAA) on cooperation in the nuclear power area.

A multinational liaison group (DGRRF) has been established by the nuclear regulators of Sweden (SSM), Canada (CNSC), Finland (STUK), France (ASN), Switzerland (ENSI) and the United States (NRC) with the objective of sharing regulatory experiences in the licensing, siting, safety assessment and construction of deep geological repositories (DGRs) through annual workshops.

SSM also participates in international research, primarily in the framework of the EU research programmes, but also as part of the IAEA and OECD/NEA. SSM regularly provides experts to assist in international peer review missions (IRRS), mainly in the framework of the IAEA's IRRS and ARTEMIS review services. SSM's international involvement and work are continually reviewed with respect to available staff resources and as part of upholding competent regulatory supervision of licensees and activities in Sweden. To support priority decisions, a classification scheme and a policy for international work are part of SSM's integrated and process-based management system.

A.8.2 SSM's international support programmes

In its annual appropriation directions, SSM is commissioned by the Government to conduct development cooperation with Eastern and Central Europe in the areas of nuclear safety, nuclear security, radiation protection, non-proliferation, environmental monitoring and management of radioactive waste. The development cooperation has been going on since the beginning of the 1990s.

The support is aimed at Ukraine, Georgia, Moldova and Armenia (the latter country is in the initial phase of cooperation after a long break). According to the current appropriation directions, cooperation with Ukraine shall be expanded to meet the consequences of Russia's invasion of Ukraine and include support to maintain and strengthen radiation safety in Ukraine, for example in the form of equipment.

Since 2018, SSM has also taken on a new role as an implementing organisation for international support projects, funded by the European Commission and by the Swedish International Development Cooperation Agency, addressing challenges related to management of legacy radioactive waste and radioactive sources in Georgia and Moldova. These projects aim at strengthening the national radioactive waste management system, development of siting and disposal programmes and supporting capacity building of national authorities, waste management organisations and other key national institutions.

A.8.3 Licence holders

A.8.3.1 General information

Utilities in Sweden have a tradition of being quite active in international cooperation to enhance nuclear safety by sharing experiences, contributing to work on international regulations and guidelines, and participating in safety assessments and peer reviews.

Swedish fuel cycle facility licence holders, such as Studsvik Nuclear AB, Cyclife Sweden AB and Westinghouse Electric Sweden AB, are global companies offering a wide range of advanced technical services to the international nuclear power industry in areas including waste treatment, consultancy services and fuel and materials products and technology. Also, representatives from e.g. SKB, AB Svafo and Barsebäck Kraft AB participate actively in international working groups whose focus is on waste management and decommissioning.

A.8.3.2 SKB

SKB gives international cooperation a high priority and works together with corresponding waste management organisations in Canada, Finland, France, Germany, Japan, Spain, Switzerland, the United Kingdom and the United States of America.

The aim of SKB's international activities is to follow research and development work conducted in other countries and to participate in international projects within the field of spent nuclear fuel and radioactive waste management but also to share knowledge and developed methods with others. The international work provides perspectives to the domestic programme and contributes to maintaining state-of-the-art competences in relevant scientific areas.

SKB participates actively in different IAEA, EU and OECD/NEA committees and working groups. SKB is involved also in many research projects within these international organisations. SKB takes an active role within the executive group of the "Implementing Geological Disposal of Radioactive Waste Technology Platform" (IGD-TP), in which twelve waste management organisations collaborate. The IGD-TP identifies and prioritises research and technological development initiatives with a vision for industrialisation of radioactive waste disposal in Europe by 2040, via three pillars: (1) safe operation of the first geological disposal facilities in Europe; (2) optimisation and industrialisation of the planning, construction and disposal operations; and (3) development of tailored solutions for disposal of the diverse waste inventories in Europe. The IGD-TP has no financial resources at its disposal but has an indirect influence on how the EU's research funding is allocated within the area. This influence has become more direct since IGD-TP acts as one of the colleges in the joint programming of EURAD, the initiative for radioactive waste research in EU. SKB is also directly engaged in the Bureau of the EURAD.

SKB's rationale for continuous participation in the platform is that it provides a shared arena for scientific cooperation and exchange throughout Europe.

SKB's collaboration with Posiva in Finland is the most extensive forum, comprising projects in the fields of repository and encapsulation technology. SKB has also extensive collaboration with the Nuclear Waste Management Organisation, NWMO, in Canada, comprising research projects related to rock mechanics and canister integrity.

An important example of SKB's international research cooperation has been represented by the Äspö Hard Rock Laboratory, where organisations from Finland, the United Kingdom, Germany and Japan have been conducting joint studies.

SKB International, a wholly owned subsidiary of the Swedish Nuclear Fuel and Waste Management Company, provides bespoke services for the management and disposal of nuclear waste and spent nuclear fuel based on the expertise, technology, know-how and experience developed in SKB's programme over the past 45 years. SKB International provides expertise, technology and management support to partner companies and organisations around the world. It focuses on the client's need to provide tailored services to reduce time spans, costs and risks in nuclear waste management and disposal programmes.

Section B – Policies and Practices

B.1 Article 32.1: Reporting

1. In accordance with the provisions of Article 30, each Contracting Party shall submit a national report to each review meeting of Contracting Parties. This report shall address the measures taken to implement each of the obligations of the Convention. For each Contracting Party the report shall also address its:

(i) spent fuel management policy;
(ii) spent fuel management practices;
(iii) radioactive waste management policy;
(iv) radioactive waste management practices; and
(v) criteria used to define and categorise radioactive waste.

B.1.1 Spent fuel and radioactive waste management policy

The Swedish policy for spent fuel and radioactive waste management is based on the legal requirements contained in the Act on Nuclear Activities, Radiation Protection Act and Environmental Code.

The most important legal principles that constitute the national policy can be summarised as follows:

- The licence holder of a nuclear activity as well as the operator of activities involving ionising radiation are to safely manage and dispose of spent nuclear fuel and radioactive waste arising from their activities.
- Funding liability.
  - The expenses for management of spent nuclear fuel and radioactive waste from nuclear fuel cycle activities shall be covered by revenues from the production of energy that has given rise to these expenses.
  - The licensee or responsible organisation/person for an activity where non-nuclear fuel cycle radioactive waste arises shall provide financial security for the waste management costs and recovery measures that the activity can incur.
- The state has ultimate responsibility for spent nuclear fuel and radioactive waste.
- Each country is responsible for the spent nuclear fuel and radioactive waste generated in that country. Disposal of spent nuclear fuel and radioactive waste from a foreign country is not allowed in Sweden other than in exceptional cases. It is also prohibited to dispose of Swedish spent fuel or radioactive waste in another country, unless a number of conditions are fulfilled in line with the Euratom waste directive and international conventions.

Another basic presumption as regard to spent fuel management is the principle of direct disposal, i.e. reprocessing will not take place even though this is not prohibited by law. In practice, spent nuclear fuel is both considered and treated as waste, although it is not legally defined as waste activities until disposed of in a repository.

The national policy further encompasses the principles in Article 4 of Council Directive 2011/70/Euratom on the responsible and safe management of spent fuel and radioactive waste, which requires that:

- the generation of radioactive waste shall be kept to the minimum that is reasonably practicable;
- the interdependencies between all steps in spent fuel and radioactive waste generation and management shall be taken into account;
- spent fuel and radioactive waste shall be safely managed, including in the long term with passive safety features;
- implementation of measures shall follow a graded approach; and
- an evidence-based and documented decision-making process shall be applied with regard to all stages of the management of spent fuel and radioactive waste.

Other principles constituting national policy are also included in the legal and regulatory framework. The Radiation Protection Act is based on the International Radiation Protection Commission's (ICRP) principles on justification, optimisation and dose limitation. The objective of the Swedish Environmental Code is to promote sustainable development and ensure a healthy environment for current and future generations. The general "rules of consideration" established in the Code identify important principles that are applicable for nuclear activities and activities involving radiation, e.g. the knowledge principle, the precautionary principle and use of best available technology (BAT), the selection of the most suitable site and the remediation liability principle. These are further described in section E.2.1.

B.1.2 Spent fuel and radioactive waste management practices

B.1.2.1 Spent fuel and radioactive waste from nuclear activities

Under the Act on Nuclear Activities, a party that holds a licence to conduct nuclear activities in Sweden has an obligation to ensure that the nuclear material, spent nuclear fuel and nuclear waste generated by its operations are safely managed and disposed of. This obligation signifies an extensive commitment on the part of a licensee until a disposal facility for this waste has ultimately been closed. The utilities operating nuclear power nuclear power reactors are also subject to a specific obligation, i.e.. they are required to, in consultation, every three years to submit an updated research and development (RD&D) programme for the safe management of spent fuel and nuclear waste. They are further obligated, in consultation, to prepare cost estimates for the management and disposal of spent fuel and nuclear waste.

Very low-level short-lived waste (VLLW-SL) is disposed of in shallow land burials that are licensed under the Act on Nuclear Activities or subject to clearance in accordance with the regulatory authority's requirements and decisions. Waste subject to clearance may be released for unrestricted use, disposed of in municipal landfills or incinerated using specific furnaces (only applicable to contaminated oil).

Short-lived low- and intermediate-level waste (LILW-SL) is treated and packaged according to a standardised system with predefined waste type descriptions (WTD) and disposed of in the disposal facility for operational waste (SFR) in rock caverns in crystalline bedrock beneath the Baltic Sea, covered by about 60 m of rock. The facility consists of five different caverns, including a 50 m deep silo. The waste is directed to different parts of the facility depending on factors such as activity content and chemical characteristics.

Long-lived low- and intermediate-level waste (LILW-LL) will be disposed of in a deep geological disposal facility situated in rock caverns in crystalline bedrock. Until this facility is in operation, the long-lived waste is stored at the reactor sites at the Studsvik Tech Park or in storage pools in the interim storage facility for spent nuclear fuel (Clab).

Spent nuclear fuel is stored in fuel pools at the nuclear power plants for at least nine months before it is transported to the central interim storage facility for spent nuclear fuel (Clab). The safety and security measures taken at the NPPs do not differentiate between spent or partially spent fuel. According to the current plans, fuel elements will be stored in Clab of at least 30 years, before being encapsulated in copper canisters and transported to the spent nuclear fuel repository for disposal. The proposed disposal method is based on the conceptual design of a deep geological repository in hard rock, with a system of engineered barriers ensuring post-closure safety through containment over very long periods of time.

B.1.2.2 Radioactive waste from non-nuclear activities

The practices developed through the nuclear waste management programme are also applicable for radioactive waste from non-nuclear fuel cycle activities. Waste arising from such activities may therefore, when needed and if appropriate, be disposed of in disposal facilities for nuclear fuel cycle waste.

B.1.3 Criteria for defining and categorising radioactive waste

B.1.3.1 Definitions

The definition of nuclear waste according to the Act on Nuclear Activities is:

- spent nuclear fuel that has been placed in a repository;
- radioactive material that has been generated in a nuclear facility and that has not been produced at or taken from the facility to be used for educational or research purposes or for medical, agricultural engineering or commercial purposes;
- material or any item that has belonged to a nuclear facility and become contaminated by radioactivity and which shall no longer be used in such facility, and
- radioactive parts of a nuclear facility that is being decommissioned.

The definition of radioactive waste according to the Radiation Protection Act is:

- Radioactive material or an object that the holder gets rid of, intends or is obligated to get rid of or for which there is no planned and acceptable use.

B.1.3.2 Categorisation

There is no legally defined waste classification scheme in Sweden for nuclear or radioactive waste. There is, however, an established waste characterisation system that is used by the Swedish nuclear industry. The characterisation system is destination-driven and customised with regard to existing and planned repositories (end points), as shown in Table B1. Section F.3.2.3 describes the waste management process and application of waste acceptance criteria.

Table B1 Waste classification scheme used by the Swedish nuclear industry.

	Cleared material	Very low-level waste short-lived (VLLW-SL)	Low-level waste short-lived (LLW-SL)	Intermediate-level waste short-lived (ILW-SL)	Low- and intermediate-level waste long-lived (LILW-LL)	High-level waste (HLW)
Definition	Material with so small amounts of radioactive nuclides that it has been released from regulatory control.	Contains small amounts of short-lived nuclides with a half-life less than 31 years; dose rate on waste package is less than 0.5 mSv/h. Long-lived nuclides with a half-life greater than 31 years can be present in restricted quantities.	Contains small amounts of short-lived nuclides with a half-life less than 31 years; dose rate on waste package (and unshielded waste) is less than 2 mSv/h. Long-lived nuclides with a half-life greater than 31 years can be present in restricted quantities.	Contains significant amounts of short-lived nuclides with a half-life less than 31 years; dose rate on waste package is less than 500 mSv/h. Long-lived nuclides with a half-life greater than 31 years can be present in restricted quantities.	Contains significant amounts of long-lived nuclides with a half-life greater than 31 years, exceeding the restricted quantities for short-lived waste.	(Nuclear fuel) Typical decay heat > 2 kW/m^3 and contains significant amounts of long-lived nuclides with a half-life greater than 31 years, exceeding the restricted quantities for short-lived waste.
Specific considerations	–	–	–	Requires radiation shielding during transport.	Requires special containment during transport.	Requires cooling and radiation shielding during intermediate storage and transport.
Destination	No final repository needed.	Shallow landfill.	Final repository for short-lived radioactive waste (SFR).	Final repository for short-lived radioactive waste (SFR).	Final repository for long-lived radioactive waste (SFL).	Final repository for spent fuel.

Section C – Scope of Application

C.1 Article 3: Scope of application

- This Convention shall apply to the safety of spent fuel management when the spent fuel results from the operation of civilian nuclear reactors. Spent fuel held at reprocessing facilities as part of a reprocessing activity is not covered in the scope of this Convention unless the Contracting Party declares reprocessing to be part of spent fuel management.
- This Convention shall also apply to the safety of radioactive waste management when the radioactive waste results from civilian applications. However, this Convention shall not apply to waste that contains only naturally occurring radioactive materials and that does not originate from the nuclear fuel cycle, unless it constitutes a disused sealed source or it is declared as radioactive waste for the purposes of this Convention by the Contracting Party.
- This Convention shall not apply to the safety of management of spent fuel or radioactive waste within military or defence programmes, unless declared as spent fuel or radioactive waste for the purposes of this Convention by the Contracting Party. However, this Convention shall apply to the safety of management of spent fuel and radioactive waste from military or defence programmes if and when such materials are transferred permanently to and managed within exclusively civilian programmes.

C.1.1 Scope of application

Reprocessing of spent fuel is not included in the Swedish waste management programme and is therefore not subject to reporting under this Article.

Sweden does not declare waste containing only naturally occurring radioactive material and which does not originate from the nuclear fuel cycle as radioactive waste for the purpose of the Joint Convention pursuant to Article 3, Paragraph 2, second sentence.

C.1.2 Conclusion

Sweden complies with the obligations under Article 3 regarding spent fuel that results from the operation of civilian nuclear reactors, radioactive waste that results from civilian applications and spent fuel or radioactive waste within military or defence programmes.

Section D – Inventories and Lists

D.1 Article 32.2: Reporting

1. This report shall also include:

(i) a list of the spent fuel management facilities subject to this Convention, their location, main purpose and essential features;

(ii) an inventory of spent fuel that is subject to this Convention and that is being held in storage and of that which has been disposed of. This inventory shall contain a description of the material and, if available, give information on its mass and its total activity;

(iii) a list of the radioactive waste management facilities subject to this Convention, their location, main purpose and essential features;

(iv) an inventory of radioactive waste that is subject to this Convention that:

a. is being held in storage at radioactive waste management and nuclear fuel cycle facilities;

b. has been disposed of; or

c. has resulted from past practices.

This inventory shall contain a description of the material and other appropriate information available, such as volume or mass, activity and specific radionuclides;

(v) a list of nuclear facilities in the process of being decommissioned and the status of decommissioning activities at those facilities.

D.1.1 Management of spent nuclear fuel

Spent nuclear fuel from Swedish NPPs is temporarily stored in fuel pools before being transported to the central interim storage facility for spent nuclear fuel (Clab), where it will be stored for at least 30 years before being encapsulated and deposited in a disposal facility.

Most spent nuclear fuel in Sweden emanates from the commercial nuclear power plants at Forsmark, Oskarshamn, Ringhals and Barsebäck. Small amounts of spent nuclear fuel originating from the research reactor R2 at Studsvik Tech Park, from the closed Ågesta reactor and from the decommissioned research reactor, R1, must also be managed.

The spent fuel from the closed research reactor R2 at Studsvik Tech Park has been exported to the United States according to contractual agreements.

About 3.3 kg of separated plutonium and approximately 9 kg of natural and depleted uranium, mainly from reprocessing of some spent fuel from the Ågesta reactor, was exported to the US Department of Energy in 2012 within the framework of the Global Threat Reduction Initiative (GTRI). All remaining spent fuel from the operation of the Ågesta reactor is currently stored in Clab awaiting future disposal in Sweden.

The fuel rods in the R1 research reactor consisted of rods of metallic uranium enclosed in an aluminium alloy casing. In 2007, the intact part of the spent fuel was sent for reprocessing in the United Kingdom. The ownership of the separated 1.2 kg of plutonium was transferred to the UK Nuclear Decommissioning Authority (NDA) in 2014 and is to be managed together with existing UK plutonium in line with UK policies. The remaining waste from the reprocessing activities was sent back to Sweden in 2009.

The corroded parts of the R1 fuel are still being temporarily stored at the Studsvik Tech Park site awaiting conditioning before being disposed of in the planned disposal facility for long-lived waste (SFL).

No spent nuclear fuel is currently being disposed of in Sweden.

D.1.2 Spent nuclear fuel facilities and inventories

D.1.2.1 Interim storage at the nuclear power plants

Each NPP unit has a fuel pool close to the reactor vessel in which spent fuel is stored temporarily for at least nine months before being transported to Clab, see Figure D1. The fuel pools constitute integrated parts of the reactor facilities and are for the purpose of the Joint Convention not considered as separate spent fuel management facilities. The quantities of spent fuel stored in pools at the nuclear power reactors as of 31 December 2022 are presented in Table D1. The pool capacity listed corresponds to the storage capacity for spent fuel. The pools also have space for the plundered reactor core, fresh fuel, scrap and boxes.

Table D1 Inventory of spent fuel in NPP pools.

Fuel pool at NPP	Pool capacity	Spent fuel stored as of 31 December 2022	
	No. of fuel assembly positions	No. of assemblies	Tonnes
O3	1,400	291	48
F 1,2,3	3,588	1,155	192
R1	1,535	0	0
R2	432	0	0
R3	204	151	71
R4	229	111	52

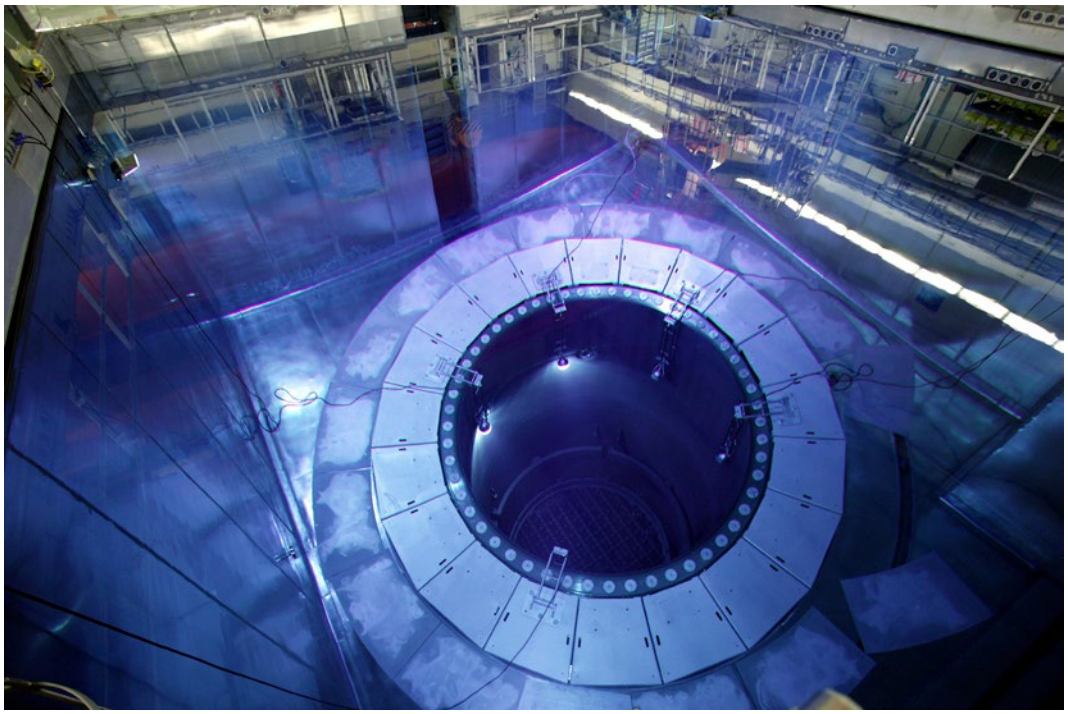

Figure D1 Reactor top and pools at one of the Swedish reactors.

D.1.2.2 Clab, the central interim storage facility for spent nuclear fuel

Spent fuel assemblies are to be stored at the Clab facility for at least 30 years. The main reason is to allow the thermal output to decay by about 90 % before encapsulation and disposal take place. Other highly radioactive components, such as control rods, are also stored in Clab awaiting disposal. An illustration of the Clab is shown in Figure D2.

After being removed from the transport cask in an unloading pool, the spent fuel assemblies are transferred to storage canisters for subsequent transport and storage. A water-filled elevator cage takes the storage canister down to the storage section, where it is placed in a predetermined position in a storage pool. Thus, unloading and all subsequent handling of spent fuel assemblies are performed under water. The water, which circulates in a closed system, acts both as a coolant and as an effective radiation shield, and no additional radiation protection equipment is needed. The water is circulated through filters to keep it clean before being returned to the pools. The heat is removed in heat exchangers and cooled by seawater in an intermediate cooling system. All safety systems have backups. Vital parts of the monitoring and control systems can be powered by a battery backup system. The storage pools are designed to withstand seismic loads as well as extreme temperature loads in the event the cooling systems should fail.

Approximately 100 people work at the facility; one-third of them with day-to-day operation, and the others with radiation protection, chemical sampling, maintenance and repairs. The number of fuel assemblies of different types stored at the Clab facility and corresponding tonnages are listed in Table D2.

Table D2 Inventory of spent fuel stored in Clab as of 31 Dec.2022.

Specification	Spent nuclear fuel stored as of 31 December 2022	
	No. of assemblies	Tonnes
BWR fuel	32,571	5,477
PWR fuel	4,263	1,839
Ågesta	222	20
Studsvik	30	3
MOX	217	23
Total	**37,303**	**7,363**
Storage capacity		8,000/11,000*

*SKB is authorised to store up to 11,000 tonnes of spent fuel in Clab from February 2024.

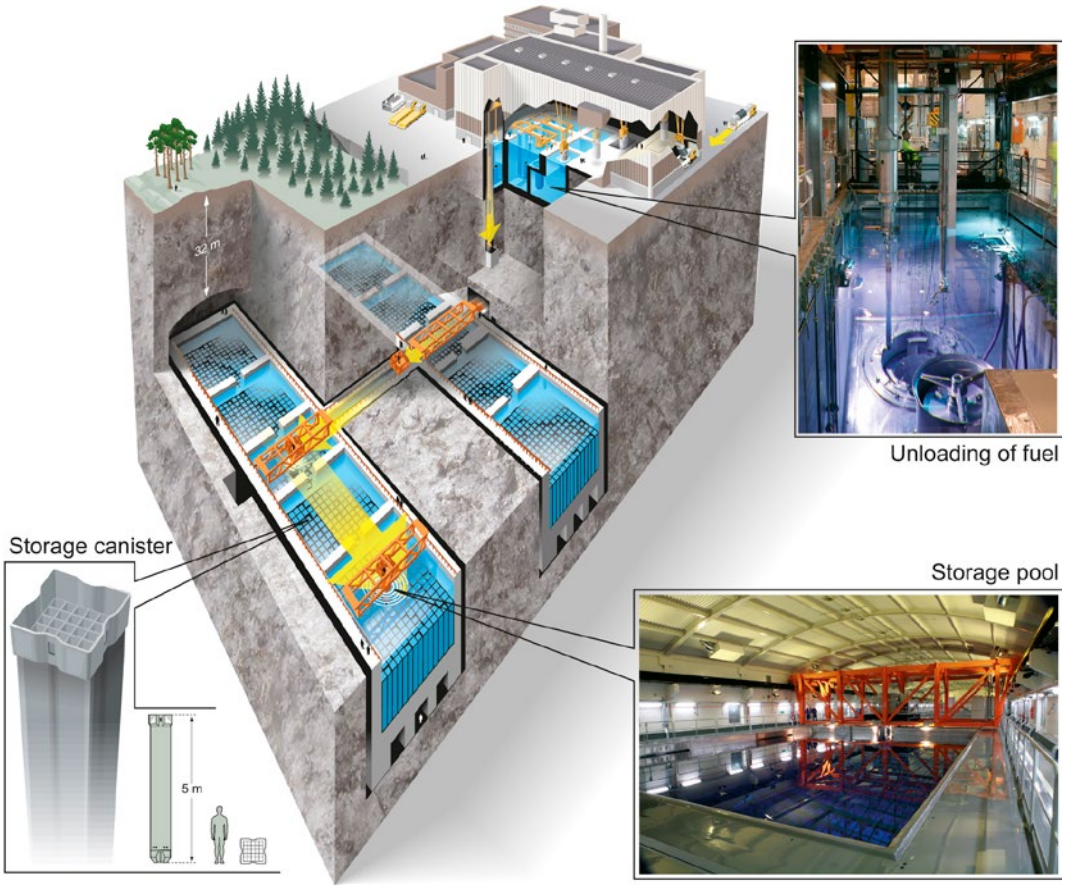

Figure D2 The Clab facility.

D.1.2.3 Spent nuclear fuel facilities and inventories at Studsvik Tech Park

As described in section D.1.1, remaining waste from reprocessing of the intact parts and corroded parts of the R1 fuel is temporarily stored on site at the Studsvik Tech Park, see Table D3.

Table D3 Spent fuel from the research reactor R1 temporarily stored at Studsvik Tech Park.

Spent nuclear fuel in storage as of 31 December 2022		
Origin	No. of assemblies	Kg
R1 fuel	1	40

D.1.3 Management of radioactive waste

D.1.3.1 The Waste Management Process

SKB and the utilities operating nuclear power reactors established early on a systematic approach by means of a "waste management process" for efficient management of nuclear waste from the reactors. There are two important basic elements in the waste management process: the Waste Acceptance Criteria (WAC) and the Waste Type Description (WTD) for different waste streams. WAC must be developed by the licensee for their specific storage and disposal facility, based on an facility-specific safety case and associated safety assessments. The WTD must be developed by the licensee of the activity or facility where the waste is generated, e.g. the licensee of a nuclear power reactor. The WTD should provide an account for all steps involved in the process from when the waste is generated up until the finally conditioned waste package is delivered to the disposal facility, and thus ensure conformity with the WAC. Among other things, the WTD needs to consider the type of waste package to be used to ensure conformity with the handling equipment at the disposal facility. Another important consideration is the potential restrictions imposed by e.g. transport regulations and radiation protection. The waste management process is further described in section F.3.2.

D.1.3.2 Management of radioactive waste at the nuclear power plants

Waste management at the NPP sites is fully integrated into the operations. Fulfilment of the requirements of the Swedish Radiation Safety Authority's general regulations is verified through regulatory review and inspection activities at the nuclear power plants, as reported under the Convention on Nuclear Safety.

Waste with very low activity (VLLW) is normally disposed of in shallow land burials on site, except for Barsebäck, which disposes operational VLLW in SFR.

Short-lived low- and intermediate-level waste (LILW) from the nuclear power plants consists of ion exchange resins from filters, metal scrap, pipes, valves, pumps, tools and protective clothing. The waste is classified and handled initially on site in preparation for disposal. The purpose of the waste handling at the power plants is to reduce its volume, solidify wet waste in concrete or bitumen, and suitably package the waste. The standardised types of waste packages are shown in Figure D3.

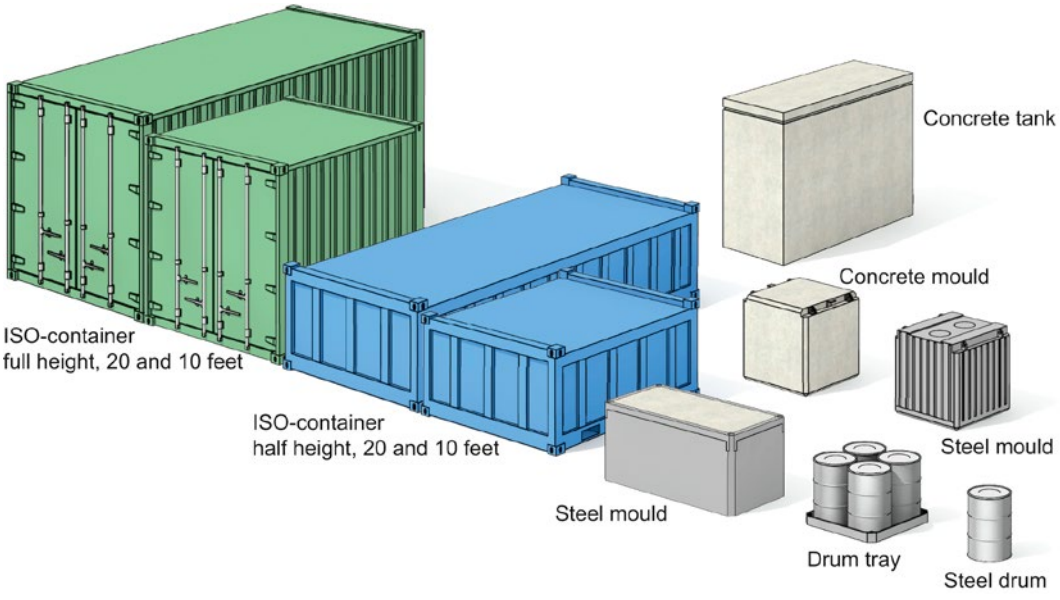

Figure D3 Standardised types of packages used for radioactive waste.

Waste is treated slightly differently at the different nuclear power plants. Table D4 illustrates the methods and packages for operational waste produced at the nuclear power plants.

Table D4 Waste treatment methods at Swedish NPPs.

Type of waste	Ringhals	Barsebäck	Oskarshamn	Forsmark
Ion exchange resins	Solidified in concrete moulds and steel moulds	Solidified in concrete and packed in steel drums	Solidified in concrete and packed in concrete mould	Solidified in bitumen and packed in steel moulds
Trash and metal scrap	Cast in concrete and packed in concrete or steel moulds Packed in standard ISO containers	Packed in concrete moulds Packed in standard ISO containers Packed in steel tanks	Cast in concrete and packed in concrete moulds Packed in standard ISO containers Packed in steel tanks	Packed in steel or concrete moulds Packed in standard ISO containers Packed in steel tanks
Sludge	Solidified in concrete, packed in concrete moulds	N.A.	N.A.	N.A.

Note: operational waste is no longer generated at the Barsebäck site following its closure.

Waste packages are placed temporarily in storage on the site, or in some cases at an external licensee's site, before being transported to SFR. As waste packages from the NPP sites are transported to SFR on a regular basis, it is not relevant for the purpose of the Joint Convention to present a list of the inventories for the interim storage at the sites.

At the Oskarshamn site, the interim storage facility for low- and intermediate-level waste is located in a rock cavern and in on-ground storage facilities. At the other nuclear power plants sites, there are special buildings used for interim storage of conditioned operational waste. Operation of the storage buildings at the sites are fully integrated in the operation of the NPP. The safety procedures and safety documentation for those activities constitutes integrated parts of the safety procedures and safety documentation for the NPP. The safety documentation describes the facility and the waste handling activities, the content of radioactive substances, supervisory activities as well as safety analyses.
See section D.1.6 for interim storage of decommissioning waste.

D.1.4 Radioactive waste management facilities and inventories

D.1.4.1 Management of radioactive waste and inventories at Studsvik Tech Park

Studsvik Nuclear AB materials research facilities
Studsvik Nuclear AB provides services in fuel and materials technologies to the nuclear power industry. Testing of materials and reactor fuel is performed in its own laboratories on site.

Hot cell laboratory, HCL
The Hot Cell Laboratory is primarily used to investigate irradiated nuclear fuel, although it is also used for studying other types of irradiated materials. In addition, the laboratory is used for conditioning, treatment and encapsulation of spent fuel fragments in packages suitable for interim storage. The laboratory has seven cells with thick concrete walls, and lead windows to protect personnel from ionising radiation. All waste is removed from the laboratory after conditioning.

The active metal laboratory, AKL
The Active Metal Laboratory is primarily used to investigate irradiated metallic materials. The laboratory has several cells with lead walls to protect personnel from ionising radiation. All waste is removed from the laboratory after conditioning.

The storage facility, FA
This facility, which contains three water pools, was built in 1965 for interim storage of spent nuclear fuel from the Ågesta power reactor. As all fuel from Ågesta has since been transferred to Clab, the facility is used for other purposes, such as storing spent fuel from other reactors, storing other radioactive materials or for temporary storage of spent fuel prior to examinations performed in HCL. Small quantities of spent nuclear fuel examined at Studsvik are transported to Clab.

Cyclife Sweden AB's radioactive waste management facilities
Cyclife Sweden AB provides services such as treatment of waste from national and international customers based on commercial agreements. A principal precondition for such international agreements is that the radioactive material and radioactive waste is returned to the customer.

The incineration facility, HA
The facility is used for incineration or pyrolysis of low-level waste (LLW) from NPPs, fuel fabrication plants, hospitals, research institutions and facilities at the Studsvik Tech Park. The work also comprises management, radiological measurement and final conditioning of the waste. Up until 2006, ash was stabilised in concrete for disposal (or returned to the country of origin).

However, as of 2016, SKB does not accept ash conditioned in concrete for disposal and work is ongoing to develop a new method for conditioning and packaging ash. The current licence conditions allow for treatment of 600 tonnes of combustible waste annually.

The melting facility, SMA
The melting facility at Studsvik is used for volume reduction of contaminated metal, see Figure D4. After melting and radiological measurement, the material may be exempted from regulatory control or returned to the customer for further management. Most often the metal ingots can be free-released while slag and dust are returned to the customer. The current licence allows for treatment of 5,600 tonnes of metal annually. Cyclife Sweden AB is in a process to establish a new melting facility, thereby increasing the annual capacity to 10,000 tonnes.

Figure D4 The melting facility (SMA) at Cyclife Sweden AB.

Treatment facilities for radioactive non-nuclear waste, FR0-A and R0-A
Disused sealed sources and radioactive waste from medical use, research and industry are mainly managed in two facilities, FR0-A and R0-A. In R0-A, ionising smoke detectors are dismantled or sorted, whereas all other disused sealed sources and radioactive waste are treated in FR0-A. Depending on the activities, dose rate, material, etc., treatment comprises sorting, volume reduction, packing and conditioning. Some of the disused sealed sources and radioactive waste may also be treated in the facilities HA, SMA or AB Svafo's facility HM (see below). Some radioactive sources are sent abroad for recycling.

AB Svafo radioactive waste management facilities
The most important facilities operated by AB Svafo at the Studsvik Tech Park are described below.

Treatment facility for intermediate waste, HM
This facility is used for the treatment of intermediate-level solid and liquid waste from facilities at the Studsvik Tech Park. Treatment of solid waste comprises sorting, volume reduction (compaction), packing and conditioning by means of stabilisation using concrete. Treatment of liquid waste comprises evaporation and solidification by means of stabilisation using concrete.

Interim storage facility for low- and intermediate-level waste, AM
The AM facility was constructed in the 1980s for interim storage of conditioned waste from facilities at the Studsvik Tech Park. The storage facility is constructed in a cavern in bedrock with a rock cover of at least 20 m. The rock is grouted with concrete, the walls are reinforced by means of rendering concrete, and special arrangements have been made to drain the rock. The storage facility is dimensioned to receive waste until around 2045. The storage area is divided into two parts: one part is used for waste requiring shielding and the other for waste not requiring shielding.

The shielded part of the AM storage facility has a capacity of about 4,000 m^3 while the unshielded part has a capacity of about 1,120 m^3. In addition, 1,000 drums can be stored in other parts of the storage facility. The waste is conditioned and packed in special containers before being placed in the storage. The ventilation and drainage systems are monitored for any radioactive substances.

The following types of waste originating from facilities at the Studsvik Tech Park are currently being stored at AM:
– operational waste from the R2 research reactor and testing performed in the reactor;
– irradiated and contaminated material from the isotopes production;
– irradiated and contaminated material from the fuel testing laboratory; and
– start sources from an old research reactor and operational waste from the waste handling facilities.

In addition, the following externally-produced types of waste currently being stored at AM:
– residual products from incinerated waste from nuclear power plants, medicine and industry;
– residual products from use of isotopes in medicine and industry;
– decommissioning waste from old nuclear facilities; and
– waste from treatment of steam generators from Ringhals.

Storage facilities for radioactive waste, AU and AUA
The AU facility is an interim storage facility for conditioned long-lived low-level waste. It is a simple unheated building made of concrete and steel. The AU storage facility contains drums with legacy waste embedded in concrete. The waste was reconditioned in the 1990s. About 7,000 drums were previously stored in the facility. The waste will ultimately be disposed of in the planned disposal facility for long-lived waste (SFL).

The AUA facility is an interim storage facility for decommissioning waste from Barsebäck, Ågesta and the R2 research reactor. The facility has been in operation since 2022. The facility is intended to be used also for other customers, if appropriate.

Monitoring of facilities at Studsvik Tech Park
Ventilation and/or exhaust systems are monitored for any radioactive substances whenever there is a risk of airborne emission. Likewise, drainage systems are monitored for any radioactive substances before the water is discharged to avoid contamination from wastewater.

D.1.4.2 Repository for short-lived low- and intermediate-level waste (SFR)

General information
The repository is situated beneath the Baltic Sea, covered by about 60 m of rock. Two 1 km long access tunnels lead from the harbour in Forsmark to the repository area. The facility currently consists of four 160 m long waste vaults: one waste vault for intermediate-level waste (1BMA), two for concrete tanks (1BTF, 2BTF) and one for low-level waste (1BLA), plus a 70 m high cavern in which a concrete silo has been built. Waste is directed to different parts of the repository depending on factors such as activity content and chemical characteristics.

The total capacity of SFR is approximately 63,000 m^3. By 31 December 2022, roughly 40,000 m^3 of waste had been disposed of. The government licence for continued operation and extension of SFR permits a maximum of 2·1016 Bq and by 31 December 2022 a total activity of approximately 6·1014 Bq had been deposited in SFR. The governmental licence further specifies that the total radioactivity in each waste vault at closure of the repository does not significantly exceed the inventory that the post-closure safety assessment is based on.

The repository is designed to isolate the waste from the biosphere to avoid harmful consequences for people and the environment both during operation and after closure. This is accomplished by emplacement in the bedrock under the seabed and by the technical barriers surrounding the waste, see Figure A14.

The silo
The waste designated for SFR that has the highest radioactivity is intended for disposal in the silo. This waste comes from many different waste streams, but the most important one comprises ion exchange resins in a concrete or bitumen matrix from the nuclear power plants. Other waste, such as metal components of different origins, is also disposed of in the silo. The amount of organic material is kept to a minimum. The maximum surface dose rate permitted in a package is 500 mSv/h. All handling of waste packages is performed using remote control equipment. The dominant nuclides (activity) are Co-60, Cs-137 and Ni-63.

The silo consists of a cylindrical concrete construction with shafts of different sizes for waste packages. The concrete cylinder is approximately 50 m tall with a diameter of approximately 30 m. The largest shafts measure 2.5 m by 2.5 m. The waste packages are placed in the shafts, normally in layers of four moulds or 16 drums. The spaces between the waste packages are gradually backfilled with porous concrete. The walls of the silo are made of 0.8 m thick reinforced concrete. In between the walls and the surrounding rock, there is a bentonite backfill averaging 1.2 m thick. The 1 m thick concrete floor at the bottom of the silo is placed on a layer of 90/10 sand/bentonite mixture.

According to the present plans, a 1 m thick concrete lid will cover the top of the silo. After closure, the lid will be covered with a thin layer of sand, then a 1.5 m thick layer of sand/ bentonite mixture (90/10), and the remaining space will be filled with sand, gravel or sand stabilised with cement. When the repository is closed, a system of plugs will be placed adjacent to the sile.

The waste vault for intermediate level waste (1BMA)
The radioactivity in the waste that is disposed of in 1BMA is generally lower than in the silo. The waste in 1BMA comes from many different waste streams. The most important one is ion exchange resins from the nuclear power plants. Other waste, such as metal components of various origins as well as contaminated trash, is also disposed of in 1BMA.

The maximum surface dose rate permitted on the packages is 100 mSv/h, and the radionuclide content is low. 1BMA has been designed to accommodate approximately 6 % of the total activity content in SFR. The dominant nuclides are Co-60, Cs-137 and Ni-63. The waste packages are of the same type as in the silo, i.e. moulds and drums.

The waste vault is approximately 160 m long, 19.5 m wide with a height of 16.5 m. Inside, there is a concrete construction to divide the vault into 15 compartments. The moulds and drums are placed in the compartments using remote-controlled equipment. During the operational phase, a ceiling is suspended above the waste to minimise water dripping onto the waste and the concrete construction. This suspended ceiling will be dismantled before the repository is closed.

The waste is stacked on top of the concrete floor in such a way that the concrete moulds act as support for the prefabricated concrete slabs and put in position as soon as the compartments are filled. It is also possible to backfill the void between the waste packages in a compartment. Lastly, a layer of concrete will be cast on top of the lid. There is a 2 m wide space between the concrete structure and the rock wall, which will be filled with crushed rock or macadam before closure. The space above the concrete structure will also be backfilled. Plugs will be placed in the two entrances to the vault when the repository is closed.

The rock vaults for concrete tanks (BTF)
There are two waste vaults in SFR for concrete tanks: 1BTF and 2BTF. The waste in 1BTF mainly consists of drums containing ash and concrete tanks containing ion exchange resins and filter aids, whereas the waste in 2BTF consists of only the latter. Moreover, some large metal components may be disposed of in the caverns.

The maximum surface dose rate permitted on the packages is 10 mSv/h. The radionuclide content is low, and the dominant nuclides are Co-60 and Cs-137. The waste vaults are approximately 160 m long, 14.8 m wide with a height of 9.5 m. The concrete tanks, each 10 m^3, are stacked on two levels with four tanks in each row. A concrete radiation protection lid is placed on top of the stacks. The space between the different tanks is backfilled with concrete and the space between the tanks and the rock wall will be filled with, for example, sand stabilised with cement. Plugs will be placed in the two entrances to the vaults when the repository is closed.

The rock vault for low-level waste (BLA)

The waste disposed of in 1BLA, short-lived waste, is mainly low-level scrap metal (iron/steel, aluminium), cellulose (e.g. wood, textile, paper), other organic materials, non-organic materials (e.g. plastics, cables) and other waste such as insulation (e.g. rock wool) packed in ISO-standard steel containers.

The maximum dose rate permitted on the surface of the waste packages is 2 mSv/h. The radionuclide contents are low, and the dominant nuclide is Co60. Some of the waste inside the containers is placed in steel drums and other types in bales.

The rock vault cavern is approximately 160 m long, 15 m wide with a height of 12.5 m. The design is very simple with a concrete floor, on which the containers are placed. During the operational phase, a ceiling is suspended above the waste to minimise water dripping onto the containers. This ceiling will be dismantled before the repository is closed.

The containers are stacked three high in rows of two. Most of the containers are half-height, allowing six to a pile. No backfilling is planned. Plugs will be placed in the two entrances to the vault when the repository is closed.

Inventory of nuclear waste disposed of in the SFR facility

The inventory of nuclear waste disposed of in the SFR facility is listed in Table D5. The nuclide-specific activity content can be seen in Figure D5.

Table D5 Inventories of radioactive waste disposed of in SFR as of 31 December 2022.

Repository section	Volume (m³)	Activity (Bq) as of 31 Dec 2022
Silo	8,306	4.53E14
1BMA	9,784	1.60E14
1BTF	2,514	1.55E12
2BTF	7,680	7.00E12
1BLA	12,300	5.67E11
SFR total	**40,585**	**6.22E14**

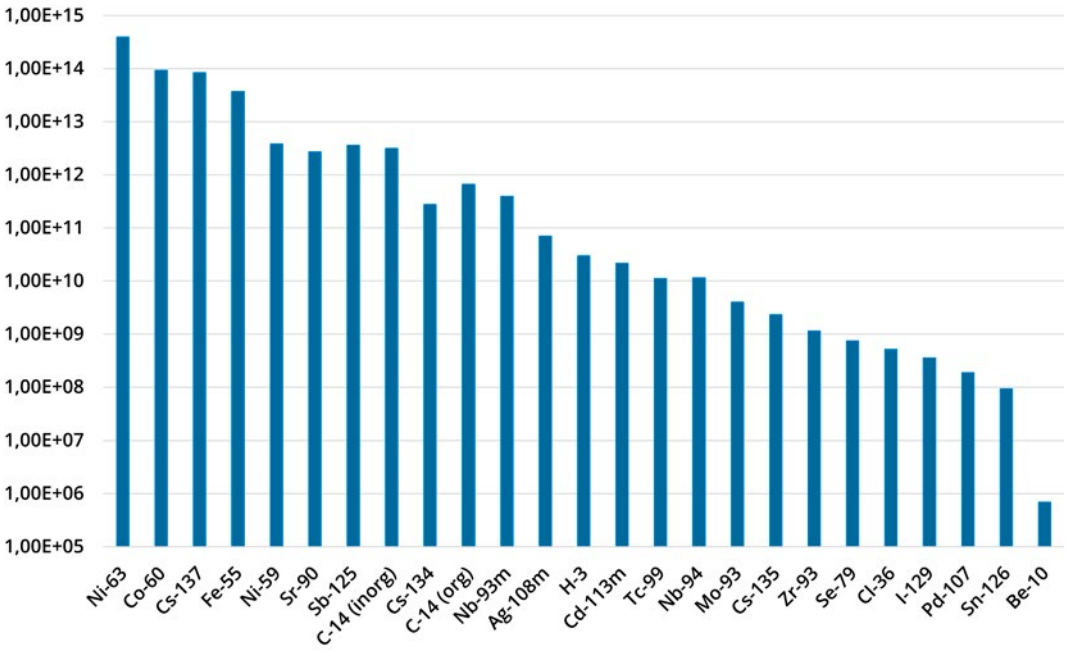

Figure D5 Radionuclide-specific activity content in SFR. The data reflects the situation as of 31 December 2022.

D.1.4.3 Shallow land burials

The nuclear power plants at Ringhals, Forsmark and Oskarshamn as well as Studsvik Tech Park have shallow land burials for very low-level waste. The total activity content is, according to each licence, limited to between 100 and 1,100 GBq per burial.

In addition to the total activity content, waste acceptance criteria specify the nuclide-specific activity concentration and surface dose rate of each individual package. The (remaining) activity concentration is specified for the future point in time when the shallow land burial is planned to be released from a radiation protection control, see Table D6.

The waste from the nuclear power plants is disposed of in campaigns undertaken at three- to five-year intervals, in between which the burial facilities are closed. The waste consists of low-level scrap and residues from the operations of the NPPs. These include piping, tools, insulation material and protective clothing as well as trash such as plastics, paper and cables. The dominant nuclides are generally Co-60, Cs-137 and Ni-63. The shallow land burial at Studsvik Tech Park contains waste from decommissioning of various old nuclear installations plus operational waste from other Studsvik facilities.

The design and layout of the shallow land burials differ, but all facilities have a top sealing layer to reduce infiltration of water, see Figure D6. The design of the top sealing layer differs between the facilities: bentonite liners, plastic membranes and massive layers of glacial clay or mixes of bentonite and sand have been used as well as mixed designs. The sealing layer of the facilities is covered with a drainage layer topped by a protective layer of e.g. soil, approximately 1 m thick. A geological barrier has been installed hydraulic down-gradient from the burials at the newer installations at Ringhals and Oskarshamn. A natural or semi-natural geological barrier reduces leakages to the environment at the burials at Forsmark and Studsvik Tech Park. There are monitoring programmes in place for sampling leachate water, for example with respect to radionuclides. The licence period includes a 30-year surveillance period (50 years for OKG) after final closure.

Figure D6 The shallow land burial at OKG.

Table D6 Inventories of waste disposed of in shallow land burials. The burial facilities at Studsvik Tech Park (AB Svafo) are closed permanently.

Site	Licence conditions			Waste disposed of as of 31Dec 2022		
	Licence period until	Volume (m^3)	Max. activity / max. alpha activity (GBq)	Mass (tonnes)	Volume (m^3)	Activity (Gbq)
Forsmark	2070	17,000	200/0.2	5,119	7,804	49,2
Oskarshamn	2075	16,000	200/0.2	6,081	12,569	22,3
Ringhals	2060	10,000	1100/0.1	5940	9180	238
Studsvik AB (Svafo)	2040	1,540	100/0.1	781	900	140

D.1.5 Nuclear facilities under decommissioning

This section presents an overview of the status of the nuclear facilities permanently shut down or being decommissioned. Table D7 lists all nuclear facilities under decommissioning.

The general timetables for the nuclear power companies' and SKB's planned decommissioning of their facilities are presented in Figure D7. The current period is dominated by activities at the nuclear power reactors Barsebäck 1 and 2, Oskarshamn 1 and 2, Ringhals 1 and 2, and the Ågesta reactor. More detailed information on the regulations of decommissioning as well as decommissioning practices is presented in section F.6.

D.1.5.1 Barsebäck NPP

The twin BWR units Barsebäck 1 and 2 were shut down permanently in 1999 and 2005, respectively, as a result of political decisions. All spent nuclear fuel was removed by 2006. A decommissioning licence according to the Environmental Code was obtained from the Land and Environment Court in 2019. Since then, segmentation of the reactor pressure vessel and the internal components of the reactor pressure vessel has been completed. Dismantling in various buildings, such as the turbine building and the reactor building, is ongoing. Site release in accordance with regulatory requirements is planned for the mid-2030s.

D.1.5.2 Oskarshamn NPP

In 2015, the owner decided to permanently shut down the two oldest BWR Units 1 and 2 at the Oskarshamn NPP before 2017. Oskarshamn 1 was permanently shut down in June 2017. In practice, Oskarshamn 2 was never restarted after an extended period of shutdown. Oskarshamn 1 and Oskarshamn 2 are currently in a dismantling and demolition state. All spent nuclear fuel, for both reactors, was removed in 2018. Decommissioning licences, according to the Environmental Code, weres obtained from the Land and Environment Court in 2018 for both reactors. Since then, segmentation of the reactor pressure vessel has commenced and segmentation of the internal components of the reactor pressure vessels completed. Dismantling in various buildings, such as the turbine building and the reactor building, is ongoing. Site release in accordance with regulatory requirements is planned for Oskarshamn 1 and 2, together with Oskarshamn 3 which is still in operation.

D.1.5.3 Ringhals NPP

In 2015, the owner decided to permanently shut down the two oldest reactors at the Ringhals NPP, Ringhals 1 (BWR) and Ringhals 2 (PWR). Ringhals 2 was permanently shut down in December 2019 and Ringhals 1 in December 2020. A decommissioning licence according to the Environmental Code was obtained from the Land and Environment Court in 2020 to start large-scale decommissioning. Shutdown operation took 16 months at Ringhals 1 and 28 months at Ringhals 2, considering cooling requirements and capacity for fuel transport. All spent nuclear fuel was removed by 2022. In June

2022, both Ringhals 1 and Ringhals 2 transitioned to service operation. SSM approved in March 2024 Ringhals' safety related documentation to commence dismantling and decommissioning.

D.1.5.4 Ågesta PHWR

The Ågesta reactor was shut down in 1974. A licence according to the Environmental Code for dismantling and demolition of the reactor was obtained in 2019. Since then, segmentation of the reactor pressure vessel and the internal components of the reactor pressure vessel has been completed. Dismantling in the reactor building, is ongoing, and it is expected to be finished in 2024/2025. Site release in accordance with regulatory requirements is planned for 2025.

D.1.5.5 Studsvik materials testing reactors

The final dismantling of Studsvik's R2 materials testing reactor, which began in 2015, is completed. Applications for clearance of the remaining buildings and sub-surface structures was approved in 2023.

D.1.5.6 Installations in Ranstad

The uranium mining and milling facilities in Ranstad were constructed and operated in the 1960s. The decommissioning of the Ranstad uranium mining and milling facility is completed and the site has been released from any further regulatory control.

Table D7 Nuclear facilities under decommissioning

Nuclear facility	Current projects	Start of project	Anticipated completion	Status
Ranstad – uranium mining/milling	Decommissioning and clearance	2013	2019	Complete
Studsvik R2 facility, materials testing reactors	Dismantling and demolition	2015	2023	Buildings cleared
Barsebäck nuclear power plant – Units 1,2	Dismantling and demolition	2020	2028	Ongoing
Oskarshamn nuclear power plant – Units 1,2	Dismantling and demolition	2020	2028	Ongoing
Ringhals nuclear power plant – Units 1,2	Dismantling and demolition	2020	2029	Ongoing
Ågesta	Dismantling and demolition	2020	2025	Ongoing

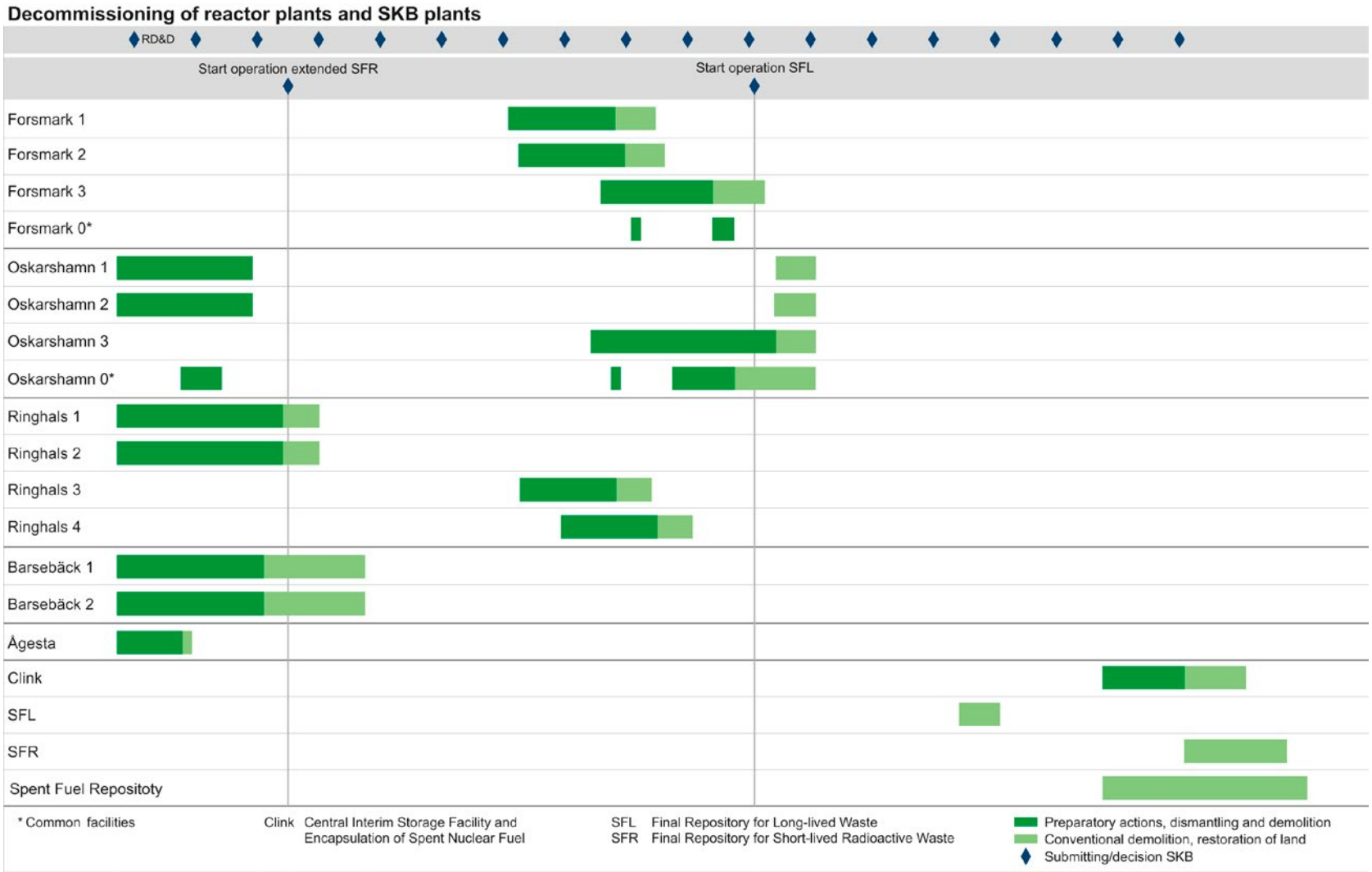

Figure D7 Schematic overview of the nuclear power companies' and SKB's timetables for decommissioning (F0 and O0 are shared facilities on the sites).

D.1.6 Interim storage of decommissioning waste

The timing for final shutdown is an important planning premise for a decommissioning project, and for the overall system of radioactive waste management. Radioactive waste management requires, for example, that waste type descriptions be revised and approved for decommissioning waste, that handling and techniques for management of large components be developed, and that waste containers that are desirable from a decommissioning perspective be developed and licensed. Furthermore, pathways need to be available for radioactive material that will not be disposed of by SKB, such as issuing a licence for shallow land burial of very low-level decommissioning waste at the nuclear power plants.

Waste from decommissioning of the first nuclear power reactors will arise before the extended SFR facility will be available for disposal of short-lived decommissioning waste and before the construction of the SFL facility for disposal of long-lived decommissioning waste. For this reason, the radioactive waste must be placed in interim storage prior to disposal.

There is a need to build additional interim storage capacity for low-level waste on site for radioactive waste materials arising from the decommissioning of the Barsebäck reactors. Waste produced during decommissioning of the reactors at Oskarshamn and Ringhals will be stored on site in existing facilities until transferred to the extended SFR or SFL disposal facilities. Radioactive waste produced during decommissioning of the Ågesta reactor is being transferred to the new storage building at Studsvik Tech Park for storage pending disposal.

Approximately half of the expected total volume of long-lived decommissioning waste is expected to arise before the planned commissioning of SFL. Since the waste cannot be finally conditioned before acceptance criteria for SFL are determined, which presupposes a defined site and concept, the long-lived waste needs to be stored in waste containers pending final conditioning. According to the current timetable, final conditioning of such waste can commence once SKB obtains a licence for the construction of SFL.

Section E – Legislative and regulatory system

E.1 Article 18: Implementing measures

Each Contracting Party shall take, within the framework of its national law, the legislative, regulatory and administrative measures and other steps necessary for implementing its obligations under this Convention.

The legislative, regulatory and other measures to fulfil the obligations of the Joint Convention are discussed in this report.

E.2 Article 19: Legislative and regulatory framework

1. Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of spent fuel and radioactive waste management.

2. This legislative and regulatory framework shall provide for:

(i) the establishment of applicable national safety requirements and regulations for radiation safety;

(ii) a system of licensing of spent fuel and radioactive waste management activities;

(iii) a system of prohibition of the operation of a spent fuel or radioactive waste management facility without a licence;

(iv) a system of appropriate institutional control, regulatory inspection and documentation and reporting;

(v) the enforcement of applicable regulations and of the terms of the licences;

(vi) a clear allocation of responsibilities of the bodies involved in the different steps of spent fuel and of radioactive waste management.

3. When considering whether to regulate radioactive materials as radioactive waste, Contracting Parties shall take due account of the objectives of this Convention.

This section is divided into five parts. The first part (section E 2.1) presents the legislative structure and the basic legal requirements of the legal and regulatory framework. The second part (section E 2.2) contains more detailed information about the legal requirements of the licensing system, prohibition, institutional control, regulatory inspection, documentation and reporting, enforcement of regulations and terms of licences and a description of the allocation of responsibilities between the bodies involved. The third part (section E 2.3) describes the regulatory framework, which refers to the various authorities' regulations. The fourth part (section E 2.4) reports on regulatory review activities. The fifth part (section E 2.5) describes the regulatory bodies responsible for different aspects of the management of spent fuel and radioactive waste.

E.2.1 National legislative framework

The framework of Sweden's legislation in the fields of spent fuel and radioactive waste management, nuclear safety and radiation protection is found in five Acts, with associated Ordinances:

- Act (1984:3) on Nuclear Activities and Ordinance (1984:14) on Nuclear Activities;
- Radiation Protection Act (2018:396) and Radiation Protection Ordinance (2018:506);
- Environmental Code;
- Act (2006:647) on Financing of Management of Residual Products from Nuclear Activities; and
- Act (2000:1064) on the Control of Dual-use Items and Technical Assistance (partly).

As reported below, the Swedish Radiation Safety Authority (SSM) has a mandate to issue regulations concerning radiation safety under the Acts on Nuclear Activities and the Radiation Protection, based on Government Ordinances.

E.2.1.1 The Act and Ordinance on Nuclear Activities

The Act on Nuclear Activities is the basic law regulating nuclear safety (as well as nuclear security, physical protection, information security and non-proliferation, but outside of the scope addressed in the Convention). It contains basic safety provisions concerning nuclear activities and applies to management of nuclear material and nuclear waste and the operation of nuclear power plants.

The Act does not contain provisions concerning radiation protection. This area is regulated in the Radiation Protection Act, see section E.2.1.2. For nuclear activities, the Radiation Protection Act and Act on Nuclear Activities should be applied in parallel and in close association with each other.

The Ordinance on Nuclear Activities contains detailed provisions regulating areas such as definitions, applications for licences, reviews, evaluations, inspections and certain exemptions from the application of the Act on Nuclear Activities. The Ordinance also mandates SSM to decide on exceptions in individual cases if there are special circumstances and if the purpose of the law is not violated.

The Ordinance also specifies that SSM is authorised to issue licences for e.g. shallow land burials for very-low level waste and other facilities managing low-level radioactive waste. SSM is also authorised to issue licences for transports of nuclear materials and nuclear waste.

Furthermore, the Authority is authorised to impose licence conditions and to issue general regulations concerning measures to maintain the safety of nuclear activities.

Safety Requirements

Nuclear activities must be conducted to meet safety requirements and fulfil the obligations pursuant to Sweden's agreements for the purpose of preventing the proliferation of nuclear weapons and unauthorised dealing of nuclear material and spent nuclear fuel.

A nuclear installation must be designed, located, constructed, commissioned, operated and decommissioned to avoid radiological emergencies and, if a radiological emergency still occurs, consequences of the emergency to be managed.

Safety in nuclear activities shall be maintained by taking all necessary measures to prevent errors in equipment, or its defective function, incorrect handling or any other circumstances that could result in a radiological accident and unlawful dealings with nuclear material or nuclear waste. The Government, or the authority appointed by the Government, may issue more detailed provisions concerning these areas. As mentioned above, SSM has the mandate to impose detailed regulations.

A new integrated analysis and assessment of the safety of a nuclear facility must be performed by the licence holder (periodic safety review) at least once every 10 years. The analysis and assessments as well as the measures proposed based on these, must be documented and submitted to the regulatory authority for review.

Definitions

The handling, transport or other dealings with the nuclear waste are defined as a nuclear activity.

General obligations of licensees and licence conditions

The licence holder for a nuclear activity shall be responsible for ensuring that all the necessary measures are taken for:

- maintaining safety, with reference to the nature of the activities and the conditions under which they are conducted;
- ensuring the safe handling and disposal of nuclear waste arising from the activity or nuclear material arising therein that is not reused; and
- the safe decommissioning and dismantling of plants in which the nuclear activity will no longer be conducted.

In addition to these three measures, the Act on Nuclear Activities also requires the application of the general "rules of consideration" contained in the Environmental Code, see section E.2.1.3.

The holder of a licence for a nuclear activity must ensure that all the necessary measures are taken for maintaining safety. These general requirements are addressed in more detailed regulations issued by SSM (see below) and, if needed, issued as licence conditions. Licensing conditions are imposed when a licence is issued and can be imposed during the period of the validity of a licence.

Disposal of nuclear waste – Safe management and RD&D programme
The holder of a licence for nuclear activities is responsible for the management and disposal of the waste produced and for decommissioning. The holder of a licence for the operation of a nuclear power reactor shall, in liaison with the other holders of a licence for the operation of nuclear power reactors, establish and carry out an RD&D programme for the safe handling and disposal of spent fuel and nuclear waste. Every third year, a report describing the programme shall be submitted to SSM for review. An important step in the review process is that the programme is sent to numerous stakeholders for consultation and comment, such as other governmental organisations, municipalities, environmental organisations, research institutions and universities.

Following the review, SSM sends a review statement regarding the RD&D programme to the Government. The Government determines whether the programme can be approved. The Government may also issue conditions concerning the content of the nuclear power operators' (through SKB) future research and development work.

E.2.1.2 The Radiation Protection Act and Ordinance
Requirements for radiation protection are set out in the Radiation Protection Act and in the Radiation Protection Ordinance. Precautionary measures listed in the Act apply not only to activities that require licences or notifications but also to activities that does not require these.

The purpose of the legislation is to protect human health and the environment against the harmful effects of radiation.

Persons engaged in activities involving radiation are obligated to take the required precautionary measures.

The persons conducting activities are also responsible for proper handling and disposal of the radioactive waste produced in or brought to the activity, which includes covering the costs associated with both the handling and disposal of the waste.

The Radiation Protection Ordinance contains detailed provisions on e.g. dose limits, licences and notifications, documentation of sources, reporting on orphan sources and supervision.

The Ordinance stipulates that the regulatory authority assigned by the Government may issue regulations regarding further provisions concerning general obligations, radioactive waste and prohibitions against activities with certain materials, etc. The Ordinance also stipulates that certain provisions in the Act do not apply to very low-level radioactive materials and technical equipment emitting only low-level radiation (i.e. exemption). The regulatory authority may also issue regulations concerning the release of very low-level radioactive material.

Radiation Protection Requirements

Definitions
The Act applies to all activities involving radiation. These are defined to include all activities involving radioactive substances and technical devices capable of generating radiation.

Consequently, the Act applies to radiation from nuclear activities and to harmful radiation, ionising as well as non-ionising, from any other source (medical, industrial, research, consumer products and NORM). The Radiation Protection Act and the Act on Nuclear Activities are applied in close association with each other regarding nuclear installations, such as the management and disposal facilities for spent fuel and radioactive waste.

The Government or the mandated authority may, to the extent it does not conflict with the purpose of the Act, prescribe exemptions in full or in part from the application of the Act. An exemption may also be combined with special conditions. Furthermore, specific conditions may be stipulated on radioactive substances or technical devices capable of generating radiation, which are not otherwise covered by the Act.

Basic requirements for radiation protection
The Radiation Protection Act is based on the International Commission on Radiological Protection (ICRP's) internationally recognised principles. These principles are as follows.

Justification: No activity is to be introduced until it has been shown to provide greater advantages than disadvantages to society. The basic principle of justification with regard to management of nuclear and non-nuclear radioactive waste cannot be questioned at this stage. The waste has been generated as a result of previous decisions.

Optimisation: All radiation doses to individuals, the number of exposed individuals, as well as the probability of receiving doses must be kept as low as reasonably achievable, while taking into account economic and societal factors. This is often called the "ALARA principle" (As Low As Reasonably Achievable).

Dose limitation: Individual exposure to radiation (dose) must not exceed the established limits for the particular circumstances. The dose limit or dose constraint can be viewed as a limit for optimisation; thus, individual doses must not exceed the established limits, even if the collective dose would be reduced as a result.

The Government, or the authority assigned by the Government, may also issue further regulations as required for protection against, or control of, radiation as specified in the Act.

General obligations of licensees and licence conditions
In addition to the above-mentioned principles, the basic requirements listed below apply for any person who conducts activities involving radiation:

- measures to limit the production of radioactive waste; and
- measures to limit discharge of radioactive substances and exposure of the environment to ionising radiation.

Furthermore, any person who conducts activities involving ionising radiation shall, from the radiation protection point of view and the nature and conditions of the activity:

- control and maintain the radiation protection in the places where radiation may occur;
- maintain technical devices, measuring and radiation protection equipment used in the activity;
- take any other measures and precautions necessary to prevent or counteract damage to human health or the environment; and
- ensure that everyone who works in the activity, and may be exposed to ionising radiation, has the knowledge and competence needed in radiation protection to function satisfactorily.

Anyone who conducts activities shall also comply with the requirement that sufficient financial, administrative and personnel resources are available to meet the obligations arising from the Act, regulations issued under the provisions of the Act and decisions issued in accordance with the Act.

The provision implies that all the necessary measures should be taken to improve radiation protection; it is thus insufficient to solely comply with the regulations or conditions issued by the responsible authority.

The Government, or the authority assigned by the Government, may also issue any further regulations required for protection against, or control of, radiation specified in the Act.

The responsible authority may impose conditions needed for radiological protection when a licence is, or has been, issued under the provisions of the Radiation Protection Act. Such radiation protection conditions can also be imposed on activities licensed within the legal framework of the Act on Nuclear Activities.

Disposal of radioactive waste – Safe management
Anyone who conducts activities involving radiation is required to treat and, as necessary, dispose of the radioactive waste which may arise in, or otherwise brought to, the activity.

Anyone who conducts or has conducted activities using a technical device that can emit radiation shall, to the extent stipulated by the Government or the authority appointed by the Government, ensure that the device is destroyed when it is no longer being used in the activity.

E.2.1.3 The Environmental Code

The objective of the Swedish Environmental Code is to promote sustainable development and thereby ensure a healthy environment for current and future generations. The Code includes general provisions on environmental protection. The Code is applicable to nuclear activities and activities involving radiation and must be applied in parallel with the Act on Nuclear Activities and Radiation Protection Act. Ordinances supplement the Code, laid down by the Swedish Government.

Requirements for Protective Measures, etc.

Definitions

In the Code, environmentally hazardous activities are defined as:

- the discharge of wastewater, solid matter or gas from land, buildings or structures onto land, air or into bodies of water or groundwater;
- any use of land, buildings or structures that entails a risk detrimental to human health or the environment due to discharges or emissions other than those referred to above, or to pollution of land, air, bodies of water or groundwater; or
- any use of land, buildings or structures that may be detrimental to the surroundings due to noise, vibration, light, ionising or non-ionising radiation or similar impact.

General rules of consideration

The general rules of consideration define several important principles that must be complied with by the implementer, e.g. below:

- The knowledge principle means that the implementer must possess the knowledge that is necessary regarding the nature and scope of the activity to protect human health and the environment against damage or detriment.
- The precautionary and BAT principles mean that the implementer shall put into practice protective measures, comply with restrictions, and take any other precautions that are necessary to prevent, hinder or combat damage or detriment to human health or the environment as a result of the activity. For the same reason, the best available technology shall be used in connection with occupational activities.
- The most suitable site principle means that, as regard to activities for which land or water areas are used, a suitable site shall be selected while taking into account the goals of the Environmental Code. Sites for activities must always be chosen to achieve their purpose with a minimum of damage or detriment to human health and the environment.
- The after-treatment liability principle means that everyone who has pursued an activity that causes damage or is detrimental to the environment shall be responsible for restoring it to the extent deemed reasonable. An individual who is liable for after-treatment shall carry out or pay for any after-treatment measures necessary. The general rules of consideration function as a preventive tool based on the polluter pays principle.

The requirements of the first three principles listed above apply to the extent that they may be considered too onerous to comply with. In making this assessment, particular consideration should be given to the benefits of protection measures and other precautions as compared to the cost of such measures (by means of cost-benefit analysis).

E.2.1.4 Legislation on financing

Nuclear power plants

The purpose of the financing arrangements, established in 1981, is to secure financing for the nuclear licensees' future costs for the management and disposal of spent nuclear fuel and nuclear waste. The objective is to minimise the risk to the State and future generations being forced to bear costs considered to be the liability of the licensees. The licensees pay recurring fees to the Nuclear Waste Fund. If there is insufficient money in the Fund to pay for the costs, the licensees will nevertheless still be liable.

SKB coordinates the nuclear power utilities' cost estimates and submits these to the National Debt Office every three years. The Debt Office reviews the cost estimates and calculates the nuclear waste fees and financial guarantees individually for each utility. The fees are calculated on the assumption that each reactor will generate electricity for 50 years, though always with a minimum remaining operating time of six years. Based on the Debt Office's recommendation, the Government decides on the nuclear waste fees and financial guarantees for a period of three years. The nuclear waste fund assets are managed by a Government authority, the Nuclear Waste Fund.

The power plant utilities must also provide financial guarantees as securities to cover fees that have not yet been paid (the credit risk amount), and to cover costs in connection with unexpected events (the risk margin).

Other nuclear facilities
Nuclear licensees, other than power reactor operators, must also pay fees to the Nuclear Waste Fund. This in practice applies to certain nuclear fuel cycle, research and waste management facilities. The build-up of adequate financial resources is based on the facilities expected remaining period of operation. The licensees must also provide a financial guarantee to cover fees that have not yet been paid (the credit risk amount). The National Debt Office decides on the nuclear waste fees and financial guarantees for a period of three years.

Legacy waste
There is also a funding mechanism for legacy waste from historic nuclear activities. Until the end of 2017, a fee was levied on the nuclear power plant licensees under the provisions of the so-called "Studsvik Act", to cover expenses for liabilities originating from the establishment of a nuclear programme in Sweden. This special funding primarily contributes to the decommissioning of old installations.

The licensees for nuclear power reactors are required to pay the additional fees necessary if the fund's assets are insufficient to cover the future liabilities, in accordance with the provisions of the Financing Act. There is also a state financing scheme administered by SSM for the clean-up of orphan sources and other non-nuclear legacy waste. See section J.1.2.2.

Non-nuclear waste
A licence under the Radiation Protection Act, may for its validity be made dependent on that the licence holder intending to conduct the activity to provide financial security for the waste management costs and recovery measures that the activity can incur. The financial security can be set gradually according to a plan that always meets the current need for financial security. If the financial security is no longer sufficient, the licensing authority may decide on additional collateral. This applies to all non-nuclear activities in which radioactive materials are used: in medicine, industry, agriculture, research and education.

The state, municipalities, county councils and municipal associations do not need to provide any financial collateral.

A licence under the Environmental Code, may for its validity be made dependent on that the licence holder intending to conduct the activity to provide financial security for the costs of remedying an environmental damage and other restoration measures that may be needed due to the activity e.g. mining operations.

E.2.1.5 Other relevant Acts

The Act on the Control of Dual-use Items and Technical Assistance
Export of nuclear material and equipment is governed by the Act on the Control of Dual-use Items and Technical Assistance as well as by Council Regulation (EC) No 428/2009 of 5 May 2009, setting up a community regime for the control of exports, transfer, brokering and transit of dual-use items. See also information under Article 27, section I.1.1.

The Civil Protection Act
The Civil Protection Act contains provisions on how community rescue services are to be organised and operated. According to the Act, the County Administrative Board is responsible for rescue operations in cases where the public needs protection from a radioactive release from a nuclear installation and when such a release seems imminent. The Act also stipulates that a rescue commander with a specified competence and extensive authority is to be engaged for rescue operations. In addition, the Act requires the owner of hazardous installations to take the necessary measures to minimise any harm to the public or environment if an accident was to occur in their installation.

The Civil Protection Ordinance contains general provisions concerning emergency planning. The County Administrative Board must draw up a radiological emergency response plan. The Swedish Civil Contingencies Agency (MSB) is responsible at national level for the coordination and supervision of the preparedness for rescue services response to a radioactive release.

SSM decides on the necessary measures for nuclear installations.

The Occupational Safety and Health Act
The Occupational Safety and Health Act contains requirements for the work environment and provisions regarding protection from accidents caused by technical equipment, dangerous materials or other work conditions. The Act also contains detailed provisions concerning responsibility and authority with respect to occupational safety issues.

The Transport of Dangerous Goods Act
The Transport of Dangerous Goods Act and Transport of Dangerous Goods Ordinance contain provisions for the purpose of preventing, hindering and limiting damage caused by transport of dangerous goods.

E.2.2 National regulatory framework

SSM issues legally binding safety and radiation protection regulations for nuclear activities and other activities involving radiation with reference to its legal mandate under its Regulatory Code (SSMFS).

SSM's regulations implement binding EU legislation and international obligations. As part of preparing SSM's regulations, consideration is given to the IAEA safety standards, international recommendations, industrial standards and norms and the rulemaking of other Swedish authorities. SSM's regulations are issued in accordance with an established management procedure that stipulates technical and legal reviews of draft versions. Under governmental rules, a review is performed of the final drafts by authorities, licensees, various stakeholders and industrial and environmental organisations.

In addition, SSM may issue general advice on how the requirements are to be interpreted. The general advice is not legally binding per se. Implementation of the requirements should be taken according to the general advice or, alternatively, equivalent methods justified from the point of view of safety should be implemented.

For each individual regulation, there is also a guidance that aims to facilitate the interpretation of each requirement and to increase understanding of the overall understanding of the regulation. The background and consideration, purpose, application and reference to each requirement are explained in the guidance. If legal rulings (appeals etc.) affect the interpretation of the requirements, the guidance will be updated with the revised interpretation.

SSM's Regulatory Code is structured in three levels as follows:
- the first level represents the requirements applicable to all licensed activities involving ionising radiation;
- the second level deals with facility/activity-specific requirements; and
- the third level consists of requirements applied to specific aspects of radiation safety.

Section L.1 contains a brief summary of the most relevant regulations relating to the safety of spent fuel and radioactive waste management.

E.2.3 Licensing

E.2.3.1 The Act on Nuclelar Activities

In principle, all activities involving nuclear material or nuclear waste constitute a nuclear activity for which a licence under the Act on Nuclear Activities is required. However, nuclear waste and nuclear material with a very low level of radiation can be released from regulatory control.

The Government is the licensing authority for nuclear facilities. SSM reviews the licence application and prepares a statement with recommendation for the Government's decision. After the Government's licence approval, SSM authorises the continued construction, operation and closure of the facility in a stepwise manner and may stipulate conditions under the Act under each phase. For certain smaller facilities and activities, SSM has the mandate to issue a licence.

E.2.3.2 The Radiation Protection Act

For activities outside the nuclear fuel cycle all handling of radioactive substances requires a licence under the Radiation Protection Act, for which SSM issues licences. In the case of export of radioactive substances, a licence may instead be required under the Act (2000:1064) on the Control of Dual-use Items and Technical Assistance.

A separate licence according to the Radiation Protection Act is not required for activities licensed according to the Act on Nuclear Activities.

E.2.3.3 The Environmental Code

According to the provisions of the Environmental Code, a licence is required for environmentally hazardous activities, which include facilities for the treatment, storage or disposal of spent fuel, nuclear waste or radioactive waste. A licence is also needed for the decommissioning of nuclear reactors.

For certain activities, including any facility requiring a licence under the Act on Nuclear Activities, the Land and Environment Court examines the application and submits comments to the Government for its decision regarding the permissibility of the proposed activity. After the Government's decision, the case is handed over to the Land and Environment Court to determine provisions concerning the environmental supervision, inspections and checks, the safety and technical design of the activity, and conditions that are necessary to prevent or limit any harmful or other detrimental impact.

E.2.3.4 Environmental impact assessments

General

The Act on Nuclear Activities, Radiation Protection Act and Environmental Code, require submission of an Environmental Impact Assessment (EIA) as a basis for the licensing.

An EIA is required for e.g. nuclear activities, such as waste management activities and facilities and decommissioning of reactors.

In other cases, with activities involving radiation, the Government or its appointed authority may prescribe that the applicant prepares an EIA before permission is given to license.

Legislation regarding EIA is in accordance with the Council Directive 85/337/EEC of 27 June 1985, amended by the Council Directive 97/11/EC of 3 March 1997 and by the Directive 2003/35/EC of 26 May 2003, on the assessment of the effects of certain public and private projects on the environment. An EIA is to be submitted together with an application for a licence for environmentally hazardous activities.

The purpose of an EIA is to identify, describe and assess environmental impacts when planning and deciding on plans and programmes (strategic environmental assessments) and activities and actions (specific environmental assessments). Environmental impact means direct or indirect effects that are positive or negative, temporary or permanent, cumulative or non-cumulative and that occur in the short, medium or long term. Below are examples of some basic components that should be included in an EIA:

- possible alternative designs and the reasons for the chosen design with regard to environmental effects;
- possible alternative locations and the reasons for the choice of site, taking into account differences in the environmental effects between the chosen site and the alternatives;
- information on existing environmental conditions before the start of the activity and how those conditions are expected to develop if the activity is not started;
- information on the measures envisaged to prevent, hinder, counteract or mitigate adverse environmental effects; and
- a statement of the consultations that have taken place and what emerged from them.

The information to be included in the environmental impact assessment must have the extent and degree of detail that is reasonable in the light of current knowledge and assessment methods and that is needed to make an overall assessment of the significant environmental impacts that the activity may be expected to cause.

The EIA-process

The following steps apply in the process of preparing an EIA.

Scoping – public consultation

As an initial scoping step the developer shall, before the work on the actual environmental impact assessment starts, conduct consultations on the location, scope and design of the activity and its environmental effects and on the content and form of the environmental impact statement.

Prior to the scoping, consultation documents must be prepared and submitted to the parties concerned, which are the County Administrative Board, the supervisory authority and the individuals who may be assumed to be particularly affected by the activity as well as other state authorities, municipalities, the general public and NGOs who may be assumed to be affected by the activity.

Consultation with other countries
In the case of activities assumed to have a significant environmental impact in another country or if a country that may be considerably affected by the activity so requests, the Swedish Environmental Protection Agency shall inform the other country and give a reasonable time to comment on whether it wishes to participate in the environmental assessment. These provisions incorporate the requirements contained in the Aarhus Convention and the Espoo Convention.

Assessment of EIA in the licensing process
When the developer has submitted its application and environmental impact assessment to the authority, the authority shall assess the impact assessment, to the extent and degree of detail that is reasonable in the light of current knowledge and assessment methods, and if needed, carry out an overall assessment of the significant environmental impacts that the activity may be expected to cause. After this, the EIA shall be announced and made available to the public for comments during at least 30 days.

In a separate decision, or in connection with the final review of the application, the licensing authority shall decide whether the environmental impact assessment meets the requirements. The authority shall also complete the environmental assessment by identifying, describing and making a final and comprehensive assessment of the environmental impact, taking into account the content of the environmental impact assessment and what emerged during the review process of the case.

When the application with an EIA has been approved, the licensing authority shall announce its decision as soon as possible. The announcement shall describe how the public can access the content of the decision.

E.2.4 Prohibition, revocation and sanction

It is prohibited to carry out nuclear activities or activities involving radiation without a licence. Any person who deliberately, or through negligence, operates an activity without the necessary permission shall be fined or sentenced to not more than two years imprisonment. The same penalty (for unauthorised environmental activity) applies under the Environmental Code.

The licensing authority may revoke a licence to conduct nuclear activities under the Act on Nuclear Activities if:

- conditions have not been complied with in some essential respect;
- the licensee has not fulfilled its obligations concerning research and development work on waste management and decommissioning, and there are very specific safety reasons to revoke the licence; or
- there are any other very specific safety reasons for revocation.

This means that revocation of a licence may be decided in cases of severe misconduct by the operator or for exceptional safety reasons. If the licence to operate a nuclear power plant is revoked, the licence holder nevertheless remains responsible for its waste management and decommissioning.

Under the Radiation Protection Act, the licensing authority may decide to fully or partially revoke a licence if the licensee does not comply with the regulations or conditions imposed pursuant to the Act, if there are particular radiation protection reasons or if the licensee requests it. Furthermore, the Government, or the authority appointed by the Government, may issue additional regulations on prohibitions and other precautions to protect human health against the risk of damage from ionising radiation.

Under the Environmental Code, a supervisory authority may impose injunctions or prohibitions on an operator for non-compliance with the obligations of the Code.

The Act on Nuclear Activities also contains provisions on sanctions. If the crime is intentional and aggravating, the individual shall be sentenced to imprisonment for a minimum of six months and a maximum of four years. Liability shall not be held if responsibility for the offence is assigned under the Penal Code or the Act on Penalties for Smuggling (2000:1225), or if the offence is trivial.

Under the Radiation Protection Act, fines or imprisonment can be imposed for violations of the law. Anyone who intentionally or through gross negligence violates the law can be sentenced to a fine or imprisonment for a maximum of two years. Anyone who intentionally or negligently violates certain provisions of the law can be sentenced to a fine or imprisonment for a maximum of six months. Liability under the Act is not held if responsibility for the offence may be assigned under the Penal Code or the Act on Penalties for Smuggling or in the instance of a minor offence deemed to be trivial.

Under the Environmental Code, the supervisory authority may issue any injunctions and prohibitions that are necessary in individual cases to ensure compliance with the requirements of the Code, including provisions, judgements and other decisions issued in pursuance thereof.

Regulations on civil liability for radiological damage are contained in the Atomic Liability Act. The Act is largely based on the contents of the Paris Convention on Nuclear Third Party Liability from 1960 and the Brussels Supplementary Convention from 1963, to which Sweden has acceded.

E.2.5 Institutional control, regulatory inspection, documentation and reporting

E.2.5.1 Institutional control

The legal framework for the design of a geological disposal facility contains requirements on passive post-closure safety solutions, meaning there should be no need for additional safety measures or environmental monitoring after closure. The institutional control will be overtaken by the State, including for example maintaining records, safeguards or land use restrictions, following the closure of a disposal facility and the termination of licensee responsibilities. The Swedish Parliament adopted amendments to the Act on Nuclear Activities and the Environmental Code in June 2020 to further formalise the state's ultimate responsibility for a closed geological repository in accordance with Sweden's international commitments (see section E.2.7).

Regarding institutional control of existing shallow land burials, SSM has issued conditions stipulating that institutional control shall continue until the radioactivity is no longer a "significant" hazard to public health and the environment. The municipalities' detailed development plans are also of importance by providing conditions concerning the use of the land.

Institutional control may also be required according to the Environmental Code and ordinances under the Code. If an area of land or water is so polluted that human health and the environment are at risk, the County Administrative Board can decide that the area constitutes an "environmental risk area".

If that is the case, the County Administrative Board may also decide, that the landowner, or the person who has conducted/conducts environmentally hazardous activities in the area, must take restoration measures to remedy or reduce the pollution or implement an environmental monitoring programme. The Board can also decide on land use restrictions.

An example of an environmental risk area is where the former uranium mining and milling activities that took place in Sweden in the 1960s, at the so-called Ranstadverket. Parts of the surrounding area is an environmental risk area and the County Administrative Board has decided on an environmental monitoring programme that will run for an initial 30 years. The Board has also imposed restrictions on land use in that area.

The Swedish Environmental Protection Agency manages a national funding programme on remediation of contaminated land from past practices. Potentially contaminated areas are identified, investigated and classified. No area has yet been identified for remediation in respect of radioactive substances only. However, identification of potentially contaminated areas is an ongoing process.

E.2.5.2 Regulatory inspections

Nuclear activities and activities involving radiation are subject to extensive inspections under various laws. For radiation protection, nuclear safety and security, SSM is responsible for the supervision of compliance with the Act on Nuclear Activities, Radiation Protection Act, the Environmental Code and for conditions or regulations imposed under the Acts.

The County Administrative Board performs supervision of other environmental aspects covered by the Code.

According to the Ordinance to the Environmental Code, SSM also provides regulatory guidance regarding supervision of pollution and other environmental damages caused by radioactive substances.

The operator must, on request, submit to the Authority information and documentation required for its supervision. The Authority is to be given access to the installation or site where the activities are conducted for investigations and sampling required for its supervision. The police authority shall provide assistance, if needed, for the supervision. See section E.3.2.6 for a more detailed description of SSM's supervisory processes and methods.

E.2.5.3 Documentation and reporting

Reporting requirements on licensees

The Act on Nuclear Activities, the Radiation Protection Act and the Environmental Code contain many different documentation and reporting requirements.

The Nuclear Activities Act and the Radiation Protection Act focus on issues related to safety and radiation protection. The Environmental Code requires operators to annually submit a general environmental report. The environmental report must describe the measures taken to comply with the conditions in the licence and the results of the measures.

SSM's regulatory code requires detailed documentation and reporting. Below are some examples of reporting requirements, in the context of the Joint Convention:

- Licensees for nuclear reactors shall report annually to SSM what measures have been taken or planned to be taken to limit emissions and discharges of radioactive substances.
- Results from monitoring of emissions to air and discharges to water of radioactive substances shall be reported to SSM.
- Results from environmental monitoring shall be reported to SSM in accordance with a defined program.
- Events leading to increased emissions of radioactive substances from nuclear facilities should be reported to SSM as soon as possible, presenting the measures taken to limit the emissions.
- Annual reporting to SSM on the management of nuclear waste include:
  - the quantities of nuclear waste occurring on the site or that have in any other way been transferred to that site;
  - nuclear waste that has been transferred to disposal or which has been transported from the facility for processing or storage at another facility, or which has been subjected to clearance;
  - nuclear waste at the site at year-end, indicating the nuclide and the locations where nuclear waste is stored; and
  - operating experience from waste management, and monitoring of waste management plans.
- Annual reporting to SSM on radioactive waste with information on:
  - amount of waste with its various properties;
  - content of radioactive substances in the waste;
  - who is responsible for the disposal of the waste; and
  - planned final management with a schedule and reference to the waste plan.
- A waste plan on the radioactive waste shall describe how and when the waste should be disposed of. The plan shall be based on an evaluation of different ways of handling the waste and kept up to date.
- Before a plant is constructed, a decommissioning plan must be drawn up for the future decommissioning of the facility. Not later than one year after the final closure of the plant, the decommissioning plan shall be renewed and reported to SSM. The plan shall include extensive details about the:
  - documentation on the plant;
  - planning conditions; and
  - decommissioning operations.
- Annual reporting to SSM from all licensees of high activity sources (HASS) regarding:
  - when a new source has been acquired;
  - if the conditions specified in a record sheet have changed;
  - when the holder has transferred the source to a new holder or to a recognised installation, supplement the information about the recipient of the source; and
  - when the practice has ceased and no sources are held.
- The licence holders for nuclear activities shall report as follows:
  - Annually report to SSM on the planned or taken measures to limit the discharge of radioactive substances, with a view to reaching defined goals. If reference values are exceeded, the measures planned to reaching the reference values shall be reported.
  - Annually report to SSM on the discharge of radioactive substances into air and water, shown as discharge of activity, and doses to individuals in a reference group.
  - Semi-annually report to SSM on the results of environmental checks.

– At least once every 10 years, licensees are required to perform a periodic safety review (PSR), i.e. an integrated analysis and assessment of the safety of their facility. The PSR should cover both nuclear safety and radiation protection to clarify how the requirements stated in legislation as well as issued in the form of regulations and conditions are met, and are expected to be met, over the following ten-year period. SSM reviews and assess thoroughly the submitted PSR and determines whether the necessary conditions exist to operate the facility in a safe manner until the next review; this outcome is documented in a review report. In the case of nuclear power reactors, the report is submitted to the Government.

Reporting requirements on the Regulatory body (SSM)
Reporting requirements also apply to SSM in accordance with the appropriation directions, Government decisions and acts and ordinances. In this context, the following reports may be mentioned:

– An annual Activity Report and Financial Statement is submitted to the Government, with a summary of results, effects and costs of the regulatory activities, in accordance with general regulations issued by the Government and Swedish National Audit Office, as required by all government authorities. In its annual report, SSM gives an overview of the Authority's supervisory activities and the status of radiation safety in society.
– Every three years the regulatory authority must submit a review report to the Government on the nuclear industry's research, development and demonstration programme for disposal of spent fuel and nuclear waste and the dismantling and decommissioning of nuclear installations (i.e. SKB's RD&D programme). The review report also proposes conditions for the future conduct of the SKB RD&D programme that the Government may wish to prescribe under the Act on Nuclear Activities, in addition to the findings, conclusions and recommendations as to the purposefulness and quality of the programme.
– The regulatory authority must report annually to the Government on the licences granted concerning the export, import or transit of nuclear waste and the construction, possession or operation of shallow landfill sites.
– The regulatory authority also issues reports to many organisations, such as the European Commission, UNSCEAR, OECD, the IAEA, etc. on a regular basis, in compliance with international conventions. Most of this reporting is within the area of environmental radiation protection, but some parts also relate to occupational radiation protection.

In addition to the above-mentioned reports, the regulatory authority issues periodic reports to inform the public of major activities. The regulatory authority also issues reports related to its regulatory research programme and regulatory reviews. All reports published by the regulatory authority are available to the media and general public.

Reporting requirements on the National Debt Office
Every three years the regulatory authority appointed by the Government (the National Debt Office) is required to submit a proposal for the nuclear waste fees to be paid by the licensees of nuclear power reactors in order to cover the costs for disposal of spent fuel and nuclear waste and the dismantling and decommissioning of nuclear installations. The regulatory authority also includes a review report on the cost estimates provided by the licensees.

E.2.6 Enforcement of regulations and terms of licences

The authorities have extensive legal, regulatory and enforcement powers. As described in section E.2.4 concerning prohibition, a licence may be revoked for activities that do not fulfil the obligations set out in the legislation. If there is an ongoing licensed activity that does not comply with regulations or the terms of the licence, the supervisory authorities may issue any injunctions and prohibitions required to ensure compliance. Injunctions or prohibitions under the Acts may carry contingent fines.

If a person fails to carry out a prescribed measure under the Acts or Ordinances, regulations, conditions issued pursuant to the Acts or under the supervisory authority's injunction, the authority may arrange for the measure to be taken at the person's expense.

E.2.7 Allocation of responsibilities

The Swedish legal framework allocates a clear division of responsibilities between the bodies involved. As already mentioned, the producer of spent fuel and radioactive waste has the responsibility of safely handling and disposing of the waste produced. All the necessary measures and precautions should be taken by the waste producer. The authorities independently supervise, regulate and review existing or planned activities involving spent fuel and radioactive waste.

The ultimate responsibility for ensuring the safety of spent nuclear fuel and radioactive waste rests with the State in accordance with Sweden's international commitments.

E.2.8 Information and transparency provisions at existing nuclear facilities

It is considered crucial to give the general public insights and information on nuclear activities, especially in municipalities where nuclear facilities (power reactors, research reactors and facilities for manufacturing, handling, storing or disposing of nuclear material or nuclear waste) are to be located. For this purpose, "Local safety boards" have been established in the municipalities hosting such facilities.

The licence holder of facilities is required to give the local safety board information on the safety and radiation protection work at their plants. The licence holder must, at the request of the board, provide information on the facts available and access to their plants and sites. The board members are appointed by the Government.

Therefore, it is important to point out that these boards do not have powers to impose requirements on the nuclear power plants or to prescribe safety-enhancing, or other measures, for these plants. These functions rest exclusively with the regulatory authorities.

For a more comprehensive description of measures for openness and transparency, see sections E.3.2.9, G.3.1.2, K.3.1.2 and K5.

E.2.9 Licensing – implementation in practice of legal and regulatory framework

This section describes the licensing system for the treatment and disposal of spent fuel, radioactive waste, very low-level radioactive waste and non-nuclear radioactive waste. The system of release is also mentioned in this context.

E.2.9.1 Facilities for the management and disposal of spent fuel and radioactive waste

General about the Licensing Process

The Environmental Code and Act on Nuclear Activities govern the licensing of facilities for handling and disposal of spent fuel and radioactive waste from the nuclear fuel cycle. In addition, the Radiation Protection Act establishes radiation protection conditions for each activity. These Acts have different purposes and involve several authorities (see Figure E1).

During the licensing process, an important instrument is the Environmental Impact Assessment (EIA). Early consultation with the individuals likely to be affected, as well as with the government agencies, affected municipalities and organisations, is emphasised in the Swedish EIA legislation. The consultations must relate to the location, scope, design and environmental impact of the proposed activity and to the content and structure of the EIA.

If an activity or measure is likely to have a significant environmental impact in another country, the Swedish Environmental Protection Agency must inform the responsible authority in that country about the planned activity or measure and give that country and its affected citizens the opportunity to take part in the consultation process concerning that application and EIA.

Permissibility according to the Environmental Code

According to the Environmental Code, the Government must consider the permissibility of certain activities such as interim storage or the disposal of spent fuel or radioactive waste. An environmental impact statement must be submitted for assessing its permissibility. The Land and Environment Court reviews that application, which is thereafter forwarded to the Government for final consideration.

Municipal right of veto

According to the Environmental Code, the Government may only decide on the permissibility provided that the municipal council concerned agrees that the activities may be located in their municipality (municipal right of veto). However, without prejudice to the municipal approval, the Government may permit an activity that involves interim storage or disposal of spent fuel or waste if the activity is of utmost importance with regard to national interests. This will not apply in cases where another site is considered to be more appropriate, or if a site has been designated for the activity in another municipality that is likely to approve the activity.

Approval according to the Act on Nuclear Activities and Environmental Code
If the Government grants permissibility in accordance with the provisions of the Environmental Code, licensing approval needs to be issued for the nuclear activity under the Act on Nuclear Activities and for the environmentally hazardous activity under the Environmental Code. The Government (or the authority appointed by the Government) grants a licence under the Act on Nuclear Activities, based on review by the regulatory authority. A licence under the Radiation Protection Act is not required for activities covered by the Act on Nuclear Activities.

Following the Government's permissibility decision, the Land and Environment Court grants a licence and issues conditions regarding environmentally hazardous activities under the Environmental Code. SSM may also issue licence conditions under the Act on Nuclear Activities and Radiation Protection Act as part of a stepwise authorisation process following the Government's licensing decision (see below).

It may be noted that the review of an application under the Environmental Code takes place in an open court hearing at the Land and Environment Court. At that hearing, all interested parties may attend, pose questions and make comments. The applicant must verbally describe all relevant aspects of its case. Prior to the court hearing, SSM submits a statement on whether the application meets the requirements of the Environmental Code. This statement is mainly based on SSM's parallel review of the licence application in accordance with the Act on Nuclear Activities. SSM is expected to participate in the hearing as the competent authority concerning nuclear safety and radiation protection issues.

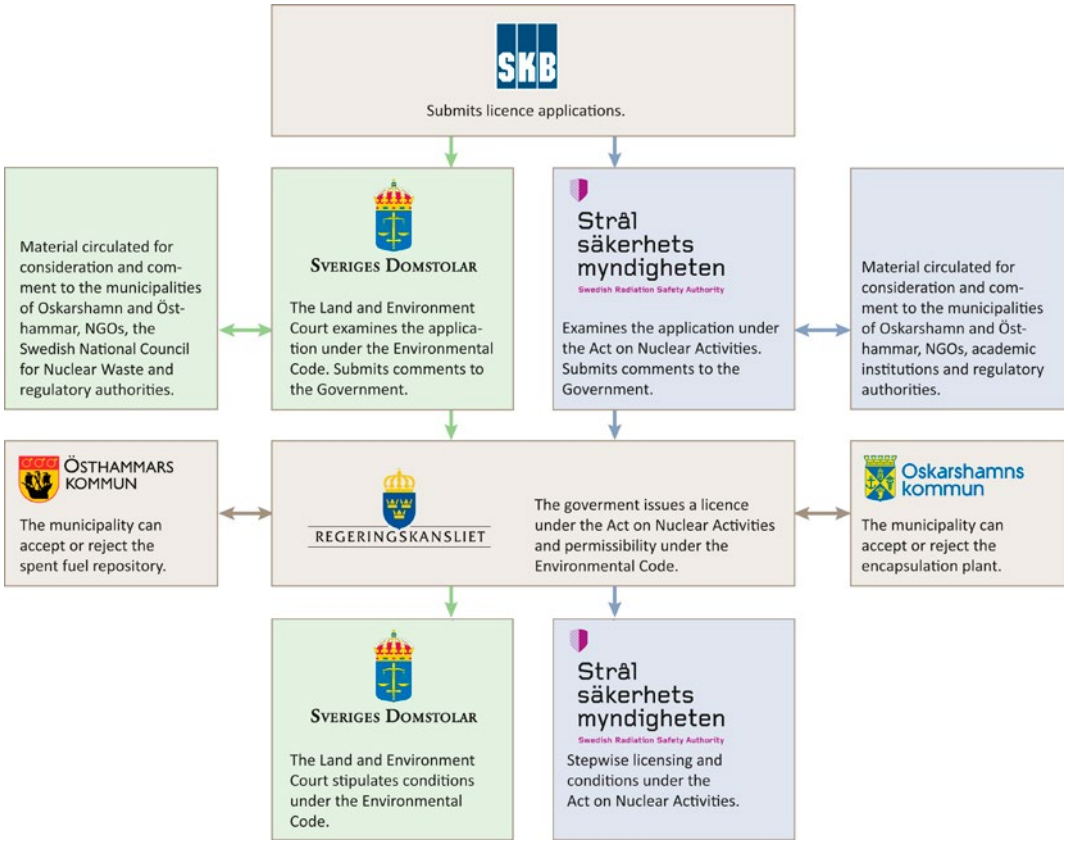

Figure E1 Process for licensing of nuclear facilities applicable to the spent nuclear fuel repository and the encapsulation plant.

Continued Stepwise Process of Regulatory Authorisation
Following governmental approval, construction may only start after SSM's review and approval of a PSAR. Similarly trial and routine operations and decommissioning may only commence after SSM's approval of an updated SAR (see Figure E2). The Government decision is again needed for de-licensing and exempting responsibilities and for final sealing of a geological disposal facility. The authority reviews the application to ensure that all obligations and licensing conditions have been fulfilled.

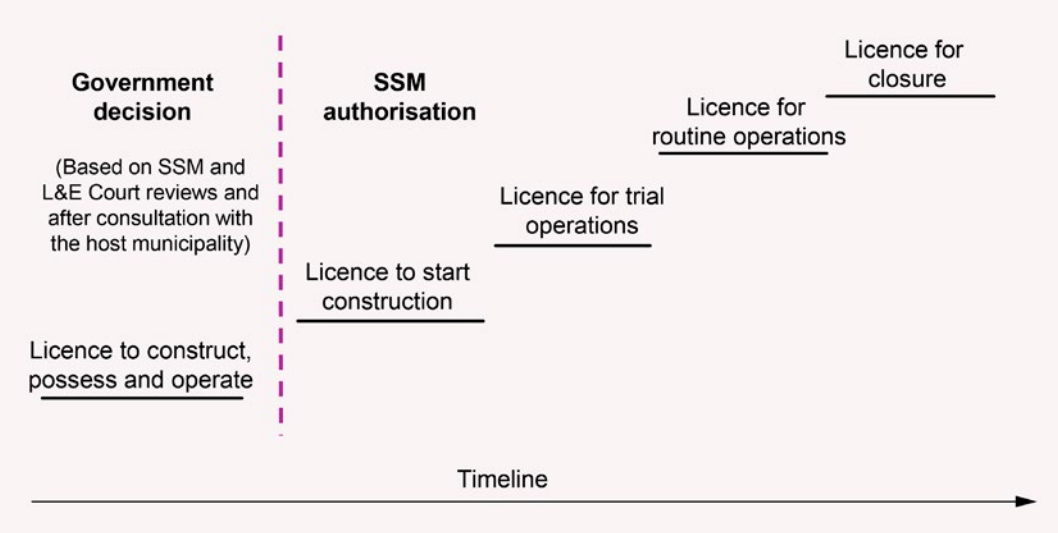

Figure E2 The stepwise process of regulatory authorisation and supervision following a Swedish Government decision to license a nuclear facility.

Safety Analysis Report

The safety analysis report (SAR) is central in the review process and must be updated throughout all the licensing steps. The SAR should provide an overall view of how the safety of the facility is managed to protect human health and the environment against nuclear accidents. The report is to describe the facility as it is built, analysed and verified as well as to demonstrate how the requirements for its design, function, organisation and activities are met.

SSM may also examine the organisational, human and administrative capacity to carry out work as well as preliminary plans for decommissioning of the facility.

E.2.9.2 Shallow land burials

Shallow burial is used in Sweden for very low-level radioactive waste from nuclear activities. Shallow land burials are licensed under both the Act on Nuclear Activities and the Environmental Code, like other nuclear installations. In the Ordinance on Nuclear Activities, SSM is mandated to licence nuclear installations such as shallow land burials up to a specified inventory limit of 10 TBq, of which a maximum of 10 GBq may consist of alpha active substances. Furthermore, shallow land burial is defined as an environmentally hazardous activity and must be approved under the Environmental Code by the Land and Environment Court. No approval by the Government is needed before the Land and Environment Court can issue a licence, including licence conditions.

Like other repositories for nuclear waste, applications must be submitted in accordance with the Act on Nuclear Activities and the Environmental Code, to SSM and the Court respectively. An important instrument during the licensing process is the Environmental Impact Assessment (EIA), which is required as a part of both licence applications. The applicant must consult the individuals, government agencies, municipalities and organisations. The consultations must relate to the scope, design and environmental impact, and to the content and structure of the EIA.

Licensing conditions can be issued under the Act on Nuclear Activities, Radiation Protection Act and Environmental Code. This means that SSM and the Land and Environment Court can issue conditions on nuclear safety, radiation protection and environmental protection, respectively. Conditions may be issued in the initial licensing process or during the period of validity of the licence.

E.2.9.3 Radioactive waste from medical use, research and industry

Handling and disposal of radioactive waste from medical use, research and industry require a licence under the Radiation Protection Act and Environmental Code.

E.2.9.4 Clearance

Clearance of nuclear materials or nuclear waste must be in accordance with the provisions of the Act on Nuclear Activities and the Radiation Protection Act and approved by the regulatory authority. Materials may be cleared for unrestricted use, or for disposal as conventional non-radioactive waste. A licence under the Environmental Code, as applicable to non-radioactive waste, may be needed if "cleared" material is to be disposed of as non-radioactive waste.

E.2.9.5 Decommissioning

According to the Act on Nuclear Activities, no specific licence is required for decommissioning nuclear facilities. However, a licence is needed for decommissioning and dismantling nuclear power reactors according to the Environmental Code. In addition to the specific requirements (see also section E.2.1.3), the applicant is required to demonstrate compliance with several principles, e.g. the knowledge principle, the precautionary and BAT principles, and the after-treatment liability principle (section F.6.1).

E.2.10 Conclusion

Sweden complies with the obligations of Article 19.

E.3 Article 20: Regulatory body

> **4.** Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 19, and provided with adequate authority, competence and financial and human resources to fulfil its assigned responsibilities.
>
> **5.** Each Contracting Party, in accordance with its legislative and regulatory framework, shall take the appropriate steps to ensure the effective independence of the regulatory functions from other functions where organisations are involved in both spent fuel or radioactive waste management and in their regulation.

E.3.1 How Sweden is governed

The Swedish Constitution is the legal basis for Sweden's parliamentary form of government and the political principles by which the State is governed. It defines and delimits the tasks of Government, establishes the basic rights and freedoms of the people of Sweden and prescribes the procedures for elections to the Riksdag (Swedish parliament).

The Government governs Sweden by executing decisions taken by the Riksdag and initiating new laws and legislative amendments. The Government is accountable to the Riksdag and must have its support to be able to implement its policies.

The Government is led by the Prime Minister, who is supported by many ministers, each with their own area of responsibility. Each ministry is responsible for several governmental authorities, tasked with applying the laws and carrying out the activities decided by the Riksdag and the Government. Governmental decisions are taken collectively in Cabinet, which means that all ministers must be in agreement. The ministers' performance of their official duties and handling of government business is scrutinised by the Riksdag's Committee on the Constitution (KU).

The Government issues instructions and yearly appropriation directions to the governmental authorities. These set out the tasks and objectives of the authorities' activities and the funding available to them. The Government thereby has substantial scope for directing the activities of governmental authorities, but it has no powers to interfere with how an authority applies the law or decides in specific cases.

The Government is responsible for recruiting and appointing the heads of governmental authorities. Each Director General is normally appointed for a period of six years.

Governmental authorities must submit annual reports and financial statements to the Government, which summarise major results, effects, revenues and costs of its activities. The Swedish National Audit Office, under the auspices of the Riksdag, scrutinises the governmental authorities and enterprises to ensure their compliance with directives, rules and regulations.

The requirements imposed on Swedish authorities for openness and provision of information services to the public, politicians and the media are very high. The principle of public access to official documents has been enshrined in one of the fundamental laws, the Freedom of the Press Act. No one needs to justify a request to view a public document or to reveal their identity to gain access to a particular document. The principle of public access also means that officials and others working in central government, municipalities and county councils have constitutional freedom of communication to the media. The principle of public access entitles the general public to access official documents, unless a decision has been made to classify them as confidential under the Public Access to Information and Secrecy Act (2009:400).

The issues of independence of the regulatory function and transparency in regulatory activities and communication with the public are further elaborated in sections E.3.2.2, E.3.2.9 and E.3.2.10.

E.3.2 The Swedish Radiation Safety Authority (SSM)

The Swedish Radiation Safety Authority (SSM) is a central administrative authority under the auspices of the Ministry of the Climate and Enterprise.

The term "radiation safety" in Sweden encompasses the areas of:

- radiation protection;
- nuclear safety;
- nuclear security and non-proliferation; and
- information security.

SSM has different roles and responsibilities as the central regulatory body in radiation safety. SSM is mandated to supervise, authorise, issue regulations and guides, coordinate nuclear and radiological emergencies, and provide expertise and services with regard to all activities that apply to radiation in society.

In this respect, SSM is the authorised regulatory body for the management of spent fuel and radioactive waste in accordance with the provisions of the Act on Nuclear Activities, the Radiation Protection Act and the Environmental Code.

E.3.2.1 Missions and tasks

The Government's directives on missions and tasks for SSM are specified in the Ordinance (2008:452) with Instructions for the Swedish Radiation Safety Authority. Provisions on funding, reporting and specific assignments are found in the Government's annual appropriation directions for SSM.

The missions and tasks can broadly be distributed into either a national or an international context, as briefly described below.

National responsibilities

SSM shall work proactively to maintain a high level of radiation safety in society, and through its activities strive to:

- prevent radiological accidents and ensure radiation safe operations and radiation safe waste management at nuclear facilities;
- minimise risks and optimise the effects of radiation in medical applications;
- minimise radiation risks in the use of products and services, or which arise as a by-product in the use of products and services;
- minimise the risks of exposure to naturally occurring radiation; and
- contribute to an enhanced level of radiation safety internationally.

Furthermore, SSM shall according to the instructions:

- ensure that regulations and work routines are cost effective and straightforward for citizens and enterprises to apply and/or understand;
- provide information and analyses within its area of responsibility prescribed by the Swedish National Debt Office to be able to carry out its tasks under the Financing Act (see section E.2.1.4);
- take the initiative for research, education and studies and to conduct external analysis and development activities to contribute to national competences for the needs of today and for the future;
- be in charge of the Swedish Metrology Institute for ionising radiation;
- operate a national dose register and, as appropriate, issue national individual dose passports;
- contribute to the development of national competences within the Authority's fields of activities; and
- provide data for radiation protection assessments and maintain competences to predict and manage evolving issues.

International cooperation
SSM's missions and tasks with regard to international cooperation include to:

- carry out Swedish obligations in accordance with conventions, EU ordinances/directives and other binding agreements (e.g. point of contact, report drafting and being the national competent authority);
- supervise that nuclear material and equipment are declared, used and in compliance with international commitments;
- carry out international cooperation and development work with community functions and organisations in countries that the Government decides on ;
- monitor and contribute to the progress of international standards and recommendations; and
- coordinate activities needed to prevent, identify and detect nuclear or radiological events; also to organise and lead the national organisation for expert advice to authorities involved in, or leading, rescue operations.

E.3.2.2 Effective independence

The *de jure and de facto* independence from political pressure and promotional interests is well provided for in Sweden. The regulatory body in radiation safety, the Swedish Radiation Safety Authority (SSM), reports to the Ministry of the Climate and Enterprise.

SSM performs its regulatory work autonomously and independently. The Government has no powers to intervene in a government authority's decision-making in applying the law or discharging its authority in individual cases. All Swedish authorities are directed by the Government by Ordinances, annual appropriation directions and budget, with decisions on tasks, the general orientation of operations and funding. Governmental authorities report on their activities and decisions to their relevant Ministry, but each minister has no power to intervene in an authority's day-to-day operations, as "ministerial rule" is prohibited. This way, the regulatory authority's effective independence in its decision making is ensured.

E.3.2.3 SSM's organisational structure

SSM consists of three topic departments derived from SSM's roles and responsibilities, i.e. policies, regulations and harmonisation, licensing, inspection and enforcement, emergency preparedness and knowledge management. The organisational structure effectively separates the authority's regulatory decision-making with respect to policies and regulations, inspection and enforcement and its licensing and authorisation work, see Figure E3.

In addition, SSM has three units responsible for internal support activities: the Legal Secretariat, the HR Secretariat and the Office of the General Director. Finally, the Department of Organisational Services is responsible for security and information management, IT and economy.

All regulatory work is coordinated between the departments to provide the right skills and resources to assigned activities, based on shared priorities and goals.

The Director General is exclusively responsible for the Authority's activities and reports directly to the Government. The Authority is supported by an advisory council consisting of a maximum of 10 members appointed by the Government, usually members of parliament, high-level agency officials or representatives of interest groups. The council has no decision-making powers. Their function is to advise the Director General and ensure public transparency (insight) in relation to the Authority's activities.

SSM's advisory committee on the safe management of spent fuel and radioactive waste is chaired by the head of the Department for Regulation and Knowledge. Its members are appointed by the Director General and represent other national or international authorities and independent institutions with relevant competence. The committee supports SSM regarding waste management practices and regulations and provides advice prior to key decision-making points and pronouncements.

SSM also has permanent advisory committees on reactor safety and research and development as well as in other fields such as UV, EM fields and the use of ionising radiation in oncology.

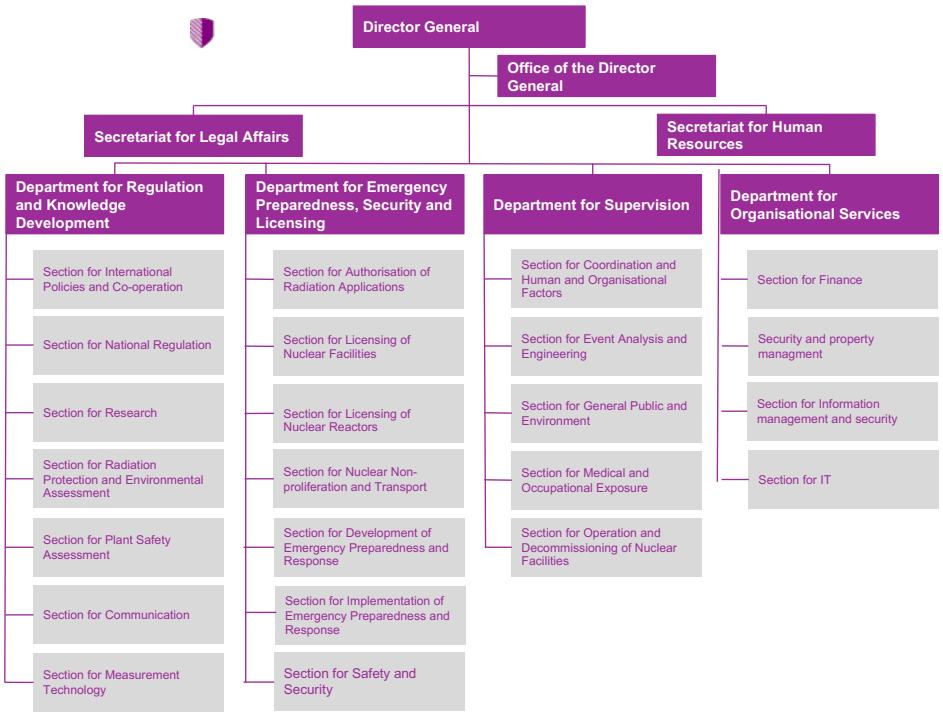

Figure E3 The present organisation of SSM (as of June 2024).

E.3.2.4 Leadership for safety

The Swedish Radiation Safety Authority (SSM) has, at the highest management level, established and integrated fundamental values in the form of a vision, goals and strategies for safety as well as key organisational values, as a basis for a strong safety culture and commitment within its whole organisation.

Vision

– A society safe from the harmful effects of radiation.

Mission statement

– SSM works proactively and preventively to protect people and the environment from harmful effects of radiation, now and in the future.
– SSM has a systematic and structured approach to continual improvements to our processes to develop our operations, render them more efficient and achieve our objectives (see management system below).

Key values

– *Credibility*, i.e. decisions based on facts and science.
– *Integrity*, i.e. accountable and independent, no undue influence.
– *Openness*, i.e. transparent, actively informative, provisions for public insight.

E.3.2.5 Integrated management system

SSM has an integrated management system that describes how the Authority controls, implements, follows up and improves its activities. The management system can be viewed as a structure of processes that together create an overview of the activities. The management system supports a systematic and effective approach and a good administration.

The management system is designed to ensure that radiation safety requirements are fulfilled in coordination with other operational requirements. The management system is also designed to support and promote a culture whereby issues impacting radiation safety are given the attention and priority that their importance require.

SSM has a process map of the existing processes in the management system in addition to the top-level documentation. This is visualised and made available for all staff in a dedicated application. In the application, there are descriptions of each step in the processes, including who should be involved, what is expected and associated documents are provided for further instructions, if available.

The management system is continuously improved to meet the results of their management reviews. Process owners and process coordinators evaluate the expediency of the processes yearly to identify what needs to be improved.

The management of SSM is controlled in a process-based approach. There are eight core processes aimed at achieving SSM's vision: "A society safe from the harmful effects of radiation". The core processes are controlled by the management process and seven supporting processes. The processes and a robust document management system support the users in their daily work. Figure E4 illustrates SSM's present comprehensive process map.

Internal and external audits

SSM conducts annual internal audits. The objective of each internal audits is to check compliance with external and internal requirements, to investigate how the "shared values" are integrated in the day-to-day work and to check whether the management system is effective and fit for purpose. SSM's internal auditors are appointed by the Director General. Audit teams are formed based on experience, competence and audit objectives.

The National Metrology Laboratory for ionising radiation is audited by Swedac, the Swedish Board for Technical Accreditation, every 3-4 years in accordance with the international laboratory standard ISO/IEC 17025. The laboratory also conducts annual internal audits with respect to the same standard, and every four years the laboratory contracts a third party an external assessor to carry out the internal audit.

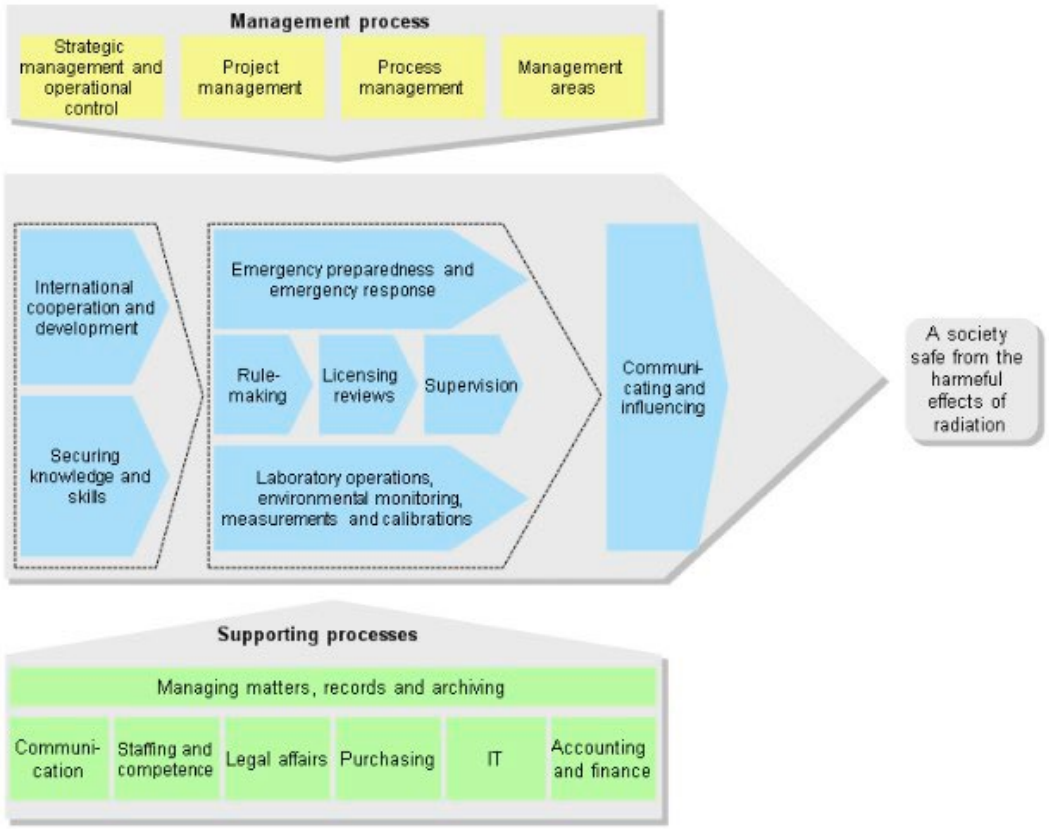

Figure E4 SSM's management system process map.

SSM places an increasing focus on the development of its processes and approaches. The fundamental driving force is to raise the level of quality of its work and consequently achieve continually improving results. Other rationales are rendering operations more efficient and improving the work environment for employees.

The work is comprehensive and the objective is to further elaborate the processes including policies, procedures and routines to achieve clarity and give the support that is needed to all employees.

E.3.2.6 Supervisory processes and methods

Regulatory supervision, including inspection, review and safety assessments, is carried out by SSM as authorised by the Ordinances on Nuclear Activities and Radiation Protection.

The documented findings from the supervisory activities provide a basis for SSM's annual integrated radiation safety evaluation for each authorised facility or activity.

Supervisory practices

SSM continues to develop its supervisory processes and methods, which are also part of SSM's overall management system. Since 2015, internal projects have been carried out with the aim of improving and simplifying, and thereby increase the quality and efficiency of, SSM's supervision.

The supervisory process is divided into the following seven sub-processes in SSM's management system:

- Compliance inspections
- Surveillance inspections
- Reviews
- Managing events
- Managing reports
- Integrated safety assessments
- Periodic safety review, PSR.

These processes are used in the supervisory programme, as described below.

Supervisory programme

Over the past six years, SSM's supervisory programme has been fundamentally revised to provide better overview, assure complete alignment with regulations and introduce a higher degree of risk-information in the frequency and scope of supervision.

The new supervisory programme was tested in 2017, and formally introduced within the reactor safety department in 2018. The programme was expanded to introduce non-reactor nuclear facilities in 2019, with due regards to a risk-informed graded approach. The programme entails considerable changes and improvements to the planning, implementation and follow-up of supervisory activities. The supervisory programme is structured in two basic parts, baseline supervision and demand-based supervision (see Figure E5). The experiences from the past 5-6 years have shown that further developments of the structure and adaptation for various facilities would be beneficial. Therefore, development of the programme is ongoing, although the basic principles remain.

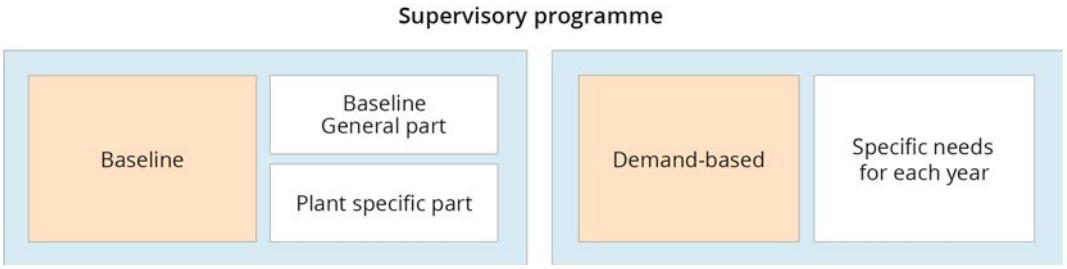

Figure E5 Supervisory programme structure.

Baseline supervision
The requirements building up the baseline supervision plan are divided into six fundamental aspects (see Figure E6):

- management and control;
- safety analysis;
- design;
- plant status;
- operation; and
- environmental impact.

The baseline supervision plan covers a period of 10 years and describes the basic supervision groups that are carried out each year for nuclear facilities in operation. Supervisory groups means the delimitation of a supervisory area, e.g. maintenance, which includes many requirements. Over the 10-year period, the baseline supervision programme covers every requirement in the regulations at least once.

The supervision groups are carried out every three, five or seven years, with due regard to a risk-informed graded approach. There is a total of 36 supervision groups, including, e.g.:

- safety analysis;
- operations;
- management system;
- safety review;
- experience feedback;
- security; and
- ALARA programme.

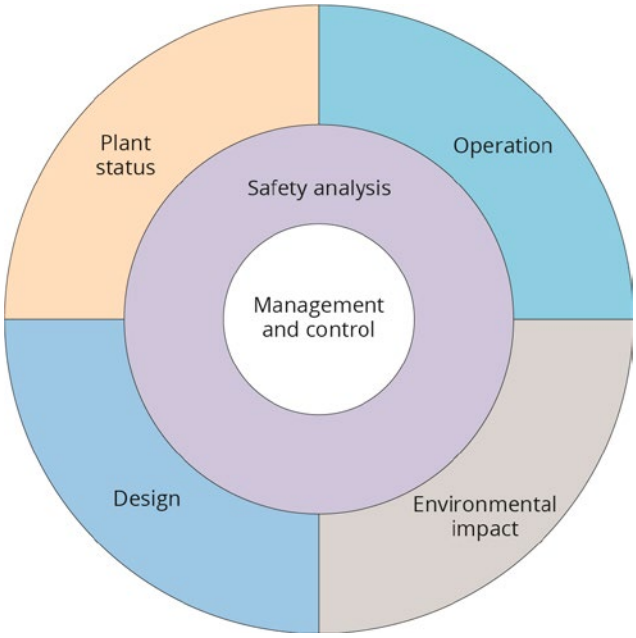

Figure E6 Fundamental aspects of the baseline supervision.

Demand-based supervision – Identification of supervision needs
As an important complement to the baseline supervision, the demand-based supervision is defined for each facility on a yearly basis. It can therefore differ from year to year, depending on:

- the results from integrated safety assessments;
- results from inspections carried out or events that have occurred;
- identified areas where supervision is deemed necessary from, e.g., events or concerns;
- major ongoing changes, technical or organisational;
- other identified needs.

Inspections
Compliance inspections are carried out by teams composed of the site inspector(s) and one or more subject matter experts. An exit meeting is held where preliminary results are communicated to the licensee. The inspection report documents the purpose and objectives of the inspection, observations, compliance and deviations from requirements, assessment of the significance of any deviations and a proposal for any further regulatory actions.

SSM carries out surveillance inspections to gather general information on safety issues and overall activities at the facility in addition to compliance inspections. Surveillance inspections for non-reactor nuclear facilities are carried out on an ad hoc/need basis, including an annual meeting with the management of the facility. Some surveillance inspections take place in connection with events, to follow up organisational change or relating to other issues, such as findings from earlier inspections. In many cases, these inspections focus on non-technical issues, such as safety management and safety culture.

The preparation and documentation from surveillance inspections are simplified in comparison with compliance inspections, but the results are systematically documented and reported at SSM management meetings. Each surveillance inspection typically takes 1–2 days on site for two inspectors or more, of which at least one is a specialist in the subject area.

If necessary, SSM also undertakes a "special supervision". Its occurrence is decided by the Director General when the Authority is dissatisfied with the safety performance of a licensee. e.g. intensified supervision may be applied for other safety reasons, e.g. during test operations after a large plant modification, meaning that more inspections are done and particular progress reporting is required.

Under SSM's regulations, inspections of the licensee programmes, activities and results of surveillance and in-service inspection of mechanical components are performed by an accredited control body ("third-party control"). If the requirements are fulfilled, a compliance certificate is issued by the control organisation.

Periodic Safety Reviews
The requirements for Periodic Safety Reviews (PSR) for nuclear power reactors, done at least every 10 years, were introduced in the early 1980s. The requirements, developed to meet IAEA Safety Standards, were extended in 2010 to cover non-reactor nuclear facilities.

The requirements prescribe that the PSR should be carried out in a systematic way. The purpose of the PSR is for the licence holder to re-assess, verify and continuously improve the safety of its nuclear installations. In addition, the PSR addresses any issues that might compromise the safety of any facility for the remaining planned operating period and proposed measures to counteract any such issues. Licensees are required to make all reasonably practicable improvements in line with a risk-informed graded approach. SSM reviews the licensee's PSR regarding the current level of nuclear safety and radiation protection, and their ability to maintain and increase it in the future. SSM's review is partly based on benchmarking against regulatory supervisory activities, while including an assessment of the licensee's ability to operate the facility safely until the next PSR.

SSM's integrated safety assessments
SSM's integrated safety assessments comprise a radiation safety assessment of each major facility under SSM's supervision every two to three years, depending on the character of that facility, in line with a risk-informed graded approach. An evaluation and general appraisal are made of the nuclear safety, radiation protection, security and non-proliferation control status of the facility in relation to the legislative requirements, based on all compliance inspections, surveillance inspections, reviews, authority decisions and other relevant information. These assessments should also cover earlier information and conclusions to identify trends that could otherwise be difficult to detect from a short-term perspective. The reports are presented at top-level management meetings with the licensees.

The traceability of data, via the analysis, assessment and final conclusions are important when drafting these reports. The text should clearly described how SSM evaluated the issues, and the report should be comprehensible to interested parties lacking expert knowledge in the assessed areas. SSM registers all identified deficiencies and issues from performed supervisory activities in a designated database in order to perform the integrated safety assessments more effectively and to improve the quality of the assessments.

E.3.2.7 Human resources

General Information

At the end of January of 2024 SSM had 295 employees: 149 women and 146 men, their average age was 49. The employee turnover rate for 2023, including retirements, was 14 %, which is a decrease from 2022 (17 %).

The employees at SSM have a relatively high level of educational background. This is a result of the many specialist areas covered by the Authority and, to some extent, because there are no dedicated Technical Support Organisations in Sweden to assist the regulatory body with specialist knowledge. In an international comparison, Sweden has few regulatory employees relative to the size of their nuclear programme.

Cycle of employment

SSM works strategically and systematically with the cycle of employment (see Table E1); the overall objective is to have the appropriate number of employees at the right time, who possess the right skills and who function as effective ambassadors for the authority. The cycle of employment includes a variety of HR areas, such as the labour law and the work environment. Table E1 shows examples related to the competence supply chain within SSM.

Table E1 SSM's cycle of employment.

Part in the cycle	Objective	Example of action
Attract	To attract candidates with the right education, experience, competence and capability as well as the appropriate attitude.	Campaigns in social media to attract new competences. Collaborations with Universities to attract students.
Recruit	To recruit the right candidate with the right competence at the right point.	Competence-based recruitment process based on merit and skill. Structured on-boarding process.
Develop	To develop the right competence based on the authority's mission and goals.	Leadership development by basic education and training. Yearly structured performance reviews for all employees.
Keep	To keep the right competencies	Recurrent structured mapping and analyses of the competencies within the authority. Ability to change position within the authority.
Terminate	To end an employment in the best way possible.	Exit interviews to receive feedback from the employees for the purpose of developing SSM.

SSM continuously works on developing the Authority's brand to attract recruit, develop and keep employees and their competences. SSM participates in student and professional fairs to attract and promote the authority as a potential employer. During 2023, the authority made advertisement campaigns on social media to attract new competences.

SSM has a competence-based recruitment process, the focus being on the candidates' required competence. This is a streamlined recruitment process and a methodology that promotes a non-discriminatory approach and strengthens the authority's employer brand.

Every new employee participates in an introductory programme and gets a mentor that guides them through their first year. This develops both new and senior employees. During a given year, employees undergo on average six days of training or education. In the yearly structured performance review, goals are set to evolve the employee's competence and skill within the role based on the authority's mission and goals.

In 2022, a structured mapping and analysis of what competences the authority has, and needs in the future, was made. During the end of 2023, a renewed mapping of the competences was made and the analysis work will be reported in 2024.

SSM has started a comprehensive initiative in 2024 to strengthen the authority's competence supply strategy, making the beginning of a strategic journey towards better preparedness for the future.

Management program
SSM developed a manager's supply programme in 2019, with the objective to provide the authority with new managers and at the same time create attractive career paths. Ten employees started the programme in 2020; in January of 2024 five of them are working as managers within the authority.

E.3.2.8 Financial resources

The regulatory activities of SSM are largely financed through yearly state budget appropriations. However, specific supervisory activities regarding spent fuel and nuclear waste disposal, as well as nuclear decommissioning, are reimbursed from the Nuclear Waste Fund, as decided by the Government.

The costs of the regulatory activities and related research financed through budget appropriations are largely recovered from the licensees in the form of fees. The fees are proposed annually by SSM, but decided by the Government. The budgets for 2021, 2022 and 2023, including the funding of the separately-financed international cooperation and development work, are shown in Table E2.

In addition, fees for reviewing certain applications, or licensing work, are paid directly to the Authority. During the last years the SSM budget has been increased, mainly to work with the preparations for new nuclear power and civil defence, and for 2023 it totalled approximately 565 million SEK.

Table E2 Budget of SSM in million SEK (1 SEK is about 0.09 EUR).

Budget item	2021	2022	2023	Source of funding
Nuclear safety, emergency preparedness and radiation protection (including administration)	327	353	394	Mainly fees
Supervision of nuclear facilities (proportion of above)	153	156	150	Fees
Nuclear non-proliferation (proportion of above)	12	11	11	Fees
Crisis management (proportion of above)	27	28	32	Fees
Scientific research and development work	83	70	65	Mainly fees
Final disposal of radioactive waste, including licensing, financial control and decommissioning	60	60	70	Nuclear Waste Fund
Historical waste, etc.	3	3	3	Tax revenues
International cooperation and development	28	28	33	Tax revenues
Total (million SEK)	**501**	**514**	**565**	

Regulatory research and assistance by external experts
The main purposes of SSM's research is, according to the Ordinance with Instructions for the Swedish Radiation Safety Authority, to:

- maintain and develop competence of importance for radiation protection and nuclear safety work; and
- ensure that SSM has the knowledge and tools needed to carry out effective regulatory reviews and supervisory activities.

SSM supports basic and applied research, which includes development of models, software and experimental studies. SSM has a total yearly research budget (for 2024) of approximately 100 million SEK (9 million EUR). In addition, research relating to nuclear waste management (mainly spent fuel disposal) is financed through the Nuclear Waste Fund, in the order of 12 million SEK/year (1 million EUR).

SSM provides funding for research projects and staffing positions at Swedish universities to develop and sustain national competence and teaching capabilities. Key areas include reactor physics, severe accidents, non-proliferation and radiation protection. Most research is funded through open procurement process.

Regulatory Research in the Area of Waste Management
SSM funds research relating to nuclear waste management (mainly spent fuel disposal) through open processes to build competence and continuity in knowledge for SSM's future assessments. The future assessments related to SKB's updated safety analysis reports in the authorisation steps for construction and operation of a spent nuclear fuel repository and of an extension of the SFR facility to accommodate short-lived low- and intermediate-level waste from decommissioning. Furthermore, SSM needs to build competence and continuity in knowledge for the assessment of a future licence application for a repository for long-lived low- and intermediate-level waste (SFL). The focus of recent years' research projects funded by SSM has been on processes linked to SKB's suggested barrier system for the geological repository for spent nuclear fuel and on biosphere issues connected to dose estimation. Additionally, SSM funded research on spent nuclear fuel and on nuclear non-proliferation and safeguards connected to the geological repository for spent nuclear fuel. SSM has also funded research linked to shallow land burials for very low-level short-lived radioactive waste from decommissioning and some social science projects, e.g. stakeholder involvement.

SSM also funds national and international research programmes and collaborations e.g. DECOVALEX, BIOPROTA and BeFo:the DECOVALEX (DEvelopment of COupled models and their VALidation against EXperiments) is an international research and model comparison collaboration for advancing the understanding and modelling of coupled thermo-hydro-mechanical-chemical (THMC) processes in geological systems; the BIOPROTA is an international collaborative forum addressing uncertainties in the assessment of the radiological impact of releases of long-lived radionuclides into the biosphere; and the BeFo (Rock Engineering Research Foundation) is a national organisation that coordinates research in rock engineering.

Sweden has no government-appointed TSO (Technical Support Organisation), so instead SSM has developed a network of national and international experts by involving universities, institutes and consulting firms in research.

E.3.2.9 Transparency in regulatory activities
According to the Ordinance with Instructions, the Swedish Radiation Safety Authority must contribute, by means of communication and transparency, towards public insight into all operations encompassed by the Authority's mandate. The aim of this work shall be, for example, to provide advice and information about radiation, its properties and areas of application and about radiation protection.

SSM publishes all its significant decisions on its website. The Constitution gives everyone the right to access documents held by the Authority. This does not apply to documents subject to confidentiality due to e.g. security aspects or other specified reasons. The Authority provides documents, upon request, not subject to confidentiality to the general public and journalists (see also sections K.3.1.5 and K.5).

Before issuing regulations, the financial and administrative implications for the companies concerned must be examined. An important aim of this analysis is that the requirements in the regulations must be justified, and not unnecessarily increase costs or administrative burden for the operators. For this reason, SSM always communicates drafts through a referral process to obtain opinions and other aspects of the proposed regulations.

Each applicant must consult with the County Administrative Board, relevant authorities, the potential host municipality, other stakeholders, NGOs and the public, as part of the preparation of an Environmental Impact Assessment (EIA) and before the application documents are submitted. The purpose of this consultation is to provide information about the planned activities and to obtain comments and suggestions on issues that need to be addressed in the EIA. If the planned activity is large and complex, numerous consultation meetings with different stakeholders may be required. SSM participates in consultation meetings primarily intended for the municipality and other stakeholders concerned. The Authority can thus explain its role in the assessment process and the legal requirements underlying the review of the application.

An application submitted to the Authority is sent on referral to many stakeholders, e.g. other authorities, the municipality concerned, County Administrative Boards, universities and NGOs. The application will also be published on the Authority's website and is open for anyone to submit comments. An international peer review of the application documents may be arranged in the event the planned nuclear activity is large and complex.

E.3.2.10 SSM's communication policy

SSM shall, through information and transparency, contribute to providing the public with insight into all activities covered by its mandates, according to the Government ordinance with instructions for SSM.

SSM's communication policy specifies the responsibility of employees and managers for internal and external communication. The overall aim with SSM's communication is to maintain and strengthen trust in the Authority so that its mission can be carried out.

SSM's communication policy emphasises the organisation's key values: credibility, integrity and openness, which should permeate all communication of the Authority. The policy further states that to maintain and strengthen trust in the Authority, SSM's communication work has to proceed from a high level of openness and visibility and be adapted to the needs and conditions of the target groups. The policy also states that SSM acts through a communicative managerial and employee approach.

Communication needs are valued and prioritised based on one or more of the following criteria and/or principles:

- Areas that are of strategic and/or principal importance for the Authority.
- Changes in radiation safety that have consequences for the Authority and target groups.
- Questions that might affect the trust of the target groups in the Authority.

SSM's communication policy is supplemented by an overall communication strategy that sets out how the Authority's goals can be achieved during certain defined periods of time. Communication plans are further developed to implement the strategy to specific topics.

E.3.3 Other relevant authorities

The following subsections describe additional Swedish government authorities with regulatory functions that are the most relevant to this Convention, as listed below:

- Swedish National Debt Office
- The Swedish Civil Contingencies Agency
- The Swedish Environmental Protection Agency
- The Swedish Work Environment Authority
- County Administrative Boards
- The Nuclear Waste Fund.

E.3.3.1 Swedish National Debt Office

The Swedish National Debt Office (NDO) is the central governmental financial manager. NDO's tasks include providing banking services for the central Government, managing central government debts, providing state guarantees and loans and to manage government support for banks.

Since 2018, the NDO is also tasked with securing the financing of nuclear waste management. NDO reviews cost estimates submitted by licensees, in accordance with the provisions of the Act and Ordinance on Financing of Management of Residual Products from Nuclear Activities (see section E.2.1.4).

For each licensee, the NDO must prepare a proposal for the nuclear waste fee that, based on an assessment, the nuclear licensee must pay over the subsequent three calendar years.

E.3.3.2 The Swedish Civil Contingencies Agency

The task of the Swedish Civil Contingencies Agency (MSB) is to enhance and support societal capacities for the preparedness for and prevention of emergencies and crises. MSB coordinates emergency preparedness funding, offsite emergency planning and oversees the planning of regional County Administrative Boards. MSB also evaluates onsite and offsite emergency exercises and initiates educational efforts.

E.3.3.3 The Swedish Environmental Protection Agency

The Swedish Environmental Protection Agency monitors conditions in the environment and progress in environmental policy. The Agency has the task of coordinating, monitoring and evaluating efforts involving many agencies to ensure compliance with the Swedish Environmental Code and to meet national environmental objectives.

E.3.3.4 The Swedish Work Environment Authority

The Swedish Work Environment Authority's overall objective is to reduce risks of poor health and accidents in occupational environments and to improve workplaces from a holistic perspective, i.e. from the physical, psychological and organisational aspects. The Authority is tasked with (for example) ensuring compliance with occupational health and safety legislation.

E.3.3.5 The Swedish National Council for Nuclear Waste

The advisory body, the Swedish National Council for Nuclear Waste, was closed down by the Government in 2022/2023 (see section A.4).

E.3.3.6 County Administrative Boards

The County Administrative Boards exercise supervision under the Civil Protection Act (2003:778) and Ordinance (2003:789) and are responsible for planning and implementing rescue operations in cases where the public needs protection from a radioactive release from a nuclear installation, or where such a release seems imminent.

E.3.3.7 The Nuclear Waste Fund

The Nuclear Waste Fund is a government authority whose mission is to receive and manage the fees paid by nuclear power companies and licensees of other nuclear facilities in Sweden. The Nuclear Waste Fund makes payments in accordance with Swedish National Debt Office's decisions.

The authority has no staff of its own. It is governed by a board of directors representing public service as well as the power plant owners. The board is responsible for maintaining an investment strategy that ensures a good return and satisfactory liquidity. Fund assets must be deposited in an interest-bearing account at the NDO or invested in treasury bills issued by the state or in covered bonds. The administration of the Nuclear Waste Fund is managed by the Legal, Financial and Administrative Services Agency.

E.3.4 Conclusion

Sweden complies with the obligations of Article 20.

Section F – Other General Safety Provisions

F.1 Article 21: Responsibility of the licence holder

1. Each Contracting Party shall ensure that prime responsibility for the safety of spent fuel or radioactive waste management rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.

2. If there is no such licence holder or other responsible party, the responsibility rests with the Contracting Party that has jurisdiction over the spent fuel or over the radioactive waste.

F.1.1 Regulatory requirements

F.1.1.1 The prime responsibility

Basic provisions in the Nuclear Activities Act assign a licence holder prime responsibility for the safety of spent fuel and radioactive waste management. A thorough presentation of the overall legal requirements imposed on a licensee under the Nuclear Activities Act, the Radiation Protection Act and the Environmental Code follows from section E.

Since Sweden's last report within the Joint Convention, new regulations have come into force, namely on the Management of Spent Fuel and Radioactive Waste from Nuclear Facilities (SSMFS 2021:7). The regulations contain functional requirements for safety management, design and construction, safety analysis and review, operations and nuclear materials/waste management. In addition, new general regulations relating to the design (SSMFS 2021:4), evaluation and reporting of radiation safety (SSMFS 2021:5) and operation (SSMFS 2021:6) of nuclear power plants have been introduced. These regulations govern to varying degrees the handling of spent nuclear fuel and radioactive waste at the nuclear power plants. Additional requirements are also to be found in the regulations on Safety in Nuclear Facilities (SSMFS 2008:1) and Filing at Nuclear Facilities (SSMFS 2008:38). These regulations clearly point out that safety shall be monitored and followed up by the licensee routinely and that deviations are identified and corrected so that safety is maintained and further developed according to objectives and strategies.

The required continuous preventive safety work includes reassessments, analysis of events in one's own and other facilities and analysis of relevant new safety standards, practices and research results. Any reasonable measure useful for safety shall be taken as a result and be documented in a safety programme that is to be updated annually.

The basic safety documentation (Safety Analysis Report, SAR, including Operational Limits and Conditions, plans for emergency response and physical protection) must be formally approved by SSM. Plant and organisational modifications and changes in the safety documentation are to be notified and SSM can, if needed, impose additional conditions and requirements. All other issues are dealt with as part of licensee self-assessments. SSM examines how this responsibility is managed.

SSM's review and supervision activities serve to ensure that licensees fulfil their responsibilities, and that they operate activities safely with regard to nuclear safety and radiation protection requirements.

F.1.1.2 The ultimate responsibility

The State has an overall responsibility for activities regulated by the Act on Nuclear Activities. The ultimate responsibility for a geological disposal facility after closure rests with the State (see section E.2.7).

F.2 Article 22: Human and financial resources

Each Contracting Party shall take the appropriate steps to ensure that:

(i) qualified staff are available as needed for safety related activities during the operating lifetime of a spent fuel and a radioactive waste management facility;

(ii) adequate financial resources are available to support the safety of facilities for spent fuel and radioactive waste management during their operating lifetime and for decommissioning;

(iii) financial provision is made which will enable the appropriate institutional controls and monitoring arrangements to be continued for the period deemed necessary following the closure of a disposal facility.

F.2.1 Regulatory requirements

F.2.1.1 Qualified staff during the operating lifetime

A detailed presentation of the overall legal requirements imposed on a licensee under the Nuclear Activities Act, the Radiation Protection Act and the Environmental Code follows from section E.

Basic provisions concerning the organisation and financial, administrative and human resources for a nuclear activity are contained in the Act on Nuclear Activities.

These basic provisions are expressed in further detail in the regulations (SSMFS 2008:1 and SSMFS 2018:1). These regulations require that activities must be conducted with an organisation that has sufficient financial and human resources designed to maintain safety. As a part of the management system, the organisation must ensure that those who work in the activity have the skills and aptitude needed for tasks that are important for radiation safety. The skills needed and those that are available must be systematically identified and documented. If it is necessary to achieve and maintain the needed skills, training should be conducted or other measures taken.

The regulations require that contractors and other hired personnel, have the competence and suitability for the tasks that are of importance for safety in the nuclear activity and that these are documented. The regulations also require an appropriate and justified balance between the use of in-house personnel and contractors for safety-related tasks. The regulations require procurement of products and services of importance for safety in the nuclear activity to be governed by the management system, and that the system clearly specifies how contractors and suppliers of services and equipment for the nuclear activity are assessed and how these assessments are kept up to date.

The regulations also contain provisions stipulating that staff must be fit for their duties. This implies the stipulation of medical requirements for fitness to work, drug testing, etc.

F.2.1.2 Adequate financial resources to support safety during operation and decommissioning

The general obligations in the Act on Nuclear Activities stipulate that in order to obtain a licence, financial resources must be committed to manage their obligations, including safety obligations. Each prospective licensee must be assessed in this respect during the licensing process.

Funding of decommissioning is provided by means of investments in government-controlled funds as regard to nuclear power reactors and nuclear fuel cycle facilities. Licensees of nuclear facilities must pay a fee to the Nuclear Waste Fund in accordance with the Act on Financing of Management of Residual Products from Nuclear Activities, as described in section E.2.1.4. This is to ensure financing of decommissioning work and safe management of spent fuel and nuclear waste, including the research needed for these activities.

F.2.1.3 Provisions for institutional control and monitoring after closure

As described in section E.2.1, the holder of a licence for nuclear activities is responsible for ensuring that all measures are taken for the safe management of spent fuel and nuclear waste resulting from the activity. The legal framework is designed so that institutional control and monitoring after closure are not required. It ensures that a licensee shall be exempted from its responsibilities when decommissioning and dismantling have taken place and all spent fuel and nuclear waste have been disposed of in a sealed and closed disposal facility.

The State has an overall responsibility for activities regulated by the Act on Nuclear Activities. It follows that the State assumes responsibility for the arrangements and costs of any institutional control or monitoring conducted once a licensee has been exempted from its responsibilities (see sections A.4 and E.2.7).

F.2.2 Measures taken by the licence holders

F.2.2.1 Qualified staff during the operating lifetime

SKB has implemented in its management system a process for systematically developing the organisation and ensuring staff is qualified and competent. The process is based on a systematic approach for complying with internal and external requirements to ensure that adequate competence is available for maintaining high safety and achieving the goal of the activities in the short and long-term. This process also clarifies roles and responsibilities within the process.

A competence and staffing analysis is carried out in conjunction with the annual planning of activities. The competence analysis shows the competence needed in a position or role to perform the required tasks in accordance with the needs of the activities. Roles of specific strategic importance, or of importance for radiation safety, are identified. The analysis is made at both individual and group levels and with a timeframe of four to five years. Strategic competence analyses, with a timeframe of about 10 years, are conducted regularly with slightly longer intervals than the annual planning of activities. The purpose of the strategic analyses for the planned construction of new nuclear facilities is to identify staffing needs (competence and number of personnel) and to secure competence during the different construction phases.

The analyses show the competence needed to execute the activities and for its further development, either by training of existing personnel or by new recruitment. Training programmes are established for individuals and groups when necessary to complement the general introductory training for all new employees.

SKB has a competence management system with competence assurance (documentation of competence and any gaps between requirements and assessed levels) performed for its own personnel and consultants.

The competence of personnel is developed for example through rotation programmes where employees are given an opportunity to work within different areas and in different roles. SKB also has a competence transfer programme to prepare for generation changes and to reduce the vulnerability to loss of competence.

There are two important prerequisites that must be considered regarding competence management in the very long term, i.e. a 50-100 year perspective:

– SKB's activities are long-term and are planned to continue for about another 70 years, i.e. up until around 2090; and
– SKB is a dominant actor in Sweden when it comes to the management of radioactive waste, but substantial tasks will also be carried out by the owner companies, suppliers and regulatory authorities.

The first point is an advantage as competence development and management can be planned in the long term.

SKB has developed strategic competence management plans and analysed the risks and problems that may arise in the long term. SKB considers potential problems to be manageable.

F.2.2.2 Adequate financial resources to support safety during operation and decommissioning

Business planning is performed on a yearly basis according to SKB's management system. SKB's board of directors, who also decide on the strategic plan for the subsequent years and ultimately each yearly budget, initiate the planning. The plan, together with the RD&D Programme (section A.6.3), cost calculations and plans for projects and investments, are the basis for issuing instructions to the organisation. Based on a payment plan, SKB then requests funds from both the Nuclear Waste Fund (sections A.8.3 and E.2.1.4) and directly from SKB's owners depending on the type of costs.

F.2.2.3 Provisions for institutional control and monitoring after closure

Post-closure institutional control and monitoring are not required by the legal framework (see section F.2.3.3).

F.2.3 Regulatory control

F.2.3.1 Qualified staff during operation

See section E.3.2.6.

F.2.3.2 Adequate financial resources to support safety during operation and decommissioning

SSM reviews the adequacy of financial resources to support safety during operation and decommissioning as an integral part of the yearly inspection programme. In addition, the National Debt Office reviews the adequacy of resources directed to SKB through payments from the Nuclear Waste Fund and decides on the reimbursements made from the Fund.

F.2.3.3 Provisions for institutional control and monitoring after closure

The legal framework for the design of a geological disposal facility contains requirements on passive post-closure safety solutions, meaning there should be no need for additional safety measures or environmental monitoring after closure. The institutional control will be overtaken by the State, including for example maintaining records, safeguards or land use restrictions, following the closure of a disposal facility and the termination of the licensee's responsibilities (see sections A.4 and E.2.7).

F.2.4 Conclusion

Sweden complies with the obligations of Article 22.

F.3 Article 23: Quality assurance

> Each Contracting Party shall take the necessary steps to ensure that appropriate quality assurance programmes concerning the safety of spent fuel and radioactive waste management are established and implemented.

F.3.1 Regulatory requirements

As of June 2018, new general requirements for nuclear activities have been implemented through SSM's regulations SSMFS 2018:1 concerning basic provisions for licensable activities involving ionising radiation. The regulations include more detailed requirements, for e.g. quality assurance, supported by clearer guidelines, compared to previous regulations. The new regulations thus contain stronger quality assurance requirements for nuclear activities with regard to the quality assurance being an integrated part of design, construction, operation and decommissioning activities. Such activities are to be managed, controlled, assessed and developed by means of an integrated management system so that requirements for safety will be met.

A management system should integrate all activities at a facility, including the necessary routines and procedures. It must be kept up to date and be documented. The approach is thus in line with the IAEA Safety Requirements on Leadership and Management for Safety, GSR Part 2.

A licensee is also required to audit periodically and systematically the efficiency and effectiveness of the management system by having an independent function in relation to the activities being audited. An established audit programme must be in place within the organisation.

Furthermore, the management system must be clear on how contractors and vendors are to be audited. The internal audit function should have a strong and independent position in the organisation and report to the highest managerial level of the facility. The audits should have continuity and auditors should have good knowledge about activities being audited. Audit intervals should consider the auditing activity itself and the management function of the facility.

The Act on Nuclear Activities contains provisions for the regulatory body to monitor activities performed by suppliers/sub-suppliers, contractors/sub-contractors and other parties delivering services to the licensed organisation.

F.3.2 Measures taken by the licence holders

F.3.2.1 Quality programmes and management systems

Licensees in Sweden that generate or manage spent nuclear fuel and radioactive waste have had their own management systems since the 1970s. The trend has been to move from quality programmes to management systems, which include quality assurance of various critical processes.

The management systems are to varying degree process oriented but important common elements are the graded approach, safety classification, validation and verification. The purpose is to create a management system where design, construction, operation and decommissioning are managed, controlled, assessed and developed so that requirements for safety are met. The overarching goal is to create a management system that supports leadership and management for safety.

The management system contains processes for managing requirements. These processes ensure that external requirements such as laws, regulatory requirements and permits, as well as internal requirements, are transformed into working methods within the different processes, and accounted for in the design of facilities.

The management system has a strong link to the safety analysis report (SAR), which normally is considered a part of the management system.

Typically, the management system is described in a series of documents structured in a hierarchical structure. The number of levels in the hierarchical structure is established by each licensee. The highest level typically contains a comprehensive description of the organisation with responsibilities for functions and processes, division of responsibilities and management principles together with policies and directives to all departments and staff units. The next level contains commitments defined by the managers responsible to work with the tasks delegated from the highest level. This includes process descriptions, objectives and instructions for the different areas of responsibility. The lower levels contain instructions for specific activities and tasks, technical documentation, job descriptions etc.

The management system is available to everyone within the organisation as well as contractors, consultants and regulatory authorities. Information and training in the management system is given in proportion to needs.

F.3.2.2 SKB's management system

SKB utilises a process-based management system to ensure that all requirements are met, processes are safe and efficient, the management system supports the line management to implement policies and that the organisation fulfils its goals and objectives.

Defining and implementing the "Line management with process support" is a central part of the management system. Each process has an owner from SKB's executive management team and is supported by a process team for its continuous development. SKB developed a model in the form of a "House", where all parts of the management system can be reached on the intranet, to support the structure and visualisation of the management system (Figure F1).

Figure F1 SKB's "House", the entrance to the management system.

The "House" consists of the following parts:

- "Overarching" contains the management system manuals, e.g. roles and responsibilities, policies as well as the business plan, programmes for improvement, and a scorecard/dashboard;
- "Organisation" contains organisational charts, and descriptions of all units and their tasks and duties;
- "Processes" contains descriptions of all processes and process instructions;
- "Facilities" contains specific information for each facility, for example operations and maintenance instructions, safety analysis reports (SAR) and all technical documentation of the facilities; and
- "Projects" contains descriptions and documentation of ongoing programmes and projects.

It is essential to evaluate performance, and therefore SKB has several ways of assessing compliance with requirements and its management system, and for learning and experience feedback:

- A "Safety Management Process" monitors safety, e.g. the operations management and decision-making related to, for example, events and modifications of facilities or organisation. This process is supported by a "Safety Review Process".
- A process for defining "Programmes for Improvement", e.g. developing an internal audit programme that is graded in frequency and depth, depending on risk and impact on safety. The audit programme addresses both daily operations and projects for modification of existing facilities or development of new facilities.
- A process for "Internal Audits" to review compliance with the management system and to identify areas for improvements. The internal audit function itself is normally audited by a team where the team leader is from another licensee (or from the corporate level), to ensure independence. The result from the internal audits is reported to SKB's Managing Director and managers accountable for observed deviations.
- A "Purchasing Process", which includes evaluation of suppliers, uses a graded approach that might include supplier audits. The process is audited and secures all purchases of goods and services that might affect, directly or indirectly, safety, the environment or personnel. Supplier audits are performed in a similar way by other licensees, to facilitate sharing of experiences from audits and to optimise learning.

F.3.2.3 The Waste Management Process is owned by SKB

SKB has defined a "Waste Management Process" as one of the main processes in its management system to fulfil the licence obligations to operate the nuclear facilities, see Figure F2. All other licensees (waste producers), whose radioactive waste SKB receives and eventually disposes of, must align their waste management activities with this process to work. The process is supported by another process for defining "Waste Acceptance Criteria (WAC)". It is essential that all handovers of waste in the overall waste management process comply with the WAC. It is also essential to keep records of all waste, since there is a long-time perspective (decades) from where the process starts and ends.

The Waste Management Process, which is owned and controlled by SKB, ensures that the process from an overall perspective is understood and agreed by all waste producers. SKB has set up joint committees with all major waste producers, primarily the nuclear power plants to increase the understanding of the process, WAC and other SKB controlled and shared central documents. Each waste producer does a breakdown of the Waste Management Process into underlying instructions, which are part of their individual producer's management system.

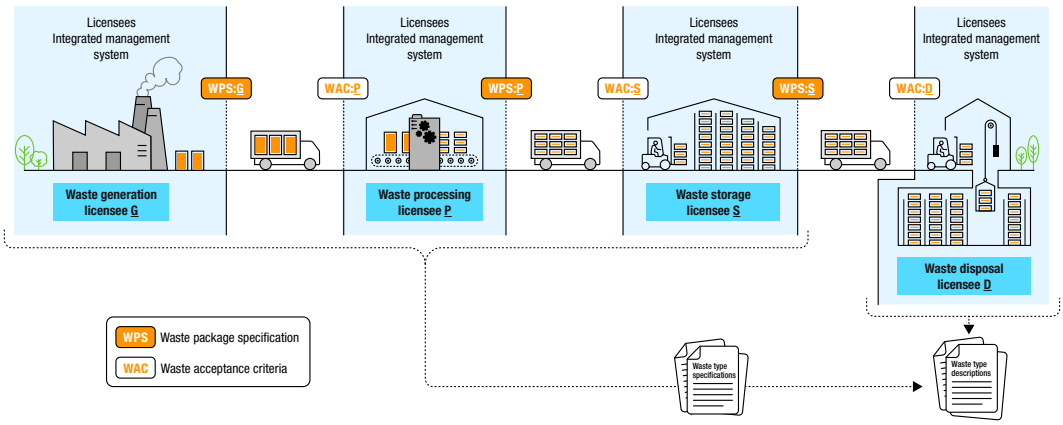

Figure F2 Description in principle of how the Waste Management Process works, but not the exact description in the main process in SKB's management system.

The central SKB-controlled and shared documents in the Waste Management Process include:

– a Waste Handbook, that describes the Waste Management Process. The handbook states for example what information SKB needs in the specifications from the waste producers and what the waste type descriptions must contain; and
– the Waste Acceptance Criteria (WAC) document is owned by SKB and stipulates the WAC applicable to SKB's repositories. All waste producers using SKB's repositories are obligated to follow these WAC.

In addition, SKB controls the Waste Type Descriptions (WTD) document, which is set up with each waste producer individually. This is a safety report for each waste type from each waste producer. The document covers all steps in the waste management process (waste production, conditioning, storage, transportation, reception and operational safety in the repository and post-closure safety) and presents the verification of WAC. SKB produces this document using a specification from the waste producer (covering the first steps; waste production, storage and transportation) as a reference.

The Waste Management Process is regularly evaluated by SKB and the interested parties, including the waste producers, to ensure that safety is not compromised and regulatory requirements are met. In addition, SKB regularly audits the handling of radioactive waste at the nuclear power plants, and other waste producers, to ensure compliance with the waste management process. These audits are defined as "process function audits" that complement the waste producers' internal audits.

F.3.3 Regulatory control

SSM conducts baseline inspections in all areas of a licensee's activities, as per the supervisory programme. The purpose of the baseline inspections is to monitor the status and progress of the licensee's principles and work on their respective system. This is to ensure that their management system directs, controls, evaluates and develops the organisation's activities. Another purpose is also to determine whether the management system is suitable, up to date, accessible and effective enough.

The purpose of an organisational baseline inspection is to determine the status of the licensee's systematic work to ensure it has an appropriate design for maintaining nuclear and radiation safety for now, and in the long term and to judge the suitability of the organisation. The inspections also include looking into the licensee's management of organisational changes.

Furthermore, SSM conducts continuous supervision of the licensee's internal audit process. The results of these audits are covered in most inspections and reviews of defined technical areas, which may also focus on audit programmes.

SSM also monitors how safety requirements are addressed in activities conducted by suppliers/sub-suppliers (and contractors/sub-contractors) or other parties delivering services to the licensed organisation.

F.3.3.1 SKB's management system

SSM in 2013 and 2014 made a special effort to review SKB's performance in managing activities at Clab and SFR, as accounted for in the previous National Report underpinning the Joint Convention Review Meeting in 2022. The outcome was that SKB was tasked to act and implement improvements. SSM concluded at the end of 2018 that the situation had improved and that SKB conducted improvement work in a systematic and satisfactory manner. Continued regulatory control is thereafter carried out as part of the baseline supervision plan for SKB's facilities.

F.3.3.2 The Waste Management Process

Regulatory review of the "Waste Management Process" is central in SSM's regulatory activities. SSM reviews the waste acceptance criteria (WAC) documents developed by SKB as well as the waste type description (WTD) documents developed by the nuclear waste producers, in addition to baseline inspections of waste management activities.

F.3.4 Conclusion

Sweden complies with the obligations of Article 23.

F.4 Article 24: Operational radiation protection

1. Each Contracting Party shall take the appropriate steps to ensure that during the operating lifetime of a spent fuel or radioactive waste management facility:

(i) the radiation exposure of the workers and the public caused by the facility shall be kept as low as reasonably achievable, economic and social factors being taken into account;

(ii) no individual shall be exposed, in normal situations, to radiation doses which exceed national prescriptions for dose limitation which have due regard to internationally endorsed standards on radiation protection; and

(iii) measures are taken to prevent unplanned and uncontrolled releases of radioactive materials into the environment.

2. Each Contracting Party shall take appropriate steps to ensure that discharges shall be limited:

(i) to keep exposure to radiation as low as reasonably achievable, economic and social factors being taken into account; and

(ii) so that no individual shall be exposed, in normal situations, to radiation doses which exceed national prescriptions for dose limitation which have due regard to internationally endorsed standards on radiation protection.

3. Each Contracting Party shall take appropriate steps to ensure that during the operating lifetime of a regulated nuclear facility, in the event that an unplanned or uncontrolled release of radioactive materials into the environment occurs, appropriate corrective measures are implemented to control the release and mitigate its effects.

F.4.1 Regulatory requirements

F.4.1.1 Regulatory requirements for occupational radiation protection

Swedish occupational radiation protection requirements follow the requirements of Council Directive 2013/59/EURATOM of 5 December 2013 laying down basic safety standards for the protection against dangers arising from exposure to ionising radiation. The principal provisions as regard to occupational radiation protection in nuclear facilities are stipulated in the Radiation Protection Act (2018:396) and in SSM's regulations SSMFS 2018:1. Further regulations on occupational exposure at nuclear facilities are stipulated in SSMFS 2008:24 and 2008:26, except for nuclear power plants under operation. For nuclear power reactors in operation, similar requirements are provided in SSMFS 2021:6, see section L.1.1.

General requirements

Anyone who conducts an activity involving ionising radiation must ensure that: (a) it is justified, i.e. the benefits to society or individuals outweigh the radiation harm; (b) the radiation protection is optimised; and (c) exposure of workers and the public is kept below the applicable dose limits. Consequently, the licensee must have the necessary staff (knowledge, competence and skills), economic resources, a management system and an effective organisation to take on these responsibilities and to ensure radiation protection.

Optimisation

Anyone who conducts an activity using, or resulting in, ionising radiation must ensure that the radiation protection is optimised and dose limits are not exceeded. In this context, dose constraints should be prescribed. The licensee must ensure that goals are set, optimisation is performed and needed resources are made available to perform the actions and work towards the established goals.

Dose limits for workers

The effective dose limit for any worker is 20 mSv per calendar year. The corresponding equivalent dose limits for the lens of the eye are20 mSv and, for skin and extremities 500 mSv. Lower limits, including age limits, apply for students and apprentices. Specific regulations also apply for pregnant and breast-feeding workers.

Data on intakes and individual radiation doses are kept in a national dose register. Dose records are retained until an individual reaches the age of 75, and for a minimum of 30 years after their work involving ionising radiation has ceased.

The average individual dose (for those who incur a radiation dose above or equal to 0.1 mSv during at least one month of the year) at Swedish nuclear power plants is approximately 1 mSv. Since 2020, no more than five persons have received radiation doses above 10 mSv during a single year and no-one has received an annual effective radiation dose above 20 mSv since 2009.

Medical examinations
Each year, all workers must arrange to obtain a new doctor's certificate as proof of their being fit for service. A full medical examination must be performed the first time a certificate is issued.

When renewing a certificate, the physician, in consultation with the employee, and taking into account the employee's health condition and the risks of exposure to ionising radiation, should assess if the future medical assessments: need to be made at shorter intervals than a year; should be based on medical examinations or health declarations; and if the scope of the medical controls should be revisited.

Supervised and controlled areas
Workplace zoning into supervised and controlled areas are regulatory requirements. Areas must be marked and information provided about dose rates, sources, contamination levels, entrance restrictions, etc. There must be documented routines for working with ionising radiation.

The workplace must be classified as a controlled area if in an area there is a risk of spreading radioactive substances (contamination) to other premises, or if the annual effective dose might exceed 6 mSv. Access is then more restricted, protective clothing and personal protection equipment might be mandatory, specific information/education required and personal dosimeters must to be issued and worn. Within a controlled area, the premises must be explicitly marked, and admittance restricted, if the risk of receiving an annual effective dose of more than 50 mSv is non-negligible.

Information and education
All workers, both permanent staff and contractors, must be informed about radiation risks, alarms, internal procedures, and receive proper education and training prior to working within a controlled area. The training must be adjusted to the scope and type of work to be performed and the existing radiological working environment. Training should be repeated at least every third year. In addition, more specific training is often required with the scope and focus adapted to the nature and environment of the work to be performed.

Site-specific instructions, radiation protection expertise
The licence holder must establish site-specific instructions for radiation protection and appoint a radiation protection manager. SSM approves the radiation protection managers, their capacity to act as a controller of the licensee's implementation of the radiation protection legislation and promoter of radiation protection work. A separate radiation protection expert function, approved by SSM, should also be appointed for the licensee to provide expertise as necessary.

Instruments and equipment
All instruments used for radiation protection and control of radiation doses must be calibrated, with metrological traceability, and before use undergo functional checks. There must be documented routines for use, maintenance and functional control.

Policy in the event of fuel failures
At a nuclear power plant, it is mandatory to have a documented policy and strategy for avoiding and managing fuel failures. The aim is to avoid unnecessary radiological impact to workers and the public and minimise the production of waste with long-lived radionuclides.

Reporting
Annual reports are required describing the radiation protection work, the progress and evaluation of optimisation work and experiences from outages. Rapid communication to the regulatory body is required in the case of an accident, or events that led or could have led to the spread of contamination or high doses. Various other reports are also required. The radiation protection expert oversees timely and accurate reporting.

F.4.1.2 Regulatory requirements for environmental radiation protection

The principal provisions on environmental radiation protection for nuclear facilities under normal operation are stipulated in: the Radiation Protection Act (2018:396); the Swedish Radiation Safety Authority's regulations (SSMFS 2018:1) on basic requirements for licensed activities with ionising radiation: and the Swedish Radiation Safety Authority's regulations (SSMFS 2008:23, amended in 2018 and 2022), concerning the protection of human health and the environment from discharges of radioactive substances from certain nuclear facilities, except nuclear power reactors in operation. Environmental radiation protection requirements are provided in SSMFS 2021:6 for nuclear power reactors in operation.

Below is a description of the key provisions.

Public dose limits, dose constraints and critical group
The effective dose limit for members of the public is 1 mSv/year. A dose constraint for discharges of radioactive substances to water and air (authorised releases) is set at 0.1 mSv/year/site, including all nuclear facilities located at that site. The dose constraint is subject to comparison with the calculated dose to the representative person. The dose models used are approved by SSM.

The dose constraint is compared with the sum of (a) the effective dose from annual external exposure, and (b) the committed effective dose resulting from a yearly discharge. A 100-year integration period is used for the committed effective dose.

Discharges, optimisation and best available technology
According to the Radiation Protection Act, measures should be taken to reduce discharges of radioactive substances as far as possible and reasonable considering existing technical knowledge and economical and social factors. Such measures should be reported to SSM each year for nuclear power plants in operation. These measures are evaluated against specific target values set by the licence holder, normally for a five-year period.

The target values can be set for specific radionuclides or for groups of radionuclides and are established in Becquerel (Bq). The dose constraint of 0.1 mSv/year for discharges is used in the planning and the work with limiting releases and restricting radiation dose to the representative person.

The dose to the public is calculated taking all relevant exposure pathways into account. The dose constraint is a tool for optimisation and the doses are supposed to be kept and optimised well below the dose constraint during normal operation.

Release monitoring
Releases of radioactive substances shall be monitored. All non-monitored releases must be investigated and an upper boundary set for possible undetectable leakage to air and water from each facility.

Releases via the main stacks of nuclear power reactors are to be controlled by means of: continuous nuclide-specific measurements of volatile radioactive substances such as noble gases: continuous collection of samples of iodine and particle bound radioactive substances; and measurements of C-14 and H-3.

Discharges of radionuclides to water shall be controlled through measurements of representative samples from each release pathway. The analyses shall cover nuclide specific measurements of gamma- and alpha-emitting radioactive substances as well as, where relevant,Sr-90 and H-3.

Controls and testing
The function and efficiency of measurement equipment and release limiting systems shall be checked periodically and whenever there are any indications of malfunctions.

Environmental monitoring
Environmental monitoring in the areas surrounding nuclear facilities is performed in accordance with site-specific programmes developed by the licence holder and reviewed and approved by SSM. These programmes specify type and sampling frequency, sample treatment, radionuclides to consider, reporting, etc. The licensees carry out the environmental monitoring themselves or by hired services. Samples are analysed by laboratories that have adequate quality assurance systems. To verify compliance, SSM performs inspections and takes random sub-samples for control measurements (bilateral inter-comparisons) at SSM or at other independent laboratories, and regularly arranges proficiency tests for the laboratories used by the nuclear facilities.

Reporting
Releases of radioactive substances to air and water, as well as results from environmental monitoring, must be reported once a year to SSM. Furthermore, the licensees report annually to SSM on adopted or planned measures to limit radioactive releases with the aim of achieving their specified target values. Events that lead to an increase in releases of radioactive substances from a nuclear facility must be reported to SSM as soon as possible together with a description of the actions taken to reduce the releases.

F.4.1.3 Protection of the environment

Protection of the environment is included in international recommendations and the Swedish legal framework.

The International Basic Safety Standards, GSR Part 3 are "designed to identify the protection of the environment as an issue necessitating assessment, while allowing for flexibility in incorporating into decision making processes the results of environmental assessments that are commensurate with the radiation risks" (paragraph 1.35).

Furthermore, in the EU BSS it is stated: "While the state of the environment can impact long-term human health, this calls for a policy protecting the environment against the harmful effects of ionising radiation. For the purpose of long-term human health protection, environmental criteria based on internationally recognised scientific data (such as published by EC, ICRP, United Nations Scientific Committee on the Effects of Atomic Radiation, International Atomic Energy Agency (IAEA)) should be taken into account" (no. 27 of the perambulatory clauses).

The Swedish Radiation Protection Act (2018:396) states that "The aim of this Act is to protect people and the environment against harmful effects of radiation". Requirements in Swedish legislation regarding protection of the environment are found in SSMFS 2008:37, the Swedish Radiation Safety Authority's regulations concerning the Protection of Human Health and the Environment in Connection with the Final Management of Spent Nuclear Fuel and Nuclear Waste. These regulations specify "protection of the environment" as protection of biodiversity and the sustainable use of biological resources. They require an assessment to be performed describing the effects on habitats and ecosystems from a radiation protection perspective to demonstrate that the environment is protected.

The Swedish Radiation Safety Authority's regulations (SSMFS 2018:1) state that "The consequences of an activity from a radiation protection point of view for the public and the environment must be assessed and documented based on the activities nature and extent".

Assessments of the protection of the environment were performed in connection with the planned Swedish spent nuclear fuel repository and for the European Spallation Source (ESS). Requirements for such assessments are also included in the licence conditions for decommissioning of the nuclear power plants entering this phase and in the licence for the pilot operation of the ESS. A similar requirement has been included in the new regulations for the operation of nuclear power reactors and will also be included for the operation of other nuclear facilities.

F.4.2 Radiation impact of spent nuclear fuel and radioactive waste management facilities

F.4.2.1 Occupational radiation doses

In general, individual and collective doses from managing radioactive waste at nuclear power plants are low when compared to the control, maintenance and service work connected with the operation. Nevertheless, work activities are planned, in compliance with the requirements, to ensure that the radiation protection is optimised. The collective effective dose for staff working with radioactive waste at the nuclear power plants is in the order of 10s of milli-man Sievert (mmanSv)/year/site. This section presents examples of radiation doses received at other facilities, including spent fuel and radioactive waste management facilities.

Clab

Radiation doses are incurred during normal operation, including receiving, unloading and cleaning of transport containers, at the central interim storage facility for spent nuclear fuel (Clab). In addition, maintenance and service of Clab's internal lifting and handling equipment, as well as the upkeep of the water purification system, also result in radiation doses. The collective effective dose has varied in the range of 10.5 and 25.7 mmanSv in recent years depending on the activities performed. Radiation dose data for the operation of Clab during the period 2019 to 2023 are shown in Table F1.

Table F1 Radiation yearly dose data for staff at Clab during the period 2019–2023.

Year	No. of exposed staff members	Collective dose (mmanSv)	Maximum effective dose (mSv)	Average effective dose (mSv)
2019	45	25.7	3.1	0.57
2020	34	22.6	2.6	0.66
2021	31	20.7	3.0	0.67
2022	26	18.3	3.0	0.7
2023	20	10.5	2.6	0.53

SFR
Open radiation sources are only in exceptional cases managed at SFR, the Swedish disposal facility for low- and intermediate-level waste. The waste received is conditioned in standard waste packages fulfilling waste acceptance criteria (WACs). Thus, radiation doses should originate from external radiation only. Contamination of transport casks and waste packages has never occurred to the extent that any airborne radioactivity, excluding naturally occurring radon and radon daughters, has been measured or reported. Since the start of operation of SFR, the total radiation dose (collective effective dose) has varied between 0.0 and 8.7 mmanSv. This is lower than the 25 mmanSv/year that the repository was designed for.

The Studsvik Tech Park
Nuclear activities at the Studsvik Tech Park are undertaken by three licensees, Studsvik Nuclear AB, AB Svafo and Cyclife Sweden AB. The majority of these activities are related to decommissioning and waste management, but some development work and research is also carried out, especially regarding nuclear fuel and materials relevant for the nuclear sector. The two research reactors, R2 and R2-0, were permanently closed in 2005. Dismantling started in 2020 and the site was released in 2024.

The annual collective effective dose for the activities at the whole Studsvik Tech Park varied between 3.1 and 143 mmanSv during the period 2019 to 2023. The average individual effective doses varied from 0.02 to 1.2 mSv/year, while the highest annual individual effective doses ranged from 0.3 to 7.4 mSv during this period. The large variation in incurred radiation doses reflects the varying types of work and activities carried out at the site. It must be underlined that a fair fraction of the collective dose is not directly connected to waste management activities, but rather to materials testing, fuel research and hot-cell activities. The same is generally true for the highest individual doses.

Westinghouse fuel fabrication plant
Annual individual effective doses are reported to be of the order of a few mSv for staff working with waste management at the fuel fabrication plant Westinghouse Electric Sweden AB (WSE). To put this into perspective, in 2021 (for 2022) the average effective dose due to external and internal exposure (committed effective dose) for all staff at WSE was 0.8 (0.8) mSv and the highest individual radiation dose 7.1 (9.3) mSv.

The collective doses for WSE varied between 0.3–6.8 manSv during 2017–2022, mostly in the lower half of the interval. It should be noted that about 60–65 % of the dose is due to internal exposure.

Ågesta
Small amounts of H-3 are released through drainage of the rock chamber where from the closed and partially dismantled Ågesta reactor (PHWR). The corresponding radiation doses to the public have been negligible.

On July 15, 2019, Vattenfall AB was granted permission by the Land and Environment Court to dismantle the Ågesta reactor. SSM decided in 2018 on new licence conditions for the dismantling work, which started in 2020 and is planned to continue until 2025. The estimated collective dose for this activity is below 100 mmanSv.

F.4.2.2 Radiation doses from releases of radioactive substances
Figure F3 displays the estimated effective dose to the representative person from the releases of radioactive substances from operating power plant sites for the years 2009 to 2022 The resulting estimated effective doses are less than or around 1 % of the stipulated dose constraint of 100 μSv at all sites. The operation of PWRs at Ringhals, due to C-14, results in slightly higher releases from this site.

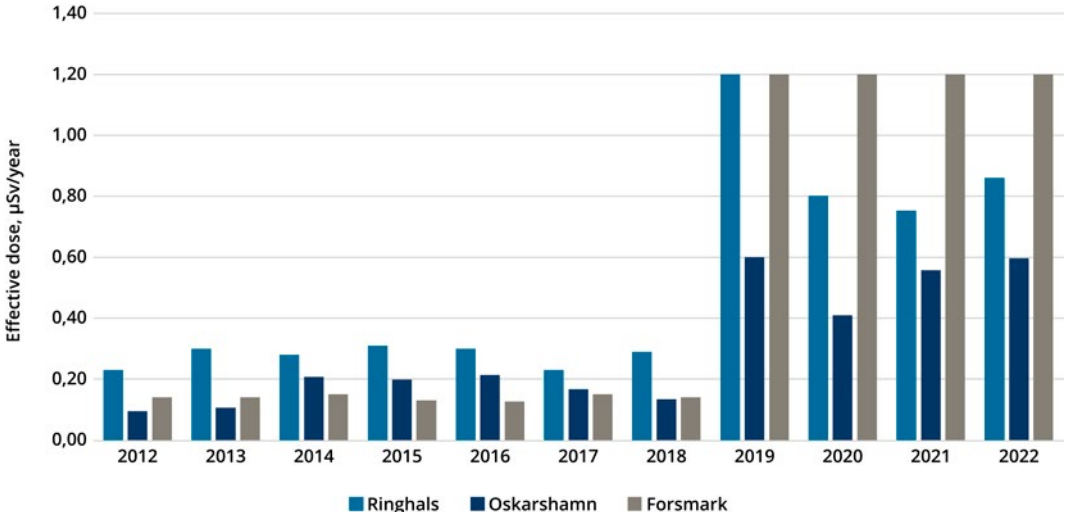

Figure F3 Estimated effective dose (µSv) to the representative person from releases of radioactive substances from sites with operating NPPs. The increase in 2019 is due to a developed methodology to calculate dose and does not represent an actual increase. The increase implied by the new methodology depends on, for example, updated dose factors and inclusion of new exposure pathways to the representative person.

The releases of radioactive substances from the Barsebäck NPP (no operating reactors) and the facilities at Studsvik Tech Park, Westinghouse Electric Sweden, Clab and Ranstad are shown in Figure F4. Extraction of uranium from waste at Ranstad Mineral stopped in 2009, decommissioning activities are completed, the facility is free-released and no longer considered a nuclear facility. The estimated doses due to releases from SFR and Ågesta are not shown as they would not be discernible on the Figure.

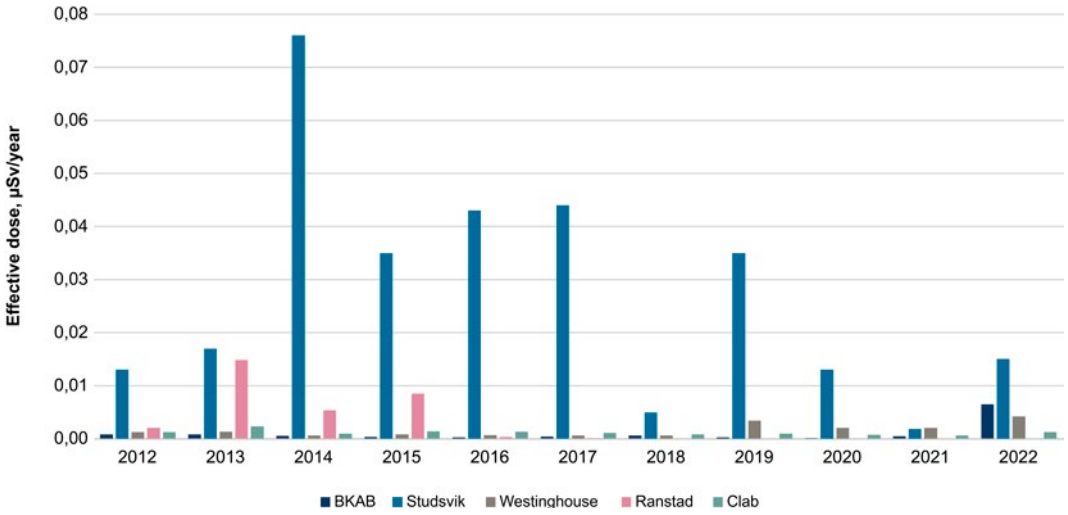

Figure F4 Effective dose (µSv/year) to the representative person for releases from Barsebäck NPP (BKAB), Studsvik Tech Park, Ranstad site, Clab and Westinghouse fuel fabrication plant. Note the logarithmic scale.

F.4.3 Regulatory control

See sections E.3.2.6 and E.2.5.2 about SSM's control and inspection work.

F.4.4 Conclusion

Sweden complies with the obligations of Article 24.

F.5 Article 25: Emergency preparedness

1. Each Contracting Party shall ensure that before and during operation of a spent fuel or radioactive waste management facility there are appropriate on-site and, if necessary, off-site emergency plans. Such emergency plans should be tested at an appropriate frequency.

2. Each Contracting Party shall take the appropriate steps for the preparation and testing of emergency plans for its territory insofar as it is likely to be affected in the event of a radiological emergency at a spent fuel or radioactive waste management facility in the vicinity of its territory.

F.5.1 Regulatory requirements

In Sweden, the state authorities Swedish Civil Contingencies Agency (MSB), Swedish Radiation Safety Authority (SSM) and the County Administrative Boards and municipalities have the authority to regulate the on-site emergency preparedness and response (EPR) arrangements of operating organisations. SSM' regulations on on-site emergency preparedness use the concept of emergency preparedness categories (1, 2, and 3) based on the IAEA's emergency preparedness categories. The regulations involve the application of a graded approach depending on the radiological hazard at the facility.

The emergency plans for the three operating NPPs and the industry facilities at Studsvik Nuclear AB, AB Svafo and Cyclife Sweden AB include the installations for spent fuel and radioactive waste management at these facilities. SKB has an emergency plan for the Clab interim storage facility for spent nuclear fuel. There is no formal requirement for an emergency plan at SFR; however, a crisis management and rescue organisation is nevertheless in place. SSM's revised regulations for emergency preparedness and response impose new requirements that, eventually, will lead to a new investigation of SFR and possible formal requirement for an emergency plan. Westinghouse Electric Sweden AB (WSE) operates the fuel fabrication facility in Västerås. This facility also has an emergency plan as per SSM's regulations.

Requirements for on-site emergency activities and plans for the nuclear facilities are included in several legally binding documents:

- Act on Nuclear Activities (1984:3);
- Civil Protection Act (2003:778) regarding protection against accidents with serious potential consequences for human health and the environment;
- Civil Protection Ordinance (2003:789) regarding protection against accidents with serious potential consequences for human health and the environment;
- SSM's regulations (SSMFS 2018:1) concerning basic regulatory requirements for all licensed activities involving ionising radiation;
- SSM's regulations (SSMFS 2014:2) concerning emergency preparedness at nuclear facilities;
- SSM's regulations (SSMFS 2021:6) on operation of nuclear power plants; and
- SSM's regulations (SSMFS 2008:1) concerning safety in nuclear facilities.

The overarching objective of the Civil Protection Act (2003:778) is civil protection for the entire country, with consideration given to local conditions for life, health, property and the environment against all types of incidents, accidents, emergencies, crises and disasters. The Act requires preventive measures and emergency preparedness to be arranged by the owner or operator of a facility conducting dangerous activities. The Act also defines the responsibilities for the individual, the municipalities and the state in cases of serious accidents, including radiological accidents. The Act contains provisions on how municipal fire brigades shall be organised, and operated, and stipulates that a rescue commander with a specified competence, with far reaching authority, is to be engaged for all rescue operations. According to the Act, the County Administrative Board is responsible for rescue operations in cases where the public needs protection from a radioactive release from a nuclear installation or in cases where such a release seems imminent.

The Civil Protection Ordinance (2003:779) contains general provisions on emergency planning and is more specific about reporting obligations, information to the public and the responsibility of each County Administrative Board for planning and implementing public protective measures, content of the off-site emergency plan, competence requirements for rescue managers and emergency planning zones around major nuclear facilities. The County Administrative Board must draw up a radiological emergency response plan. At a national level, MSB is responsible for the coordination and supervision of preparedness work for rescue services' response to radioactive releases. SSM decides on necessary measures for emergency planning at the nuclear installations and supervises the nuclear installations regarding these plans.

The Act on Nuclear Activities contains general provisions on emergency response in the event of accidents at a nuclear facility. The Act requires the licensee to have an organisation with sufficient financial, administrative and human resources to carry out protective measures in connection with an accident at their facilities

SSM's regulations SSMFS 2008:1 require the licensee to take prompt action in the event of an emergency to:

- classify the event according to the alarm criteria;
- alert the facility's emergency preparedness organisation;
- assess the risk and size of possible releases and time related aspects;
- return the facility to a safe and stable state; and
- inform the responsible authorities.

The actions must be documented in an emergency preparedness plan that is subject to safety review by the licensee and must be approved by SSM. The plan shall be kept up to date and validated through regular exercises. SSM is to be notified of changes to the plan. The licensee is required to assign staff and provide the suitable facilities, technical systems, tools and protective equipment needed to perform the emergency preparedness tasks. The emergency planning should include all design-basis accidents as well as beyond design-basis events including severe events and combinations of events such as fire or sabotage in connection with a radiological accident.

SSMFS 2014:2 uses the concept of emergency preparedness categories (1, 2, 3 and 4) based on the IAEA's emergency preparedness categories, which introduces the application of a graded approach depending on the radiological hazard at the nuclear facility. The different emergency preparedness categories 1-4 are defined in the annex to the regulations SSMFS 2018:1.

SSM's regulations SSMFS 2014:2 on emergency planning and preparedness have a radiation protection perspective, including requirements for:

- emergency planning including alarm criteria and alarming;
- logistics centre;
- emergency rooms, premises, facilities and assembly places;
- training and exercises;
- iodine prophylaxis;
- personal protective equipment;
- evacuation plan;
- contacts with SSM;
- radiation monitoring;
- emergency ventilation;
- collection of meteorological data; and
- communication equipment.

The requirements differ regarding logistics centre, radiation monitoring, emergency ventilation and collection of meteorological data depending on the radiological hazard assessment and subsequent emergency preparedness categorisation of the facility.

SSM's regulations SSMFS 2018:1, SSMFS 2008:1, SSMFS2021:5-7 include basic regulatory requirements for all licensed activities involving ionising radiation. The regulations also transpose provisions of Council Directive 2013/59/Euratom, which have not been included in the new Radiation Protection Act. SSMFS 2018:1 imposes extensive requirements relating to human factors on:

- safety monitoring and follow-ups;
- the operating organisation and its design;
- management system, including safety culture;
- safety objectives and strategies;
- responsibilities and levels of authority;
- competence assurance, fitness for duty;
- occupational environment;
- planning of nuclear activities;
- design adapted to human capabilities and limitations;
- operational experience feedback; and
- event investigation.

F.5.2 National structure

As accounted above, the Swedish Civil Contingencies Agency (MSB), the Swedish Radiation Safety Authority (SSM), and the County Administrative Boards) and municipalities have the authority to regulate the on-site EPR arrangements of operating organisations. MSB is responsible for matters relating to protection against accidents, emergency preparedness and civil defence, to the extent that no other authority is responsible. The responsibility refers to measures before, during and after an accident, crisis, war or danger of war. Each County Administrative Board is geographically responsible for their county area and the highest civilian total defence authority within the county and is therefore responsible for the state administration in the county to the extent that no other authority is responsible for special administrative tasks. The municipalities are responsible for a large part of the community service that exists where the population lives. The municipalities are obligated to carry out certain activities. It is the municipalities' responsibility to secure the supply of staff and skills in the operations, in both normal and emergency situations.

Sweden's structure for emergency preparedness and response for nuclear emergencies is shown in Figure F5.

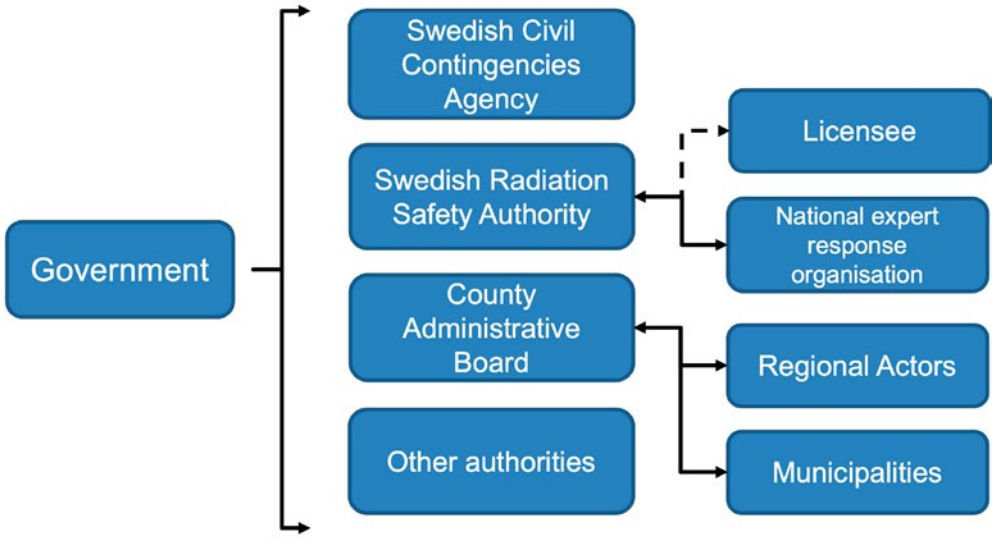

Figure F5 The Swedish national structure for emergency preparedness and response for nuclear emergencies.

The County Administrative Board in each affected region is geographically responsible for planning and leading the regional emergency preparedness work. Each board decides on measures to be taken to protect the public, issues warnings, provides information to the public, and is responsible for decontamination following radioactive fallout and releases. The responsibility for directing rescue services also rests with the County Administrative Board in each affected county unless the Government decides otherwise.

A national contingency plan for dealing with a nuclear accident has been in place since 2015. This national plan describes basic preconditions such as the legislation and the authorities involved in the management of an incident and the responsibilities of these authorities. The plan also describes the national coordination and liaison work of relevant authorities. The document outlines the resources available at national level and how they are requested and coordinated. International assistance is also described in the plan. In addition to this contingency plan, there is a national action plan for improvements to emergency preparedness work.

The Government is responsible for emergency management at a national level. The Government's mandate is primarily concerned with strategic national issues. The Government has the overall responsibility to ensure that an effective crisis management system is in place and that the crisis communication is credible. The State Secretary to the Prime Minister is responsible for leading the overall crisis management process, assessing the need for coordination at the Government Offices, and when necessary, convening a meeting of the Strategic Coordination Group that comprises state secretaries at the ministries whose activity areas are affected. The Government Offices has a special Director General and a secretariat for crisis management. They support the State Secretary to the Prime Minister and develop, coordinate and follow up crisis management. The Director General's responsibilities include ensuring that the Government Offices make necessary preparations for crisis

management response. This may include early warning of a situation that may develop into a crisis, or training and exercises to increase general crisis management capacity. The Crisis Management Coordination Secretariat monitors developments both nationally and internationally around the clock. It is able to raise an alert and produce comprehensive status reports and an overview of the combined impact on society of all individual events. After a crisis situation, the Secretariat should be able to follow up and evaluate the measures taken.

MSB is responsible for matters relating to protection against accidents, emergency preparedness and civil defence, to the extent that no other authority is responsible. The responsibility refers to measures before, during and after an accident, crisis, war or danger of war. MSB has the responsibility to support coordination of preparedness measures taken by local, regional and national authorities. MSB also contacts international organisations,

provides communication networks for competent authorities during extraordinary events. It has the overall responsibility for the Swedish national digital communication system ("Rakel") that is used by national emergency services and others in the fields of civil protection, public safety and security, emergency medical services and healthcare during emergency situations. MSB also assists the Swedish Government Offices by providing documentation and information in the event of emergencies, providing methods for crisis communication, and coordinating official information to the public.

SSM is responsible for giving advice on radiation protection in connection to nuclear and radiological emergencies. SSM shall also provide technical advice in the event of a nuclear or radiological emergency for preventing, identifying and detecting nuclear and radiological events that can damage human health and/or the environment. SSM is the appointed National Competent Authority in the event of a nuclear or radiological emergency in Sweden, or outside Sweden but with consequences for Sweden. SSM is responsible for:

- providing advice and recommendations concerning protective measures in the area of radiation protection;
- radiation measurements including dispersion prognoses;
- maintaining and leading a national organisation for measurement and expert support; and
- providing advice and recommendations to the authorities assigned to deal with the impact of the event.

SSM is also responsible for keeping the Government informed about the situation, expected developments, available resources, measures taken as well as planned, and to provide the information needed to give an overview of the situation following a request by the Crisis Management Coordination Secretariat at the Prime Minister's Office, or by MSB.

A number of authorities, organisations and laboratories will work together, or operate as supporting functions to the above-mentioned national organisations in the event of a nuclear or radiological emergency. Participating authorities that have liaison roles for crisis management include, for example, the Swedish Food Agency (SFA), which areas of responsibility include food and drinking water and the Swedish Board of Agriculture (SJV), which areas of responsibility include feed and animal protection. Other authorities that have responsibilities during crises and that liaise with SSM, or receive advice and recommendations from SSM, include the County Administrative Board, MSB, the Swedish Board of Health and Welfare, the Swedish Customs, the Swedish Meteorological and Hydrological Institute (SMHI), the Swedish Police Authority, the Swedish Coast Guard, Regions, the local rescue leader and medical personnel.

SMHI will provide SSM with data and computational resources to perform dispersion calculations from a radiological or nuclear emergency in the event of a radiological or nuclear emergency, regardless of whether it occurs domestically or abroad.

It is SSM's responsibility, as both an EU and IAEA designated Competent Authority, to promptly inform the European Commission, neighbouring countries that might be affected and the IAEA in accordance with the IAEA's Conventions on assistance and early warning and the European Commission's Convention on early warning. Furthermore, SSM is also responsible for continuously providing information on the measures that Sweden intends to take due to an emergency situation.

In the event of an emergency at a Swedish NPP, the licensee is responsible for immediately contacting the national alarm centre (SOS Alarm AB), which will in turn alert the authorities and organisations responsible for emergency management, see Figure F6. In the event of an emergency at a nuclear facility categorised in emergency preparedness as a category 2, the alarm chain is similar in terms of the role of SOS Alarm AB.

In the event of a radiological or nuclear emergency abroad (including a possible request for assistance), the alert will go to SMHI, which is the national warning point. Upon an alert, SMHI will, through SOS Alarm AB, contact the officer on duty at SSM. The officer on duty at SSM will then contact the Government ministry offices and central and regional authorities with roles and responsibilities in the urgent phase of a nuclear emergency.

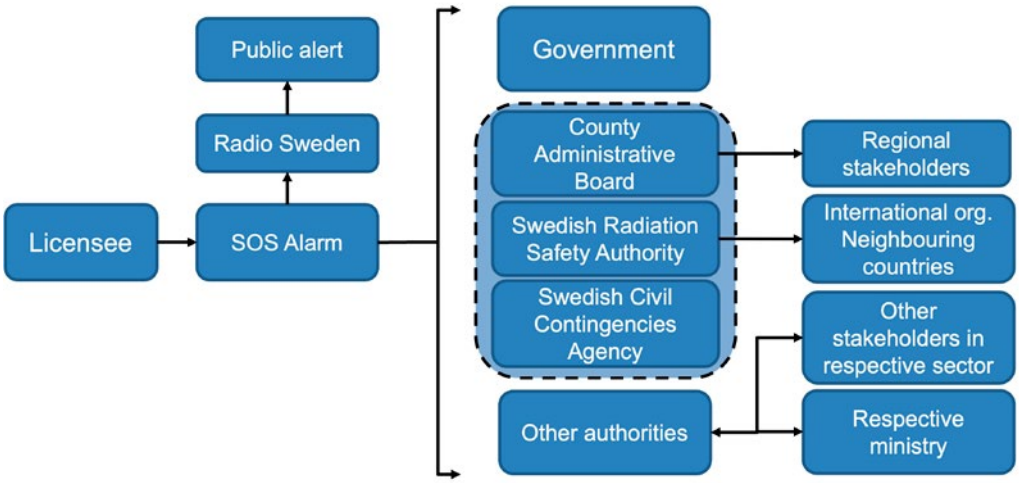

Figure F6 Alarm sequence for an emergency event at a Swedish nuclear facility.

F.5.3 National monitoring

The national expert response organisation comprises government authorities, organisations and laboratories that have expertise in radiological assessment and radiation monitoring. This organisation, coordinated by SSM, has as its main purpose to perform radiation measurements. Figure F7 lists the contracted authorities, organisations and laboratories that have capabilities encompassing laboratory analyses and field monitoring, mobile and airborne monitoring, weather forecasting and plume dispersion prognoses. Individuals engaged in this response organisation may also have an additional role in providing expert advice during the response.

Swedish expert response organisation:

- Swedish Defense Research Agency, FOI (Stockholm, Umeå)
- Geological Survey of Sweden (Uppsala)
- SSM (Stockholm)
- Linköping University (Linköping)
- Göteborg University (Göteborg)
- Lund University (Malmö)

Figure F7 Sweden's national expert response organisation for nuclear and radiological emergencies.

Sweden operates a gamma monitoring network with 28 stations nationwide, and 30 stations around each NPP. Each station continuously records dose rates, and data is automatically transmitted to SSM's radiation monitoring system RadGIS. Increased radiation levels trigger automatic notifications. Figure F8 shows monitoring stations set up around the Forsmark NPP.

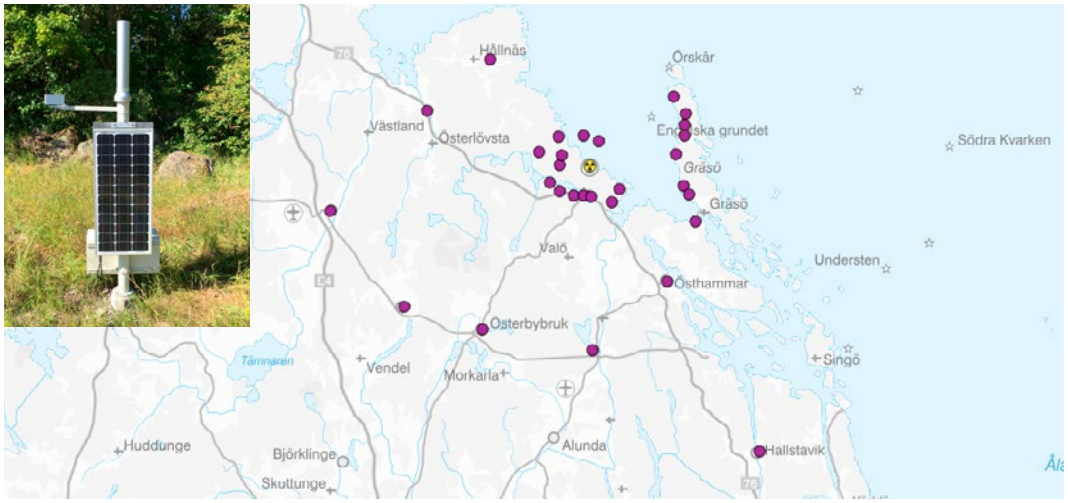

Figure F8 Monitoring stations around the Forsmark NPP (the insert shows a monitoring station).

Sweden also has six permanent air sampling stations operated by the Swedish Defence Research Agency (FOI) and a Comprehensive Nuclear-Test-Ban Treaty (CTBT) station located in Stockholm. These stations continuously sample air to collect any airborne radioactive material. Air filters are regularly collected and transported to a laboratory for measurement and evaluation. The detection system is sufficiently sensitive to measure activity levels in the order of 10s of micro becquerel per cubic metre [$\mu Bq/m^3$] and is also used for environmental monitoring.

As the County Administrative Boards are responsible for implementing public protective actions during and after a nuclear emergency, the boards' emergency response planning also encompasses radiation monitoring. Mobile monitoring of dose rates and collection of air samples for the purpose of public protective actions are performed by local rescue services from municipalities within each county at predefined locations or routes. During a nuclear emergency, the relevant County Administrative Board coordinates response and monitoring activities with the national expert response organisation and government authorities.

F.5.4 Medical emergency preparedness

The county council is responsible for medical disaster preparedness. Injured persons are treated at the site of the emergency, in hospitals or at medical health centres.

More advanced treatment and care can be arranged at major national hospitals, mainly university hospitals. Cooperation and sharing of resources also take place between European hospitals in the event of major accidents. The Nuclear Medical Expert Group (RNMEG) is part of the operative emergency resources available to the National Board of Health and Welfare (NBHW) in connection with radiological incidents. They assist the NBHW, and through the NBHW also other authorities, with specific medical advice regarding, for example, acute and late radiation injuries and treatment thereof. Practitioners from the medical fields of haematology, oncology, radiology, and disaster medicine are represented in RNMEG.

F.5.5 Exercises

Emergency preparedness exercises of various scopes are conducted every year in Sweden. These vary in complexity from simple tests of alarm systems to full-scale national exercises. Periodical testing of the alerting systems between the power plants and authorities is performed each year.

Every other year, a large exercise is carried out at one of the three nuclear power sites for the purpose of checking the planning and capability of the on- and off-site organisations. The full-scale exercises are designed to enable evaluation of command at the regional level, national inter-agency liaison and public communication. The full-scale exercises are often also used for testing international communications.

The respective County Administrative Board where the plant is located has the responsibility for planning these exercises, often with the assistance of MSB, which is also in charge of evaluations and follow-up analyses. SSM participates in planning and evaluation. Usually, 15 to 30 organisations participate in these exercises, including the regulatory bodies.

Sweden has a long tradition of participating in international emergency preparedness exercises. This allows for testing aspects related to bilateral and international agreements on early notification and information exchange. Sweden regularly participates in the IAEA Convention Exercises (ConvEx), the OECD/NEA International Nuclear Emergency Exercises (INEX), and yearly ECURIE exercises.

F.5.6 Measures taken to inform neighbouring states

Sweden has ratified the International Convention on Early Notification and the Convention on Assistance in the Case of a Nuclear Accident. An official national point of contact has been established that is available around the clock. Sweden has registered field and laboratory resources with the international assistance programme, Response and Assistance Network (RANET), managed by the IAEA under the Convention on Assistance in the Case of a Nuclear Accident, and participates actively in developing the RANET system.

Sweden has bilateral agreements with Denmark, Norway, Finland, Germany, Ukraine and the Russian Federation regarding early notification and exchange of information in the event of an incident or accident at an NPP in Sweden or abroad. An agreement has also been signed at regulatory body level with Lithuania. Sweden uses the ECURIE information system for information exchange within the European Union and the Unified System for Information Exchange in Incidents and Emergencies (USIE) system for notification and information exchange between the IAEA Member States.

In addition, the five Nordic countries of Denmark, Finland, Iceland, Norway and Sweden have compiled a Nordic manual (NORMAN) for cooperation between their respective regulators in response to and preparedness for nuclear and radiological emergencies and incidents. The manual describes practical arrangements regarding communication and information exchange to fulfil the stated obligations in bilateral agreements between the Nordic countries. These arrangements also apply to nuclear facilities as a response to events or threats of malicious use of radioactive material and threats or malevolent acts. They also include small scale events, such as the spreading of rumours and minor incidents, having consequences limited to public concern and interest by the media or a need for exchange of technical information between nuclear and radiation safety regulatory bodies. The arrangements also prescribe all phases of events, including intermediate and recovery.

NORMAN also takes into account the current international development concerning response to and preparedness for nuclear and radiological incidents and emergencies as well as other key international initiatives. Communication exercises are performed five times per year, in compliance with NORMAN. These exercises include procedures for alerts and communication by means of video conference systems.

F.5.7 New developments in emergency preparedness

The Government has decided to build up its civil defence in view of security-related developments around Sweden. This includes 10 emergency service sectors, covering 60 authorities, i.e. authorities with special significance for public emergency preparedness and total defence.

Access to clean drinking water, electricity supply and transport infrastructure are just some of the necessities for society. The emergency authorities must be able to withstand threats and risks, prevent vulnerabilities, manage peacetime crises and perform their duties in the event of a heightened state of alert to ensure that these key functions work during normal times and a crisis.

The new emergency planning zones entered into force on 1 July 2020 and are implemented as of 1 July 2022. The Swedish Radiation Safety Authority is currently developing regulations for workers in radiological emergencies and is also investigating the alarm criteria for other nuclear facilities.

Sweden's second full-scope IRRS review was carried out in November 2022. From the recommendations, SSM is now investigating and identifying non-nuclear facilities that could be placed in emergency preparedness category 3.

The Nordic Flag Book is to be published and translated in English. It is currently being revised and will be approved in June 2024. It represents a common Nordic view on how the internationally accepted radiation protection principles apply in the Nordic countries, within the framework of national regulations.

A decision support document for an accident at WSE will be sent to the County Administrative Board for comments during 2024. Clab interim storage facility for spent nuclear fuel will also develop a decision support document.

SSM developed national guidelines on protective actions during a nuclear or radiological emergency at facilities and activities belonging to emergency preparedness category 4. The guidelines supplement the review of Swedish emergency planning zones and distances (SSM Report 2017:27), which took into consideration facilities belonging to emergency preparedness categories 1, 2 and 3. The guidelines use the concepts of reference levels, dose criteria and operational intervention levels in an emergency exposure situation, in line with recommendations contained in ICRP 103 and IAEA GSR Part 7. The guidelines were finalised during December 2020.

FOI, MSB, SFA, SJV and SSM collaborate closely within the national expert group on decontamination and remediation of radionuclides (NESA) in which a representative of the County Administrative Boards is also appointed. The purpose of NESA is to collect and share information on different aspects of remediation among the participating organisations, other central authorities and the County Administrative Boards. In November 2023, a delegation of members from NESA and the County Administrative Boards visited Japan to learn from Japan's experience from decontamination and remediation after the nuclear reactor accident in Fukushima Daichii. The generous sharing of experiences from the study tour will be incorporated into the national guidelines on remediation in the event of fallout of radionuclides in Sweden.

In recent years, there has been a significant development in radiation monitoring equipment within the County Administrative Boards in the NPP counties. SSM has procured a new system for mobile dose rate measurements intended for mapping of fallout from vehicles after an NPP accident. The system was commissioned in 2022 and consists of many instruments and a central server. The instruments significantly raised the effectiveness for fallout mapping of the radiation monitoring for these organisations in the three Swedish NPP counties. Radiation monitoring data from the instruments are transferred to SSM and can be accessed in real-time in SSM's radiation monitoring system RadGIS.

During 2021, the Swedish Civil Contingencies Agency (MSB) purchased new mobile air samplers to be used by the County Administrative Boards. MSB has also, during 2022–2024, distributed new hand-held instruments for radiation monitoring to all Swedish municipalities and County Administrative Boards.

The Swedish regulatory framework implemented the Council Directive 2013/59/Euratom, which led to several changes relating to emergency preparedness and response in the Swedish radiation protection legislation. Hence, the following developments are also of relevance to the obligations of Article 25:

- A new Radiation Protection Act (2018:396) that entered into force on 1 June 2018. It is applicable to workers and the public during an emergency.
- A new Radiation Protection Ordinance (2018:506) that entered into force on 1 June 2018. It sets reference levels to be applied in the case of a radiological emergency and includes requirements for optimisation.
- Updated regulations, SSMFS 2014:2 (revised through SSMFS 2018:26), concerning on site emergency preparedness and response, entered into force on 1 June 2018. The regulations contain new requirements for logistics centres and provisions concerning the ability to receive aid and support from external organisations and renamed some concepts.
- The structure of the regulations have been changed. Some requirements that were previously found in SSMFS 2014:2 (on site emergency preparedness and response) are now found in SSMFS 2018:1 (basic regulatory requirements for all licensed activities involving ionising radiation).
- Two Ordinances, 2015:1052 and 2015:1053, entered into force on 1 April 2016. These ordinances replace the former Emergency Preparedness and Heightened Alert Ordinance (2006:942) that is now split into two parts without any major revisions of its content.

F.5.8 Regulatory control

Over the past few years, regulatory control of on-site emergency preparedness and response focused on implementing the new requirements regarding logistics centres introduced in the regulations SSMFS 2014:2, which entered into force on 1 July 2018. During 2018 and 2019, surveillance inspections were carried out at all the nuclear facilities in emergency preparedness category 1 to ensure that the facilities had established logistics centres as required (see Table F2).

Table F2 Swedish nuclear facilities by emergency preparedness category.

Facility	Emergency preparedness category
Forsmarks Kraftgrupp AB (NPP)	1
OKG AB (NPP)	1
Ringhals AB (NPP)	1
SKB Clab (central interim storage facility for spent fuel)	2
Westinghouse Electric Sweden AB (fuel fabrication facility)	2
Studsvik Nuclear AB (facilities for fuel and materials testing)	3
Cyclife Sweden AB (facilities for waste treatment)	3
AB Svafo (waste management and storage)	3
Barsebäck Kraft AB (permanently shutdown NPP)	3

In addition, some inspections of facilities in emergency preparedness categories 2 and 3 were carried out and observations of some exercises at facilities in emergency preparedness category 1.

Regulatory control showed that on site emergency preparedness at the Swedish nuclear facilities been strengthened in recent years and that the main elements of SSMFS 2014:2 have been effectively implemented.

F.5.9 Conclusion

Sweden complies with the obligations of Article 25.

F.6 Article 26: Decommissioning

Each Contracting Party shall take the appropriate steps to ensure the safety of decommissioning of a nuclear facility. Such steps shall ensure that:

(i) qualified staff and adequate financial resources are available;

(ii) the provisions of Article 24 with respect to operational radiation protection, discharges and unplanned and uncontrolled releases are applied;

(iii) the provisions of Article 25 with respect to emergency preparedness are applied; and

(iv) records of information important to decommissioning are kept.

F.6.1 Regulatory requirements

According to the Act on Nuclear Activities, a licence holder for a nuclear activity is responsible for ensuring that all measures are taken to ensure safe decommissioning of facilities, in which the operation has been discontinued, i.e. all operations at the facilities have ceased and all radioactive waste has been disposed of. The licence holder is not exempted from responsibilities under the Act until decommissioning has been completed and all radioactive waste has been disposed of in a final repository that has been closed.

According to the Radiation Protection Act, a licence holder for a nuclear activity must take all the measures necessary for radiation protection of people and the environment. Furthermore, the licence holder must take all the necessary measures for clearing the remaining buildings and the site as soon as reasonably possible when a nuclear facility is to be decommissioned.

No specific licence is needed for decommissioning nuclear facilities, according to the Act on Nuclear Activities. However, a licence is required for decommissioning and dismantling of nuclear power reactors according to the Environmental Code. In addition to the specific requirements (see also section E.2.1.3), the licensee is also required to demonstrate compliance with several principles, e.g. the knowledge principle, the precautionary and BAT principles and the after-treatment liability principle.

The general regulations SSMFS 2018:1 and SSMFS 2008:1 define "decommissioning" as: measures adopted by licensees after the final shutdown of a facility in order to dismantle and demolish the facility in a safe manner as well as to reduce the amount of radioisotopes from the nuclear activities in the remaining buildings and the site to such levels so that they can be cleared. The regulations SSMFS 2018:1, and in particular SSMFS 2008:1, set out general requirements relating to decommissioning, including documentation of the facility, prerequisites for planning and the decommissioning activity itself.

In 2017, and updated in 2018, SSM issued additional licence conditions for decommissioning of Units 1 and 2 of the Barsebäck, Oskarshamn and Ringhals nuclear power plants and the Ågesta reactor. These licence conditions complement the provisions of SSMFS 2018:1 and SSMFS 2008:1, concerning e.g. the content of the following safety documentation.

These additional licence conditions facilitated the licensee's efficient preparation of the safety report, and supporting documents, for dismantling and demolition.

SSM's authorisation is based on the reviews and approvals of the safety documentation and the environmental monitoring programme for dismantling and demolition. The safety documentation consists of the safety report, the operational limits and conditions, the waste management documentation, and supporting documents such as the final decommissioning plan and the decommissioning strategy. The safety documentation and environmental monitoring programme may be revised and approved by SSM during the execution of decommissioning.

Before the dismantling and demolition activities are allowed to commence, the licensee must notify SSM of their work package. These notifications complement and concretise the previously approved safety documentation. After the completion of the work the licensee must prepare and submit a work package report to SSM. This report contains, amongst other things, information on the amount, content and treatment of the radioactive waste produced.

Moreover, a final decommissioning report on the actual execution of the decommissioning work is required to be submitted to SSM after the dismantling and demolition work is completed. This report must include descriptions of the experience gained and the final state of the facility. This report should also include a description of the management of all the waste arising from dismantling and demolition, including conventional waste.

The regulations SSMFS 2008:38 require archiving of documentation at nuclear facilities. The licence holder must archive documentation related to safety and the radiation protection aspects of the practice. If the practice ceases, the licensee's archived documentation are to be transferred to the National Archives of Sweden or Regional Archives.

Detailed requirements on keeping registers for radioactive waste at nuclear facilities are stipulated by SSMFS 2021:7. The register must contain information on the waste's origin, its amount and radionuclide-specific content.

Requirements for clearance of materials and release of sites are stipulated in the regulations SSMFS 2018:3, concerning exemptions from the Radiation Protection Act and the clearance of materials, building structures, and sites.

The main criteria for clearance of potentially contaminated waste, materials, and buildings are:

- removal of contamination as far as reasonably achievable; and
- dose criterion of 10 μSv/year to any member of the public.

The main criteria for site release are:

- removal of contamination as far as reasonably achievable;
- dose criterion of 100 μSv/year to any member of the public; and
- in the case of release for restricted use: reliable restrictions must be in place such that the effective dose to any member of the public would not exceed 1 mSv/year if the restrictions should fail.

The clearance of building structures and areas in accordance with a control programme must be approved by SSM.

Clearance of waste, materials or buildings is only applicable on potentially contaminated objects, i.e. not on objects that are judged to be free from contamination or activation from the licensed activity. In some cases, this is checked by taking samples or making in-situ measurements. It is accepted in practice to require that the detection limits for these measurements should be less than 10 % of the clearance levels. The licensees may instead apply for exemptions on a case-by-case basis.

The remaining general obligations applicable to decommissioning and dismantling activities contained in SSMFS 2018:1, SSMFS 2008:1, and several other regulations include:

– availability of qualified staff and financial resources (as accounted for in section F.2);
– application of provisions with respect to operational radiation protection, discharges and unplanned and uncontrolled releases (as accounted for in section F.4); and
– application of provisions with respect to emergency preparedness (as accounted for in section F.5).

F.6.2 Measures taken by the licence holders

Licence holders are responsible for decommissioning of their nuclear facilities. Decommissioning of the plants is described in plans that are maintained throughout the facilities' operation. The degree of details depends on the amount of available information. These decommissioning plans also form the basis of decisions on financing for decommissioning activities.

Management of decommissioning waste is coordinated through SKB and includes future transport and disposal of decommissioning waste.

F.6.2.1 Nuclear power plants

Twelve commercial reactors were commissioned at the Ringhals, Forsmark, Oskarshamn and Barsebäck sites in southern Sweden between 1972 and 1985, see Figure A1. As a result of political decisions, the BWR Barsebäck Units 1 and 2 were shut down permanently in 1999 and 2005, respectively. In 2015, the operators decided on an additional phase-out by 2020 of the four oldest reactors at Oskarshamn (BWR Units 1 and 2) and Ringhals (BWR Unit 1 and PWR Unit 2). The decision was based on the overall business and energy market situation with falling electricity prices.

Oskarshamn 1 was permanently shut down in June 2017. Oskarshamn 2 stopped operating since a substantial modernisation programme began in 2013 and permanently shut down in December 2016. The operator, OKG, applied for a licence to decommission the reactors pursuant to the Environmental Code. In 2018, the Land and Environment Court authorised OKG to commence decommissioning, even if additional requirements were stipulated when approving the application. The licences, including approval from SSM, for decommissioning Units 1 and 2 were obtained in 2019.

At Ringhals, Unit 2 was permanently shut down in December 2019 and Unit 1 in December 2020. A decommissioning licence was obtained from the Land and Environment Court in 2020 according to the Environmental Code. In March 2024, SSM approved Ringhals' safety related documentation to commence dismantling and decommissioning.

The planned operating time for the remaining six operating reactors is currently 60 years. This applies to the reactors Forsmark 1, Forsmark 2 and Forsmark 3, Oskarshamn 3 as well as Ringhals 3 and Ringhals 4, which were commissioned between 1980 and 1985.

All spent nuclear fuel at Barsebäck Units 1 and 2 was removed by 2006. In 2019, a decommissioning licence was obtained from the Land and Environment Court, in accordance with the Environmental Code. Since then, segmentation of the reactor pressure vessel and of its internal have been completed. Dismantling in various buildings, such as the turbine building and the reactor building, is ongoing. Site release is planned for mid-2030s, in accordance with regulatory requirements.

SKB has been contracted by the nuclear power companies to participate in planning and execution of future decommissioning. SKB's participation mainly involves compilation of the development needs identified by the licensees, coordination of general methods and procedures for transport and disposal of radioactive waste and compilation of the decommissioning-related costs reported by the licensees. The nuclear power companies have jointly agreed on the tasks SKB coordinates in connection with waste management, for example development of industry guidelines for clearance and industry guidelines for reporting of decommissioning plans. In the future, each nuclear power company will be responsible for the future decommissioning nuclear waste inventory, while SKB will be responsible for compiling the inventory and imposing requirements for the waste (waste acceptance criteria) so that it can be transported and disposed of in the appropriate repository.

Plant-specific and scenario-specific decommissioning studies have been performed for all the Swedish nuclear power plants to estimate waste quantities, timetables and costs. The studies serve as a basis for determining capacities in SKB's planned waste management system and fees to be allocated to the Nuclear Waste Fund.

SKB and the nuclear power companies participate in various national and international fora and collaborations on decommissioning that may be of value for activities in Sweden.

The licence holders and SKB have increased focus on decommissioning planning due to the challenges posed by the accelerated timetable for the decommissioning of the four reactors at Ringhals and Oskarshamn and the start of segmentation and interim storage of reactor pressure vessel internal components at the Barsebäck nuclear power plant. The licensees need to provide interim waste storage at their sites, or externally, because the dismantling and demolition of Barsebäck 1, Barsebäck 2, Oskarshamn 1, Oskarshamn 2, Ringhals 1 and Ringhals 2 commenced before the extended SFR is ready to receive decommissioning waste. Several interim storages have therefore been constructed at different sites.

The decisions to permanently shut down the four reactor units have made the competence and staffing plans even more important. Activities regarding competence planning have therefore been intensified and the plans are now more detailed. The goal is to secure competencies during the entire decommissioning process and to support a good transition process when the sites are progressing from having several reactors in operation to only having one or two at each site. The need for special training in relation to decommissioning activities will influence training activities in the future.

F.6.2.2 Ågesta PHWR

The pressurised heavy water reactor in Ågesta was permanently shut down in 1974. In November 2008, a licence for continued care and maintenance until 2020 was issued under the Environmental Code.

In 2019, a licence for the dismantling and demolition of the reactor was granted under the Environmental Code. Since then, the segmentation of the reactor pressure vessel and its internal components has been completed. Dismantling in the reactor building is ongoing and expected to be finished in 2025. Site release is planned for 2025in accordance with regulatory requirements.

F.6.2.3 Old research and other facilities at Studsvik Tech Park

Studsvik materials testing reactors

The two materials testing reactors at Studsvik (one tank type and one mobile pool type) were permanently shut down in 2005. The final dismantling of Studsvik's R2 materials testing reactor, which began in 2015, is finished. Applications for clearance of the remaining buildings and sub-surface structures were approved in 2023.

Other installations

Other old facilities at the Studsvik Tech Park are to be decommissioned in the future. Preliminary decommissioning plans for these facilities have been prepared by the licence holders and submitted to SSM for evaluation, in accordance with requirements contained in the general regulations.

F.6.2.4 Studsvik Nuclear, Svafo and Cyclife facilities at Studsvik

Studsvik Nuclear, Svafo and Cyclife are licensees of many nuclear facilities at the Studsvik Tech Park. Preliminary decommissioning plans for these nuclear facilities have been prepared and submitted to SSM in accordance with requirements in the general regulations.

F.6.2.5 Installations in Ranstad

The uranium mining and milling facilities in Ranstad were constructed and operated in the 1960s. In total, about 200 tonnes of uranium were produced. The uranium open-cast mine and mill tailings deposits were restored and covered in the 1990s. Until 2009, part of the facility was used for extracting uranium from waste originating from the nuclear fuel fabrication.

All dismantling, demolishing and restoration activities have been completed. In 2019, SSM approved the clearance of the site, which has been released from regulatory control.

Only the mill tailings deposits will remain under institutional control. The the licensee's remaining duties consist of the preparation of the final decommissioning report and compilation of archive documentation.

F.6.2.6 SKB facilities

SKB developed a new decommissioning plan for the facility in preparation for its application for the extension of SFR, which was submitted in 2014 under the Act on Nuclear Activities. Decommissioning of SFR will begin when operation ceases. Decommissioning is completed when the above-ground facility has been released from regulatory control and there are no radiological reasons to prevent the establishment of another industrial activity on the site. Nuclear power plants are currently planned to operate for 60 years and a few more years for Clink. Decommissioning of SFR could therefore start in the early 2070s.

SKB has conducted a decommissioning study of the combined Clab and encapsulation facility (Clink), based on the current planning, waste volumes, the content of radionuclides and costs. A decommissioning plan was prepared for the Clab facility. It was updated in 2020 with clarification of how dismantling and demolition are planned for the underground parts of the facility.

A preliminary decommissioning plan was prepared for the spent nuclear fuel repository. It was included in the application for disposal of spent fuel under the Act on Nuclear Activities and the KBS-3-system under the Environmental Code. The decommissioning plan was updated in 2017 to harmonise with current regulations and follow the industry-wide structure for a decommissioning plan.

No decommissioning plan has yet been prepared for SFL, since the design of the facility is only in the conceptual stage. Decommissioning will start in conjunction with repository closure, which is expected to take place in the mid-2050s.

F.6.2.7 Westinghouse fuel fabrication plant

A preliminary decommissioning plan for the Westinghouse fuel fabrication plant has been prepared and submitted to SSM in accordance with requirements in the general regulations.

F.6.3 Regulatory control

See sections E.3.2.6, E.2.5.2 and F.3.3 for details on SSM's system of controls and inspections.

SSM analysed its personnel resources needed for authorising dismantling and demolition activities and their regulatory control, in addition to issuing additional licence conditions for decommissioning, see section F.6.1. SSM intends to maintain adequate staffing.

SSM also adapted its approach to reviewing safety reports to better address issues specific to dismantling and demolition. Thereby, SSM could within 18 months thoroughly review and approve the safety reports and supporting documents for dismantling and demolition of Units 1 and 2 of the Barsebäck and Oskarshamn nuclear power plants and the Ågesta reactor. SSM used its experience from reviewing the safety documentation for dismantling and decommissioning of Ringhals 1 and 2.

During the decommissioning period of a nuclear reactor, SSM's regulatory control is two-fold: first, it is based on a systematic basic inspection programme for nuclear facilities; and second, it is linked to work packages. Typically, all dismantling and demolition measures are bundled into work packages per reactor. An example of a typical work package is the segmentation of the reactor pressure vessel. SSM conducts on-site inspections to supplement the review process encompassing the work packages. Follow-up inspections are conducted during the implementation of the work packages. Following completion of a work package, a final report must be submitted to SSM for review.

SSM is currently performing regulatory control of ongoing dismantling measures at Units 1 and 2 at Barsebäck and Oskarshamn nuclear power plants and the Ågesta reactor. SSM's regulatory control at Units 1 and 2 at Ringhals nuclear power plant will focus on dismantling and demolition, which will commence in 2024.

SSM's regulatory control of decommissioning is not only restricted to the classical tools of reviews and inspections. SSM has continued to take a more proactive stance and has arranged, for instance, annual workshops on the various technical and regulatory issues of decommissioning. Regularly, 80–100 participants from the industry join these workshops. There is a mix of lectures given by nationally and internationally-recognised experts and group discussions that support the building-up of knowledge and networks necessary for the safe and efficient implementation of the large-scale decommissioning programme in Sweden.

F.6.4 Conclusion

Sweden complies with the obligations of Article 26.

Section G – Safety of Spent Fuel Management

The articles of the Joint Convention that specifically relate to the safety of spent fuel management (Articles 4 to 10, covered in this section) have many similarities to the articles that specifically address the safety of radioactive waste management (Articles 11 to 17, covered in section H). To avoid unnecessary duplication, reporting on those matters (primarily regulatory requirements) that are common to both section G and section H is presented in full in section G only. Where relevant, references to these accounts are then made from the corresponding parts of section H. Where the Convention's requirements differ between the safety of spent fuel management and the safety of radioactive waste management, this is stated in the respective section. All aspects of the safe management of spent nuclear fuel, including development of a geological disposal facility, are covered by this section, whereas the relevant aspects of the programme for other radioactive waste disposal facilities are described in section H.

G.1 Article 4: General safety requirements

Each Contracting Party shall take the appropriate steps to ensure that at all stages of spent fuel management, individuals, society and the environment are adequately protected against radiological hazards. In so doing, each Contracting Party shall take the appropriate steps to:

(i) ensure that criticality and removal of residual heat generated during spent fuel management are adequately addressed;

(ii) ensure that the generation of radioactive waste associated with spent fuel management is kept to the minimum practicable, consistent with the type of fuel cycle policy adopted;

(iii) take into account interdependencies among the different steps in spent fuel management;

(iv) provide for effective protection of individuals, society and the environment, by applying at the national level suitable protective methods as approved by the regulatory body, in the framework of its national legislation which has due regard to internationally endorsed criteria and standards;

(v) take into account the biological, chemical and other hazards that may be associated with spent fuel management;

(vi) strive to avoid actions that impose reasonably predictable impacts on future generations greater than those permitted for the current generation;

(vii) aim to avoid imposing undue burdens on future generations.

G.1.1 Regulatory requirements

G.1.1.1 The general obligations of licence holders

All licence holders of nuclear facilities are expressly responsible for the safe management and ultimate disposal of the spent nuclear fuel and radioactive wastes that they generate, including those arising from the decommissioning and demolition of their facilities. As noted in section E.2.1.1, the Act on Nuclear Activities requires the holder of a licence for the operation of a nuclear power reactor, in liaison with other licence holders for the operation of nuclear power reactors, to establish and carry out an RD&D programme for the safe handling and final disposal of spent fuel and nuclear waste associated with their activities. Every third year, a report on the RD&D programme must be submitted to the Swedish Radiation Safety Authority, SSM, for evaluation. SSM then submits its review statement to Government and the Government determines whether the programme is to be approved, specifying any necessary conditions regarding its future scope and content.

The legal obligations on licence holders of nuclear power plants do not formally extend to requiring them to provide for the disposal of spent fuel from facilities other than their own reactors. However, it was implicitly assumed when drafting the Act on Nuclear Activities that such additional quantities could readily be accommodated in the licence holders' arrangements for disposal. Costs for the management and disposal of all spent fuel are the responsibility of respective licence holders.

G.1.1.2 Basic provisions and licence obligations

According to the Radiation Protection Act (2018:396), any party that conducts an activity involving ionising radiation (including both nuclear and non-nuclear licensees) must take measures to limit as far as is reasonably practicable the generation of radioactive waste.

Basic safety obligations on licence holders for nuclear facilities are stipulated in the Act on Nuclear Activities. These provisions are further clarified in the basic regulatory requirements for radiation safety in association with licensed activities (SSMFS 2018:1) and in regulations on safety in nuclear facilities, including the safe management of nuclear materials and waste from nuclear activities. SSM is currently updating its radiation safety regulations relating to nuclear activities. Regulations that were previously applicable to all types of nuclear facility (SSMFS 2008:1) are gradually being replaced by three separate groups of regulations covering different types of installation (see section E.2.2). Moreover, a separate regulation (SSMFS 2021:7) has been introduced regarding the management of waste from nuclear facilities, replacing certain parts of the general regulations on radiation safety.

Since Sweden's last report within the Joint Convention, new general regulations have been introduced relating to the design (SSMFS 2021:4), evaluation and reporting of radiation safety (SSMFS 2021:5) and operation (SSMFS 2021:6) of nuclear power plants. At the time of preparing this report, corresponding regulations for geological disposal facilities and other types of nuclear facility were being finalised. In the meantime, the existing general safety regulations (SSMFS 2008:1), as described in previous national reports under the Joint Convention, continue to apply to these types of facility.

The regulations (SSMFS 2021:7) regarding radiation safety in relation to waste and spent fuel management at nuclear facilities establish basic provisions for ensuring adequate protection at all stages in the management of spent fuel and radioactive waste from nuclear activities. Under these provisions, the licensee shall:

- ensure that waste management planning is under the control of a quality-assured management system that takes all factors into account, enabling plans to be transferred into decisions on necessary organisational, administrative and technical measures;
- undertake necessary investigation and evaluation of available waste management methods, the potential need for development of new methods, options for limiting the generation of additional waste during waste management, and the need for organisational, administrative and technical measures; and
- ensure that a documented plan is drawn up and kept up to date for all radioactive waste and spent fuel arising from or supplied to the licensed activity, showing how and when waste of different origins is to be managed, through separation, processing, storage, transport and final disposal.

Radiation protection and nuclear safety during waste management and spent fuel management operations are subject to general safety regulations for the control and safe operation of nuclear facilities, as noted above for nuclear power plants (SSMFS 2018:6), and for other nuclear facilities (SSM 2008:1), such as the central interim storage facility for spent nuclear fuel, Clab. These include a requirement to undertake, document and maintain a safety analysis showing how facilities and management systems for spent fuel and radioactive waste management, alongside other relevant aspects of facility safety, ensure compliance with regulatory requirements regarding design, function, organisation and operation. The regulatory provisions also include requirements to establish documented guidelines for how safety shall be maintained at the facility and to ensure that the personnel performing duties important for safety are well acquainted with the guidelines.

Two separate regulations currently prescribe general requirements related to the design and assessment of post-closure safety for disposal facilities. These include: regulatory provisions specific to the protection of human health and the environment in connection with the final management, including disposal, of spent nuclear fuel and nuclear waste, with a focus on application of radiation protection principles for the long term (SSMFS 2008:37); and regulatory provisions concerning principles for assuring and assessing post-closure safety of a disposal facility (SSMFS 2008:21). As noted above, a unified set of regulations relating to the design, evaluation and reporting of radiation safety, and operation of geological disposal facilities is currently in preparation.

G.1.1.3 Criticality and removal of residual heat

The general safety regulations (SSMFS 2008:1), which currently apply to centralised facilities for the interim storage and disposal of spent nuclear fuel, state that radiological accidents are to be prevented by the design, construction, operation, monitoring and maintenance of a facility. Requirements relating to the prevention of unintended criticality are addressed in provisions for defence in depth, while heat generation and removal of residual heat must be considered when establishing the operating limits and conditions of any nuclear facility, including storage facilities for spent fuel, both for normal operation and design-basis events. Provision must be made in the design of storage arrangements for reserve capacity to enable relocation of material. Passive safety functions shall be used as far as is reasonably practicable in the design of systems for storage of spent fuel.

Equivalent requirements regarding the prevention of criticality and removal of residual heat for irradiated nuclear fuel are also specified in regulations (SSMFS 2021:4 and SSM2021:6) that cover the design and operation of nuclear power plants.

G.1.1.4 Interdependencies among the different steps in spent fuel management

The fact that licence holders are responsible for the handling and disposal of the spent nuclear fuel they generate provides an incentive to consider all steps from generation to disposal. Detailed requirements are stipulated in SSM's general regulations on safety in nuclear power plants (SSMFS 2021:4, SSMFS 2021:5 and SSM2021:6), the safety of other nuclear facilities (SSMFS 2008:1) and the control of nuclear waste and nuclear material (SSMFS 2021:7). These requirements relate to:

- performance of safety analysis to guide spent fuel management planning and decision making;
- maintenance of an up-to-date inventory of spent fuel held on site;
- comprehensive planning for spent fuel management, including final disposal;
- derivation and use of acceptance criteria relating to safety and radiation protection throughout all steps in the spent fuel management chain; and
- measures for the management of non-conforming material.

G.1.1.5 Protection of individuals, society and the environment

Section F.4.1describes general safety provisions relating to radiation protection in Sweden. Radiation protection of the public and the environment in connection with operational spent fuel management is addressed in general regulations relating to the safety of nuclear power plants and other nuclear facilities (see above). As noted in section G.1.1.2, safety and radiological protection objectives for disposal facilities are currently established in separate regulations (SSMFS 2008:37 and SSMFS 2008:21). At the time of preparing this report, regulations for geological disposal facilities and other types of nuclear facility (including the interim storage of spent fuel) were being updated. Fundamental principles and requirements for radiological protection in relation to spent fuel management and disposal can be summarised as follows:

- Human health and the environment shall be protected from the detrimental effects of ionising radiation during all stages of the final management of spent nuclear fuel or nuclear waste, as well as in the future, in accordance with internationally endorsed criteria and standards.
- A disposal facility for spent nuclear fuel and/or nuclear waste shall be designed so that the annual risk of harmful effects after closure does not exceed 10-6 for a representative individual in the group exposed to the greatest risk.
- Disposal of spent nuclear fuel and nuclear waste shall be implemented so that biodiversity and the sustainable use of biological resources are protected.

G.1.1.6 Account of biological, chemical and other hazards

Biological, chemical and other hazards associated with an activity are addressed from a regulatory perspective in the licensing process under the Environmental Code (sections E.2.3 and E.2.9). The operator is required to continuously take protective measures and precautions to prevent or hinder their activities from causing detriment to human health or the environment from chemical, biological and other hazards, including radiological hazards. Any such risks that might be associated with the activity should be analysed and reported in the corresponding Environmental Impact Assessment (EIA). The EIA should also include a description of the measures, through design and management actions, that are envisaged to prevent, reduce or remedy adverse effects associated with these hazards (section E.2.3.4). Specific licence conditions relating to mitigating measures taken by the operator of a particular activity are typically imposed at the time of licensing.

G.1.1.7 Striving to avoid impacts and undue burdens on future generation

As described in section B.1.1, the overall system for management of spent fuel and radioactive waste is governed by fundamental legal principles adopted by the Swedish Parliament. One of these principles is that financial costs for the treatment and disposal of spent fuel and radioactive waste from nuclear activities, including decommissioning and dismantling activities, must be covered by fees that licensees are required to pay. A second principle is that the licensees are responsible for the safe disposal of spent nuclear fuel and radioactive waste from nuclear activities. Although the State formally takes ultimate responsibility for spent nuclear fuel and radioactive waste from nuclear activities, the goal of these principles is to avoid a burden on future generations, especially with regard to the fundamental aspects of safety and financial costs. The legal principles also imply that actions should be taken without undue delay, i.e. the generation that has benefited from the nuclear power generation should also deal with the management and disposal of the spent nuclear fuel and radioactive waste that was produced.

SSM's regulations (SSMFS 2008:23) on discharges of radioactive substances require that human health and the environment shall be protected from harmful effects of ionising radiation during the operation of a nuclear facility as well as in the future. Furthermore, regulations (SSMFS 2008:37) relating to the final management of spent fuel and nuclear waste specifically require that human health and the environment shall be protected from detrimental effects of ionising radiation during all stages, including after closure of a disposal facility.

G.1.2 Measures taken by the licence holders

G.1.2.1 The general obligations of licence holders

RD&D programme 2022

The nuclear industry, through its co-owned company SKB, has since the mid-1970s performed research on the long-term management of spent fuel and final disposal of radioactive waste. The formal requirement for an RD&D programme to be submitted for regulatory evaluation was established in 1984 when the Act on Nuclear Activities entered into force. Since 1986, SKB has produced thirteen RD&D programmes, with a central focus on development of the KBS-3 system as the industry's preferred alternative for the disposal of spent fuel. The status of SKB's licence application in relation to establishing KBS-3 is outlined in sections A.9.4, A.10.2 and K.1.1.

In September 2022, SKB submitted the most recent RD&D programme to the regulator, SSM, for review and public consultation, in preparation for the Government's decision concerning the reactor licence holders' fulfilment of their legal obligations. In their RD&D Programme 2022, SKB presented its plans for research, development and demonstration for the period 2023–2028 (SKB Report TR-22-11, December 2022, can be downloaded from www.skb.se).

The programme consists of three parts:

Part I SKB's activities and plan of action;
Part II Waste and final disposal; and
Part III Decommissioning of nuclear facilities.

The plan of action developed by SKB on behalf of its owners gives the rationale for the research, development and demonstration needed in order to construct and commission new facilities for spent nuclear fuel and waste management. In terms of the KBS-3 system for final management of spent nuclear fuel the programme entails the construction and commissioning of a new facility for encapsulation of spent nuclear fuel adjacent to the Clab interim storage facility, the spent fuel repository, and the development and manufacture of transport casks for canisters of spent nuclear fuel.

Even though SKB has reached maturity in research and development required to obtain licences under the Nuclear Activities Act, further research and technology development is needed to support construction and commissioning of the facilities. Research relating to the final repository for spent fuel is focused on providing knowledge to enable a more realistic assessment of post-closure safety that can be used as a basis for optimisation of repository design and layout. The research programme includes further work on process understanding regarding the characterisation and behaviour of spent fuel, processes affecting canister corrosion mechanisms and slow resaturation of the bentonite buffer.

Technology development is focused on completing the detailed design of both the encapsulation plant and spent fuel repository. Technology and methods for the industrial production of canisters must be developed and described prior to the construction of the encapsulation plant. Technical systems must be specified, including methods for nuclear fuel measurement, the drying of fuel assemblies as well as the remote welding and inspection of canisters during encapsulation. For the disposal facility, technology development includes the definition of investigation methods to verify the site descriptive model for the Forsmark site, further development of technical systems for deposition, backfilling and sealing of deposition tunnels, as well as methods for constructing repository accesses and excavating deposition tunnels and deposition holes. Technology development also takes place in the field of nuclear safeguards, in liaison with IAEA, Euratom and SSM.

G.1.2.2 Basic provisions and licence obligations

Specific measures taken by the licensees regarding general safety requirements are discussed in sections G.3.2 (facility siting), G.4.2 (facility design and construction), G.5.2 (assessment of facility safety) and G.6.2 (facility operation). General measures taken by licence holders with respect to the continued safe management of spent fuel include the following.

Spent fuel storage at reactor sites

All spent nuclear fuel was removed from the Barsebäck Units 1 and 2 and transferred to the Clab central storage facility by 2006. Facilities for spent fuel storage have also been emptied at Oskarshamn Units 1 and 2, which have been permanently shut down since June 2017 and December 2016, respectively. By June 2022, all fuel from Ringhals Units 1 and 2 had been transported to Clab.

The process of handling damaged fuel with failed cladding during the emptying of nuclear power plants is the subject of special consideration. Two separate methods have been developed, both of which entail the use of water-tight special containers with the dimensions of PWR and BWR fuel. The intention is that these containers will subsequently be encapsulated and disposed of in the same way as standard fuel elements. In the method used in the storage pools of the nuclear power plants, developed by Westinghouse and known as Quiver, the content of the container is dried after the cladding has first been punctured to ensure complete drying. An alternative method has been developed for damaged fuel that has been sent for analysis and/or treatment at Studsvik Tech Park. Here the damaged fuel rods are segmented in hot cells before drying, transferred to special cases and finally placed into transport boxes that have the same dimensions of PWR or BWR fuel elements.

Central storage facility for spent nuclear fuel (Clab)

SKB is the licensee for Clab, the central interim storage facility for spent nuclear fuel located at the OKG site. Clab's operations were initially (from 1985) contracted to OKG. In January 2007, SKB took over Clab's operations to manage the facility as part of SKB's own organisation.

The storage capacity at Clab is limited in two main respects: the permissible quantity of spent nuclear fuel in the facility and the number of physical storage positions in the pools. In 2021, the Government granted a licence to SKB to enable an increase in the quantity of spent nuclear fuel stored in Clab from 8,000 to 11,000 tonnes. In 2024, SSM approved the updated safety report so that trial operation can commence.

Existing documentation shows that there are a small number of fuel assemblies with leaking fuel rods at Clab. A detailed plan for handling these fuels will be established as part of the current RD&D programme, taking into account of experience from discharging damaged fuel at nuclear power plants. In addition, the long-term inspection programme for fuels in interim storage has revealed weaknesses in the construction for certain fuel types that could potentially cause problems when handling the fuel. This information is being considered in the design development of the encapsulation facility.

As noted in Sweden's Sixth Report under the Joint Convention, all areas of improvement identified in the post-Fukushima stress test analysis of Clab have been addressed by SKB. It has been shown that the facility can withstand an earthquake with a return frequency of 10-5/year with a safety factor of 2. The updated SAR shows that boiling of the pool water will not occur within a period of 30 days after loss of electric power supply or other extreme disturbances of the cooling system.

Transportation of spent fuel
About 90 casks filled with spent nuclear fuel are currently transported annually between the nuclear power plants and Clab. A contract was signed in October 2013 with Holtec International Power Division, Inc. for the design, licensing and manufacturing of five new spent fuel transport casks with auxiliary equipment. The NRC's approval of the new cask HI-STAR 80 was obtained at the end of September 2018 and the US Department of Transport issued a licence. The whole system is planned to be in operation in 2026.

New bottom shock absorbers for existing fuel transport casks (Type TN17/2) have been delivered. The cask supplier has updated the safety analysis report accordingly.

At present M/S Sigrid makes about 20 trips per year, which means that there is an overcapacity in the transportation system. After 2030, the need for transportation of spent nuclear fuel and radioactive waste is expected to double when several of SKB's new facilities have been commissioned. This includes, in particular, the additional transport of encapsulated nuclear fuel from the Clink facility to the spent fuel repository. Work is being carried out by SKB to ensure that assumptions regarding transport needs, including logistics associated with servicing and transhipments between sea and land, are verified and, where necessary, revised.

Biological, chemical and other hazards associated with spent fuel management
This topic was addressed as part of SKB's RD&D programme as well as during the national consultations carried out under the Environmental Code regarding SKB's plans for disposal of spent nuclear fuel. Non-radiological environmental risks arising during construction and operation of the planned facilities (encapsulation facility and geological repository) were assessed (SKB Report 2009, P-09-78, can be downloaded at www.skb.se) and the outcomes presented by SKB in the EIA submitted to the Land and Environment Court as part of the licence application for the disposal of spent nuclear fuel. A post-closure chemotoxic assessment for the disposal of spent nuclear fuel was also performed by SKB (SKB Report 2010, P-10-13, can be downloaded at www.skb.se).

G.1.3 Regulatory control

G.1.3.1 The general obligations of licence holders

Evaluation of the RD&D programme
In September 2022, SKB submitted the nuclear reactor licensees' thirteenth programme for research, development and demonstration, RD&D Programme 2022, to SSM for review and broad consultation with national stakeholders. In March 2023, SSM submitted the results of its evaluation and a statement to the Government with a recommendation to approve SKB's RD&D programme.

In its statement to Government, SSM concluded that the reactor licensees' programme was sufficiently comprehensive in terms of the range of issues considered and that planned measures for safe handling of spent nuclear fuel were sufficient for the licensees to be considered to have met to have their obligations according to the Act on Nuclear Activities. SSM further noted that the programme, as presented by SKB, provided transparency and understanding with regard to SKB's and the reactor licensees' plans and programme, as required by legislation. SSM intends to continue to monitor and evaluate SKB's ongoing development and optimisation of the disposal system within the framework of its mandated regulatory supervision of licensed activities, following the Government's formal approval in January 2022 of the KBS-3 system for final management of spent fuel, including the planned geological disposal facility at Forsmark. SSM recommended that SKB should consult with the Authority to avoid unnecessary double accounting of development activities between future reporting of the RD&D programme and the supervision of the facility development and operation.

In its decision on the 2022 RD&D programme, in December 2023, the Government agreed with SSM's conclusions, noting that continued public insight into the industry's plans and programme for the management of spent nuclear fuel is of significant importance, even after licensing has taken place. Among other things, the Government (as highlighted also by SSM) underlined the importance of work to develop appropriate measures for preservation of information regarding the disposal facility.

G.1.3.2 Basic provisions and licence obligations

Inspections and surveillance

SSM undertakes compliance and surveillance inspections relating to the safe management of spent fuel in accordance with its legal authorisation and the mandate defined by the Government. Supervision of activities that deal with chemical and biological hazards is primarily exercised by the relevant County Administrative Boards.

The results of inspections and surveillance are fed back to nuclear facility licensees, summarised annually in meetings at senior management level and compiled routinely in reports that provide an integrated evaluation of radiation protection and safety. These reports are produced annually for the nuclear power plants and every three years for SKB. In the latest integrated evaluation for SKB, published in February 2022, SSM assessed radiation safety associated with the Clab interim storage facility to be satisfactory in several areas, reflecting an improved evaluation compared with "acceptable" category assigned in the previous integrated review.

SKB was considered to have good routines for following up and remedying self-identified deficiencies and proposed areas for improvement, as well as routines for addressing the outcome of SSM's reviews, operational surveillance and inspections. SSM noted, in particular, a continued improvement in the area of organisation, management and governance of operational safety. SKB's efforts with regard to competence and staffing were also assessed to be satisfactory, while deficiencies in the performance of primary and independent safety reviews were considered to have been satisfactorily remedied. These and other observations led to the conclusion that SKB had demonstrated an increased capacity for following up deviations, deficiencies and areas for improvement compared with the results of the 2018 evaluation.

In addition to integrated evaluations based on surveillance, inspection and review activities, an overall evaluation of a licensee's capacity to continue conducting its activities is made at least every ten years through a review of the licensee's periodic safety review (PSR). Sweden's previous national report contains a summary of SSM's review of SKB's latest PSR of Clab and SFR (completed in 2019).

G.1.4 Conclusion

Sweden complies with the obligations of Article 4.

G.2 Article 5: Existing facilities

> Each Contracting Party shall take the appropriate steps to review the safety of any spent fuel management facility existing at the time the Convention enters into force for that Contracting Party and to ensure that, if necessary, all reasonably practicable improvements are made to upgrade the safety of such a facility.

G.2.1 Review of existing facilities for spent fuel management

By the time Sweden became a party to the Joint Convention, the situation was satisfactory with regard to safety of spent fuel management facilities. The elements of the Joint Convention have long been implemented in the form of requirements imposed by the Swedish legal and regulatory framework, as well as being implemented in practical arrangements for the management of spent nuclear fuel. Dedicated inspection and review activities confirm that licensees' activities continue to be conducted in conformance with the legal and regulatory requirements for the safe management of spent nuclear fuel.

G.2.2 Conclusion

Sweden complies with the obligations of Article 5.

G.3 Article 6: Siting of proposed facilities

1. Each Contracting Party shall take the appropriate steps to ensure that procedures are established and implemented for a proposed spent fuel management facility:

(i) to evaluate all relevant site-related factors likely to affect the safety of such a facility during its operating lifetime;

(ii) to evaluate the likely safety impact of such a facility on individuals, society and the environment;

(iii) to make information on the safety of such a facility available to members of the public;

(iv) to consult Contracting Parties in the vicinity of such a facility, insofar as they are likely to be affected by that facility, and provide them, upon their request, with general data relating to the facility to enable them to evaluate the likely safety impact of the facility upon their territory.

2. In so doing, each Contracting Party shall take the appropriate steps to ensure that such facilities shall not have unacceptable effects on other Contracting Parties by being sited in accordance with the general safety requirements of Article 4.

G.3.1 Regulatory requirements

G.3.1.1 Assessment of safety and environmental impact

A licence under both the Environmental Code and the Act on Nuclear Activities is required in order to construct, possess and operate any nuclear facility (the licensing procedure is described in sections E.2.3 and E.2.9). An application must demonstrate that the requirements are fulfilled in accordance with these legal instruments as well as those of the Radiation Protection Act. It must also be shown that the more detailed requirements prescribed in SSM's regulations can be met. Key regulations relating to consideration of safety issues in the siting of proposed facilities for management of spent fuel are:

- regulations concerning safety in nuclear facilities (SSMFS 2008:1);
- regulations concerning safety in connection with the disposal of nuclear materials and nuclear waste (SSMFS 2008:21); and
- regulations concerning the protection of human health and the environment in connection with the final management of spent nuclear fuel and nuclear waste (SSMFS 2008:37).

The Environmental Impact Assessment (EIA) and a first preliminary safety report are key elements of the parallel licencing applications.

The Environmental Code requires, as part of the general "rules of consideration", that site selection is undertaken in such a way as to make it possible for the objectives of the activity to be achieved with minimum damage and detriment to human health and the environment. The Environmental Code also specifies procedures for carrying out the EIA as well as its content. The EIA must contain the following elements:

- a description of the planned activity or course of action with details of its location, design and scope;
- a description of the measures that are planned with a view to avoiding, mitigating or remedying adverse effects;
- the information needed to establish and assess the main impacts on human health, the environment and management of land, water and other resources that the planned activity or course of action is likely to have;
- a description of possible alternative sites and alternative designs, together with a statement of the reasons why a specific alternative was chosen, as well as a description of the consequences if the activity or measure is not implemented; and
- a non-technical summary of the information.

Requirements regarding the content of the preliminary safety report, submitted in support of a licence application under the Act on Nuclear Activities, are stated in regulations concerning safety in nuclear facilities, and include (for example) the following:

- A description of how the site and its surroundings can affect the safety of the facility during its operational lifetime.
- A description of the design basis, including the requirements that have determined the design and construction of the facility. Descriptions of facilities for the final management of spent fuel or nuclear waste shall contain requirements that are determined by how safety is to be achieved in the corresponding disposal facility after closure.
- A description of measures taken to ensure adequate protection of workers, the public and the environment from the harmful effects of radiation, as required by the Radiation Protection Act and regulations prescribed under that Act.

Regulations (SSMFS 2008:37) relating to development of geological disposal facilities specify that site selection is seen to be an element of the identification and implementation of the best available technique for the repository system as a whole.

G.3.1.2 Public information and involvement

The legal framework for licensing of nuclear activities stipulates provisions on transparency, openness and public participation. Several procedures involve the public as part of siting of new spent nuclear fuel management and nuclear waste facilities. As mentioned above, an EIA must be performed for any new nuclear facility. Swedish legislation emphasises the role of the public and other stakeholders in establishing the scope of the EIA. The programme for developing an EIA must for instance contain a plan for the formal process of consultation with stakeholders. In particular, the developer must initiate early consultations with those parties that might be affected by a new facility.

Parties that must be consulted include:

- municipalities that may host the facility;
- regulatory authorities, primarily SSM and the relevant County Administrative Boards in the case of facilities for spent fuel and nuclear waste management;
- national environmental organisations;
- local interest groups; and
- affected individuals, e.g. landowners or those living close to a proposed site.

The County Administrative Boards have an important function besides participating in consultations based on their role as a regulator for environmental issues. They are required to assist the developer in identifying stakeholders and to facilitate consultations and the exchange of information.

In addition to the requirement on the applicant to conduct public consultation in combination with the development of an EIA, the regulatory authority for radiation safety (SSM), invites a broad range of interested parties to provide comments in association with its periodic evaluation of the nuclear power plant licence holders' joint RD&D programme (see section G.1.1). In summary, interested parties are provided with information regarding, among other things, the programme for development of new facilities and the possibility to influence the pre-licensing process through comments and opinions.

According to the Act (2006:647) and Ordinance (2008:715) on Financing of Management of Residual Products from Nuclear Activities, the municipalities that might host a spent nuclear fuel or nuclear waste management facility, including a disposal facility, are to be reimbursed for engagement and information activities aimed at their residents. Since the mid-1990s, municipalities have been reimbursed by this mechanism for their information activities associated with SKB's siting process in connection with the geological disposal of spent fuel. The municipalities of Östhammar and Oskarshamn continue to receive financial compensation via the Nuclear Waste Fund as the prospective host communities for the disposal facility and encapsulation plant, respectively.

Previous arrangements enabling non-profit and non-governmental organisations to obtain financial support for their participation in the public consultation activities relating to SKB's programme and licence applications were withdrawn by the Government in 2023, following the decision to approve licensing of the KBS-3 system for final management of spent nuclear fuel. Environmental organisations must now apply for grants from the budget allocated to the Swedish Environmental Protection Agency for distribution to non-profit organisations that seek funding for activities in support of Sweden's national environmental quality goals.

The host municipality has had a right to veto prior to the Government's final decision in relation to licensing the development of an encapsulation plant and a spent nuclear fuel repository. Both municipalities formally declared their support for SKB's plans in 2021, prior to the Government's approval decisions. In practice, the formal consultations, financial support to host municipalities and certain environmental organisations and the municipal right to veto are considered to have been very beneficial to the overall quality of engagement and to wider public acceptance of the licensing process for a spent fuel repository. Guided by recommendations from regulators and Government in their reviews of the reactor licensees' RD&D programme, SKB's strategy of involving local communities on a voluntary basis in the siting process for a spent fuel repository has been another important factor.

The Swedish approach to stakeholder engagement and its role in achieving wide acceptance for the siting process was recognised as part of the overall good practice relating to the KBS-3 programme identified in the 2023 ARTEMIS review.

G.3.1.3 Consulting contracting parties

Sweden has ratified the Convention on Environmental Impact Assessment in a Transboundary Context (the Espoo Convention). The purpose of the Convention is to seek cooperation to prevent transboundary environmental effects and it imposes a requirement to informing neighbouring countries and the general public about planned activities that might cause environmental effects. The provisions of the Convention are mainly implemented in the Swedish Environmental Code by means of requirements for consultation relating to the production of Environmental Impact Assessments (EIA). The Environmental Code specifies that if another country may be affected, the responsible authority designated by the Government shall inform the competent authority in that country about the planned activity. The country concerned and its citizens who may be affected should be given the opportunity to take part in the consultation process. The Government has designated the Swedish Environmental Protection Agency to be responsible for this task.

Sweden invited all countries around the Baltic Sea for a joint consultation meeting in March 2016 regarding SKB's KBS-3 licence application under the Environmental Code, in accordance with Article 5 of the Espoo Convention. The parties had previously been provided with information, compiled by SKB, and were given the opportunity to submit comments relating to the assessment of the environmental impacts of the project, covering both the planned encapsulation plant and the planned geological disposal facility for spent nuclear fuel. A record of the process, including statements from neighbouring countries and SKB's responses to the issues raised, was submitted to the Land and Environment Court as part of the scrutiny of the licence application under the Environmental Code.

As a Member State of the European Union, Sweden is also required to apply Article 37 of the Euratom Treaty. This Article obliges each Member State to provide the Commission with general data relating to any plan for the disposal or discharge of radioactive waste in whatever form to enable a determination to be made on whether implementation of the plan is liable to result in radioactive contamination of the water, soil or airspace of another Member State. Information regarding the planned encapsulation plant and geological disposal facility for spent nuclear fuel will be submitted at the appropriate time to the Commission in accordance with Article 37.

G.3.2 Measures taken by the licence holders

All planned major facilities for spent fuel and radioactive waste management, including repositories, will be sited, constructed and operated by SKB. The supporting RD&D programme is also run by SKB. The following activities have recently been carried out or are in progress:

- The RD&D programme has been reported on every third year since 1986. The most recent RD&D report was submitted to SSM in September 2022.
- Consultations and an EIA for the planned encapsulation facility and repository for spent nuclear fuel began formally in 2002, but in practice started as part of SKB's siting programme in the mid-1990s. The consultations were concluded in May 2010.
- Consultations and an EIA for the planned extension of the final repository for short-lived radioactive waste, SFR, began in 2010 and a licence application was submitted to SSM in December 2014.

A summary of the siting process and related consultations in respect of the planned repository for spent nuclear fuel was provided in Sweden's Fifth National Report published in 2014.

G.3.3 Regulatory control

There are no current programmes or processes related to the siting of facilities for management of spent nuclear fuel in Sweden. Regulatory control under the Act on Nuclear Activities and the Environmental Code in relation to the siting of an encapsulation facility and a geological disposal facility for spent fuel has been described in previous national reports under the Joint Convention. This process is now considered complete following decisions by the Government in January 2022 to approve SKB's plans as part of the licensing process for these facilities.

G.3.4 Conclusion

Sweden complies with the obligations of Article 6.

G.4 Article 7: Design and construction of facilities

Each Contracting Party shall take the appropriate steps to ensure that:

(i) the design and construction of a spent fuel management facility provide for suitable measures to limit possible radiological impacts on individuals, society and the environment, including those from discharges or uncontrolled releases;

(ii) at the design stage, conceptual plans and, as necessary, technical provisions for the decommis sioning of a spent fuel management facility are taken into account;

(iii) the technologies incorporated in the design and construction of a spent fuel management facility are supported by experience, testing or analysis.

G.4.1 Regulatory requirements

Regulatory requirements in Sweden for limiting the possible radiological impact on individuals, society and the environment, including impacts from discharges or uncontrolled releases, are based on the provisions contained in the Act on Nuclear Activities, the Radiation Protection Act and the Environmental Code.

G.4.1.1 Suitable measures to limit radiological impact

SSM's regulations (SSMFS 2018:1) regarding radiation safety in association with licensed activities involving ionising radiation state that there must be defence in depth, adapted to nature of the activity and involving the application of several consecutive technical, organisational and administrative measures, to counter the occurrence and limit the development of events and conditions that are of significance to radiation safety. Such measures should also be designed to maintain the effectiveness of the barriers placed between a radiation source and workers, the general public and environment. All facilities, premises and locations where licensed activities are carried out must be designed so that radiological exposure of the workforce from ionising radiation, as well as the dispersal of radioactive material, can be limited and measured. Moreover, their design must be such that release of radioactive material to the environment is limited and can be monitored as far as is reasonably practicable so that exposure of the public to ionising radiation is avoided. Results from monitoring of releases to air and water must be documented and reported.

SSM's general regulations (SSMFS 2008:1) concerning safety in nuclear facilities provide more detailed requirements that apply to the construction, operation and decommissioning of all nuclear installations other than nuclear power plants (see section G.1.1.2), including facilities for the treatment, storage and disposal of spent fuel and radioactive waste. A basic requirement is that radiological accidents shall be prevented through a basic facility-specific design that incorporates multiple barriers as well as a facility-specific defence in depth system. The defence in depth shall be achieved by ensuring that:

- the design, construction, operation, monitoring and maintenance of a facility is such that abnormal events, incidents and accidents are prevented;
- multiple devices and measures exist to protect the integrity of the barriers and, if the integrity should be breached, to mitigate the ensuing consequences; and
- any release of radioactive substances as a result of extreme events, incidents and accidents is either prevented or, if not possible, controlled and mitigated through devices and prepared measures.

Further requirements on design and construction for limiting radiological impact associated with geological disposal facilities are defined in specific regulations (SSMFS 2008:21 and SSMFS 2008:37) regarding safety and radiological protection objectives for the final disposal of nuclear material and nuclear waste. Safety after the final closure of a repository shall be maintained through a system of passive barriers, each of which should work in one or more ways to contain, prevent or delay the dispersal of radioactive material, either directly or indirectly through protecting other barriers in the disposal system. The barrier system should be able to withstand the conditions, events and processes that may affect the function of individual barriers and should be designed and implemented with regard to Best Available Technique (BAT). The objective is to ensure that all reasonable measures to assure the protective capability of a disposal facility are considered in all stages of its development, operation and final closure.

G.4.1.2 Conceptual plans and provisions for decommissioning

The Act on Nuclear Activities establishes that the holder of a licence for nuclear activities is responsible for the safe decommissioning of their facilities.

The Act on Nuclear Activities also states that licence holders of nuclear power plants shall ensure that comprehensive research and development activities are conducted in order to fulfil the requirements concerning decommissioning and waste management. Moreover, all licensees for nuclear activities are responsible for financing the measures needed to manage and dispose of nuclear waste and spent nuclear fuel as well as to decommission and dismantle their facilities.

Regulations (SSMFS 2008:1) concerning safety in nuclear installations contain requirements relating to the development and maintenance of decommissioning plans for nuclear facilities, stating that safe decommissioning must be taken into account when designing a facility and that conceptual plans for decommissioning shall be made available prior to construction and kept under review thereafter (see also section L.1.1).

G.4.1.3 Technology supported by experience

General regulations (SSMFS 2008:1) concerning safety in nuclear installations incorporate specific requirements regarding design and construction. A facility must be designed to:

- be able to withstand component and system failures;
- have reliability and operational stability;
- be able to withstand events or conditions that can affect the installation's barriers or safety functions; and
- enable maintenance, inspection and testing of those systems, components and equipment that are relevant to safety.

Design principles and design solutions must be tested under conditions representative of those that may occur during the intended use of a facility. If this is not practicable, they must be tested or assessed in a manner that demonstrates that they have the durability, reliability and operational stability required to be able to fulfil their function and importance to the safety of the facility. Consideration must also be given to the capability of operational personnel to monitor and manage the facility under normal operational conditions, as well as during abnormal events, incidents and accidents that may occur.

With regard to the design and construction of a repository, it is clear that the scope for testing and learning from experience is limited, especially in relation to the timescales for safety performance after its final closure. This places particular emphasis on the evidence base for demonstrating, as noted above, good understanding of the conditions, events and processes that may affect the function of individual barriers in the disposal system, and that all reasonable measures have been considered to assure its protective capability.

G.4.2 Measures taken by the licence holders

G.4.2.1 Suitable measures to limit radiological impact

The safety philosophy applied in the design of all Swedish nuclear facilities is based on the principles of defence in depth and of using multiple barriers to prevent the unplanned release of radioactive material to the environment. Facilities are designed to ensure that releases of radioactive material in normal operation are limited as far as is reasonably practicable.

This safety philosophy underpins the design and planned construction of the encapsulation facility and final repository for spent fuel according to the KBS-3 system.

G.4.2.2 Conceptual plans and provisions for decommissioning

Implications of reactor decommissioning for intermediate storage of spent fuel

The first stage when decommissioning nuclear power plants comprises the removal of reactor internals and defueling, ultimately involving the transport of all remaining spent fuels from temporary storage at the reactor site to the central interim storage facility, Clab, which is operated by SKB. Dismantling and demolition of fuel storage pools at the reactor sites are planned to be undertaken as part of the overall programme of work defined by the power plant licensee.

Emptying of the final cores is also dependent on the capacity of Clab to receive the spent fuel. The closure of several nuclear power plants in the period 2016–2021 resulted in an increased demand to receive spent fuel at Clab to accommodate the complete unloading of the reactors in a timely manner. This required careful planning of deliveries of spent fuel so that reception at the interim storage facility could progress without significant delay in defueling or other aspects of decommissioning at the nuclear power plants.

In the 2040s, when it is planned that the most modern reactors will be decommissioned, the capacity of Clab is not assumed to be a limiting factor. This is because fuel will start to be encapsulated and transported to the spent fuel repository and thereby free up space in the interim storage pools.

Decommissioning of Clink
The decommissioning plan for the combined interim storage and spent fuel encapsulation facility (Clink) was updated by SKB in 2013 in conjunction with compiling supplementary documentation for its licence application. SKB will formally update the plan when seeking SSM's approval of the PSAR, which is required for starting the construction of the encapsulation plant. Clink will be decommissioned when all spent nuclear fuel has been encapsulated and disposed of in the spent fuel repository. The timetable depends on when the last nuclear power reactor is permanently shut down. According to current planning, decommissioning of Clink could commence in around 2070 and be concluded within five to seven years. During work on preparing the decommissioning plan for Clink, no reason has emerged as to why the decommissioning should be more complicated than for other nuclear facilities, whose decommissioning is due sooner.

Decommissioning of the spent fuel repository
A preliminary decommissioning plan was prepared for the spent fuel repository and is included in the licence applications under the Act on Nuclear Activities for final disposal of spent nuclear fuel and under the Environmental Code for the KBS-3 system as a whole. The plan was updated in 2017 to harmonise with current regulations and to follow the industry-wide structure for a decommissioning plan. Decommissioning begins after operation is concluded, i.e. when all spent nuclear fuel has been disposed of and the deposition tunnels have been backfilled and sealed. Decommissioning entails closure of the remaining parts of the underground openings and demolition of the surface facilities. No contamination is expected to be present in the facility at the time of closure and therefore demolition can be carried out in the same way as for a conventional facility.

G.4.2.3 Technology supported by experience

General information
The principle of proven technology is broadly accepted and implemented in the design and construction processes for nuclear facilities in Sweden. A reference design has been adopted for the repository barriers for long-term safety that fulfils the design premises for the KBS-3 system as described in the licence applications for Clink and the spent fuel repository (see sections A.10.2 and K.1.1). A feasible approach to production and a quality control programme was also presented.

The licence applications for Clink and the spent fuel disposal facility were developed based on SKB's research, development and demonstration programme, including experience from preliminary safety analyses, starting with the KBS-3 report in 1983 (the first complete safety analysis of the KBS-3 method), followed by SKB-91 (focusing on the technical barriers), SR-97 (focusing on the geological barrier), SR-Can in 2006 and finally SR-Site. The SR-Site assessment has recently been updated and will be used as a reference to the preliminary safety assessment report for the disposal facility, approval of which by SSM is a precondition to start construction.

These iterative safety analyses fulfil multiple roles, including guiding the technical development of the disposal method and site selection, identifying areas requiring further research and determining whether a repository for radioactive waste complies with the regulatory requirements for long-term safety. This stepwise process, including reviews by the authorities, international experts as well as interested stakeholders of both the safety analyses and SKB's RD&D reports, has proven to be an effective way of raising the level of knowledge regarding management and disposal of spent nuclear fuel. It has also provided feedback to SKB's technological development and design work.

The Canister Laboratory, Äspö Hard Rock Laboratory and Multi-purpose Test Facilities have been used for several years to develop technologies for encapsulation and disposal of spent fuel. In addition, certain tests have been conducted and will continue to be undertaken in the future in collaboration with Posiva, SKB's sister organisation in Finland. There are also underground laboratories and laboratories for metallurgical research available in Europe and other parts of the world. In addition, there are industrial facilities in many countries with access to the knowledge and resources needed to carry out development work for SKB.

The experience gained from experiments and tests in these laboratories will continue to be used to take forward the detailed design and construction of the encapsulation plant and repository for spent nuclear fuel. Technological development is moving from basic schematic solutions to solutions tailored to an industrialised process involving stipulated requirements for quality, cost and time. A large proportion of the remaining development work consists of building up a production system with effective quality control.

Design premises
The design premises comprise requirements that the KBS-3 facilities with their barriers must satisfy to ensure safety both during operation and after closure. The design premises specify e.g. what mechanical loads the barriers must be able to withstand, limitations concerning the composition and properties of the barrier materials, acceptable deviations in the dimensions of the barriers and acceptance criteria for the various under-ground openings.

An initial set of design premises and related requirements is specified in the applications for regulatory authorisation to start construction of the spent fuel repository and the encapsulation facility. However, it is not possible to specify from the start all detailed design premises for a given product or process. Requirements, technological developments and safety assessments must instead be defined as the work proceeds. Revisions to the design premises included in the licence applications have been carried out together with Posiva (Posiva SKB report 01). These revisions are being used as input to the preliminary safety analysis report (PSAR) (see section G.5.1) that is being developed by SKB.

The basic principles for evaluating design premises pertaining to several barriers in the spent fuel repository are:
– the design premises shall altogether lead to compliance with requirements related to the safety of the entire spent fuel repository;
– the design premises shall be feasible and verifiable for all the barriers concerned; and
– preference is given to design premises that entail simple, robust and effective solutions.

These principles are used to establish requirements for fuel, canister, buffer, backfill, closure and underground openings in relation to each other. The revised design premises serve as a basis for the preliminary safety analysis reports, which SKB compiles prior to the start of construction of the spent fuel repository and Clink's encapsulation plant. The design premises will be formally presented to SSM when the PSAR is submitted.

Further revision of the design premises will be performed in response to any conditions issued during the licensing process and in conjunction with updating of the safety analysis reports. More detailed specification or re-appraisal of the relative importance of requirements between different systems may also be needed during finalisation of detailed design prior to implementation.

Quality control and inspection
"Quality control and inspection" refers to the measures that need to be taken to provide assurance that the requirements imposed on the facilities during operation and after closure of the spent fuel repository are satisfied. The goal is that the outcome should conform to acceptable values for those properties that contribute to safety and radiation protection.

The production line reports that support SKB's licence applications describe the planned production methods and plans for quality control and inspections in the manufacture and installation of the barriers that assure post-closure safety. The work on quality control and inspection measures will progress as the development of production and testing methods progresses towards full-scale industrialisation. Systems for quality control and inspections will be established and implemented to quality assure the production of the barriers.

Important activities in this process are to:

- establish principles for safety and quality classification;
- establish what aspects are to be quality controlled and quality inspected, when quality control and inspections are to be performed, and by whom, whether first, second or third parties;
- establish and qualify processes, methods, equipment and personnel for manufacturing and installation, testing and inspection; and
- establish the procedures that are to be applied in production to ensure that the KBS-3 repository satisfies quality requirements.

Plans

In the short term, the goal of technological development is to ensure that the technology needed for starting construction of the spent fuel repository and encapsulation plant is available. In the case of the spent fuel repository, this development mainly refers to investigation methods and technology for construction of the repository accesses. Documentation is also needed to describe how matters relating to nuclear safety will be addressed prior to the start of trial operation, i.e. during construction of accesses, the central area and the first deposition area. This document is called "Suus" (Swedish acronym for "safety during construction of the final repository") and is being prepared by SKB prior to the start of construction. Technological development is also needed for the various systems that must be in place in the repository area, descriptions of which support the PSAR that will be presented by SKB in support of its application for approval prior to starting construction.

After submission of the PSAR, there are several milestones during the design and construction of the planned facilities where key inputs are needed from technological development. These include the following:

- When starting the detailed design of the encapsulation plant, the component technical systems must have already passed their own detailed design phase. When starting the detailed design of the canister manufacturing facility, the technology and methods for production of canisters must be fully developed and shown to work on an industrial scale.
- Prior to the start of construction of the encapsulation plant and canister manufacturing facility, the systems that have undergone detailed design must have been procured and plans for qualification established and incorporated into the plans for construction.
- Before detailed design of the spent fuel repository's accesses can start, the observational method for underground construction must be implemented and a detailed characterisation programme for ramp and shafts must be available.
- Below the level of the top seal on the spent fuel repository, the design premises stipulate requirements for the permeability of the installations intended to seal the repository at depth. This in turn imposes other requirements for rock works below the level of the top seal. It must then be verified that excavation methods, inspection programmes and methods for rock support and grouting satisfy these requirements.
- Detailed design of the production of buffer and backfill shall be completed as a basis for the detailed design of the production building at the repository site.
- Installation methods and methods for testing and inspecting buffer and backfill must have been designed in detail and verified prior to detailed design of the deposition area.

Technical systems that are needed in the combined storage facility and encapsulation plant, Clink, must have been purchased, fabricated, installed, tested and qualified prior to commissioning tests of the KBS-3 system. Furthermore, before commissioning tests can be conducted, methods and sub-processes for excavation of deposition tunnels and deposition holes in the repository must have been devised and qualified. The deposition system must also be put into non-active operation before commissioning tests can be undertaken, which means that technical systems for handling and transport of canisters, buffer and backfill must have been fabricated, installed and tested. The systems will undergo integration tests to ensure that equipment and technical systems are fully compatible before conducting the commissioning tests. Qualification of processes with associated equipment, personnel and suppliers must have been completed and documented. A comprehensive system must also be implemented for quality control and inspection of canister manufacturing, production of buffer and backfill components, handling and installation of canister, buffer and backfill, and the process of underground construction.

A renewed safety analysis report (SAR), reflecting the facilities as they have been constructed, must be submitted to SSM for approval before trial operation of Clink and the spent fuel repository. Subsequently, before regular operations, a supplemented SAR must also be prepared and submitted to SSM (see section G.5.1). Results and experience from commissioning tests and trial operation in each facility must be presented in this updated SAR. This means that the production reports relating to technology deployment will be updated using results and experience from full-scale tests, qualification work and commissioning tests.

G.4.3 Regulatory control

Approval for increasing the interim storage capacity for spent fuel at the Clab facility from 8,000 to 11,000 tonnes was originally included in the joint application for a final repository for spent nuclear fuel. Planned safety-enhancing measures for the existing fuel storage pools, in particular with regard to the associated increase in residual heat generation, were considered as part of the overall application. Following the Government's decision in August 2021 to separate out approval of the change in storage capacity from the remainder of the joint licence application, design measures specific to residual heat removal for the storage pools under potential accident conditions have been scrutinised by SSM.

In particular, SSM identified a need to assess and compare alternative approaches to providing emergency cooling for the prevention of fuel damage within the storage basins, as support for SKB's proposed design. Satisfactory resolution of this question was also established by the Land and Environment Court as one of the conditions attached to the licence issued under the Environmental Code in June 2022. In June 2023, SSM approved SKB's preliminary safety report (PSAR), which incorporated the required comparison of alternative safety-enhancing measures. The comparison reflected the projected timeframe when reserve cooling capacity would be required in the event of an accident, the probability that such measures would be required and the balance of cost and benefit. SSM's decision also took account of the fact that Clab is an existing facility, which limits the possibilities for changes in design without introducing new risks.

A description of the history of regulatory review and assessment of SKB's design of the planned encapsulation facility and geological disposal facility for spent nuclear fuel has been provided in Sweden's previous national reports under the Joint Convention. SSM will be engaged over the coming years in reviews of the detailed design specifications and safety reporting submitted by SKB, prior to authorisation of the start of construction, active trial operation and routine operation of these facilities, in order to verify continued compliance with regulatory requirements and with the Government's licence conditions under the Act on Nuclear Activities issued in January 2022. Some optimisation and refinement of design details is expected during the construction phase and industrialisation of the manufacture of repository components, but a condition of the licences under both the Environmental Code and the Act on Nuclear Activities is that facilities should be constructed and operated substantially in accordance with the documentation submitted as a basis for the licence applications.

G.4.4 Conclusion

Sweden complies with the obligations of Article 7.

G.5 Article 8: Assessment of safety of facilities

Each Contracting Party shall take the appropriate steps to ensure that:

(i) before construction of a spent fuel management facility, a systematic safety assessment and an environmental assessment appropriate to the hazard presented by the facility and covering its operating lifetime shall be carried out;

(ii) before the operation of a spent fuel management facility, updated and detailed versions of the safety assessment and of the environmental assessment shall be prepared when deemed necessary to complement the assessments referred to in paragraph (i).

G.5.1 Regulatory requirements

G.5.1.1 Assessment of safety

Requirements for safety assessment, safety review and reporting are specified in SSM's regulations (SSMFS 2008:1) concerning safety in nuclear facilities. These apply to the operation of all types of nuclear installations other than nuclear power plants (see section G.1.1.2), including facilities for treatment, storage and disposal of spent fuel and radioactive waste. Basic provisions regarding safety assessment and review can be summarised in the following paragraphs.

Safety analysis
Analyses of conditions of importance for the safety of a facility shall be carried out before a facility is constructed and taken into operation. The analysis shall subsequently be kept up to date. The safety analyses shall be based on a systematic inventory of events, event sequences and conditions that could lead to a radiological accident.

Safety report
A preliminary safety report (PSAR) shall be prepared before a facility is allowed to be constructed to demonstrate how relevant safety requirements are met. The safety report (SAR) shall be updated to reflect the plant as it has been constructed, analysed and verified before trial operation of the facility is allowed to start. The SAR and associated documentation of operating limits and conditions must subsequently be supplemented based on the experience from a programme of commissioning tests before the facility is allowed to be taken into routine operation. At each of the above steps, the safety report shall be evaluated and approved by SSM.

The safety report must subsequently be kept up to date. For example, plant modifications are to be assessed against conditions described in the SAR. Plans for substantial changes must be reflected in a new PSAR, which must be approved by SSM before being used as the basis for trial operation of the modified facility. New safety standards and practices, which have been assessed by the licensee and found applicable, shall be documented and inserted into the SAR as soon as associated modifications or other plant measures have been performed.

The content of the safety report is specified in the regulation SSMFS 2008:1. All plant structures, systems and components of importance for the defence in depth are to be described in the SAR.

Safety review
A safety review shall confirm that all applicable safety-related aspects have been taken into account and that appropriate regulatory requirements are met with respect to the safety in design, function, organisation and activities of a facility. The review must be carried out systematically and be documented. A first safety review is to be performed within those parts of the organisation responsible for the specific issues under consideration ("primary review"). A second safety review shall then be performed by an internal safety review function established for this purpose, which has an independent position relative to those parts of the organisation responsible for design and operation.

Safety programme
After it has been taken into operation, the safety of a facility shall be continuously analysed and assessed in a systematic manner. Any need for improvement regarding safety measures, engineering or organisational issues that arises as a result of such analyses and assessments shall be documented in a safety programme. The safety programme must be updated on an annual basis.

Periodic safety review of facilities
At least once every ten years, licensees of nuclear facilities are required to perform a periodic safety review (PSR), i.e. an integrated analysis and assessment of the safety of the facility.

Modifications
A safety review shall be performed for engineering or organisational modifications to a facility that can affect the conditions specified in the safety report and essential modifications to the report made accordingly. SSM must be notified before such modifications may be included in the safety report. SSM has the power to impose additional requirements or conditions with respect to the modifications.

Post closure safety
Additional requirements concerning the long-term radiation protection and nuclear safety of a disposal facility are stipulated in the regulations (SSMFS 2008:21) concerning safety in connection with the disposal of nuclear material and nuclear waste and in the regulations (SSMFS 2008:37) and general advice on the protection of human health and the environment in connection with the final management of spent nuclear fuel and nuclear waste.

The regulations SSMFS 2008:21 contain requirements for the design of the repository, barrier functions and safety reporting. The safety assessment for a disposal facility shall address all features, events and processes that might lead to the dispersion of radioactive substances after closure. Such safety assessments are required as a basis for applications for construction, operation and closure of a disposal facility. The safety assessment must cover the length of time for which barrier functions are required, though at least ten thousand years.

The regulations SSMFS 2008:37 comprise basic requirements for protection of human health (expressed as a risk target), general environmental protection goals and the application of optimisation and Best Available Technique (BAT). The corresponding guidance advises on reporting for different time periods after closure, selection of scenarios and calculation of risk, as well as addressing uncertainties and risk dilution.

G.5.1.2 Environmental assessment

An environmental impact assessment (EIA) shall be prepared for a licence application under the Act on Nuclear Activities. The same applies for licensing under the Environmental Code.

The Environmental Code contains detailed requirements regarding what an EIA should address and how it should be prepared.

The purpose of an EIA is to establish and describe the direct and indirect impacts of a planned activity or measure, as listed below. An environmental impact statement must include the following information:

- a description of the planned activity or course of action with details of its location, design and scope;
- a description of the measures that are planned with a view to avoiding, mitigating or remedying adverse effects, for example action to prevent the activity or measure leading to an infringement of an environmental quality standard;
- the information needed to establish and assess the main impacts on human health, the environment and management of land, water and other resources that the planned activity or course of action is likely to have;
- a description of possible alternative sites and alternative designs, together with a statement of the reasons why a specific option was chosen as well as a description of the consequences if the activity or measure is not implemented; and
- a non-technical summary of the information.

G.5.2 Measures taken by the licence holders

G.5.2.1 Safety assessments

Background

Some key aspects of the assessment work undertaken by SKB, including the role of external peer reviews, were described in Sweden's Fifth National Report according the Joint Convention, published in 2014. SKB is currently developing the basis for assessment for the PSAR for the spent fuel repository and Clink, which will be submitted to SSM. The Government's licence stipulates that the PSAR must be approved by SSM before starting the construction.

Interim storage facility, Clab

SSM identified areas of improvement relevant for the safety analysis report of Clab, based on the initial review of the licence application for an encapsulation plant for spent fuel to be co-located with Clab. SSM subsequently (2013) issued an improvement notice to SKB to update its safety analysis report in areas relating to safety requirements, safety analysis and safety classification. As a result, SKB has modernised the safety analysis report for Clab in several steps between 2016 and 2020.

The safety analysis has most recently been supplemented with a probabilistic safety assessment, including a human reliability analysis of all safety-related manual actions. The basic safety concept of Clab relies on passive and inherent safety with extensive grace periods before any action is needed to avoid adverse conditions. The human reliability analysis strengthens the safety case for relying on manual actions to achieve a safe state in case of incidents or accidents at the facility. The safety demonstration has also been extended to include a more comprehensive risk assessment of beyond design basis accidents. SKB considers that the safety analysis, which is based on IAEA and WENRA guides for design extension conditions, demonstrates that safety margins in the design of the facility are such that sequences leading to significant fuel degradation are practically eliminated.

Combined spent fuel storage and encapsulation facility, Clink
SKB's updated (January 2015) safety analysis for the combined encapsulation plant and storage facility, Clink, was undertaken in response to SSM's request for an improved system description. The scope was also extended to account for the safety implications of increasing the interim storage capacity from 8,000 to 11,000 tonnes of spent fuel. Supporting documents to the licence application under the Act on Nuclear Activities, including the EIA, were correspondingly updated, as were supporting materials to the licence application according to the Environmental Code. The design of the facility and description of how the requirements are met will gradually be clarified and specified during the licensing process.

As part of the consultation process undertaken by the Swedish Environmental Protection Agency, in accordance with Article 5 of the Espoo Convention, SKB provided an account of its assessment of the consequences of planned and potential discharges during operation.

Repository for spent nuclear fuel
More in-depth assessments and analyses of some aspects of the safety assessment SR-Site, based on SKB's reference design for disposal according to the KBS-3 method at Forsmark, were reported to SSM between 2013 and 2015 in response to requests for supplementary information during the regulatory review of the licence application under the Act on Nuclear Activities.

Furthermore, SKB submitted in April 2019, as part of the licensing process and at the Government's request, the results from additional theoretical and experimental studies relating to potential copper corrosion mechanisms, together with an updated analysis of their implications for radiation safety (SKB Report 2010, TR-19-15, can be downloaded at www.skb.se). This was partly in response to the Land and Environment Court's conclusion that further documentation was required to clarify the long-term protective function of the copper canisters in the KBS-3 disposal concept for the repository to be considered permissible in accordance with the provisions of environmental legislation. From SKB's perspective, however, the work was already planned as part of the updated supporting material for the PSAR to be submitted to SSM as part of an application to commence construction of the repository. The central conclusions of SKB's safety analysis remain unaltered, i.e. that a KBS-3 repository capable of fulfilling long-term requirements for radiation protection and safety can be built and safely operated at the Forsmark site.

G.5.3 Regulatory control

G.5.3.1 Clab
As noted in section G.4.3, SSM assessed and approved SKB's preliminary safety report (PSAR) relating to the safety implications of an increase in the licensed storage capacity from 8,000 to 11,000 tonnes of spent nuclear fuel. A primary area of focus in the safety assessment was a comparison of the implications of alternative approaches to the provision of emergency cooling for preventing fuel damage within the storage basins. SSM's decision to approve the PSAR took account of the fact that the storage will take place within the existing facility, which limits the possibilities for changes in design without introducing additional risks.

In February 2024, SSM approved an updated safety report (FSAR), submitted by SKB in accordance with the Government's licence conditions for increased storage capacity. This was a necessary step to enable SKB to begin storing fuel within Clab beyond the previous limit of 8,000 tonnes, as part of SKB's trial operation under their revised Government licence and in accordance with requirements outlined in G.5.1.1. The next step is for SKB to submit a supplemented safety report describing lessons learned from the trial operational period, in order for SSM to determine whether the facility can go over to routine operation.

G.5.3.2 KBS-3 disposal system
Some key aspects of the regulatory review activities undertaken by SSM, including an account of the parallel processes for licensing under the Swedish Environmental Code and the Act on Nuclear Activities, were described in Sweden's previous national reports under the Joint Convention published in 2014, 2017 and 2020. This information included a summary of the key findings from SSM's review of SKB's licence applications for the combined spent fuel storage and encapsulation facility and the planned repository for spent fuel as well as SSM's response to Government's request for further comment and clarification of matters raised by stakeholders.

At the time of preparing this report, SSM was preparing to review the documentation, including PSAR, that SKB must submit before beginning construction of both the encapsulation plant and repository for spent nuclear fuel, following the Government decision in January 2022 to grant licences for these facilities under the Act on Nuclear Activities. Prior to that, however, hearings related to the formal licensing of the KBS-3 disposal system under the Environmental Code are planned to take place in the Land and Environment Court in September 2024.

G.5.4 Conclusion

Sweden complies with the obligations of Article 8.

G.6 Article 9: Operation of facilities

Each Contracting Party shall take the appropriate steps to ensure that:

(i) the licence to operate a spent fuel management facility is based upon appropriate assessments as specified in Article 8 and is conditional on the completion of a commissioning programme demonstrating that the facility, as constructed, is consistent with design and safety requirements;

(ii) operational limits and conditions derived from tests, operational experience and the assessments, as specified in Article 8, are defined and revised as necessary;

(iii) operation, maintenance, monitoring, inspection and testing of a spent fuel management facility are conducted in accordance with established procedures;

(iv) engineering and technical support in all safety-related fields are available throughout the operating lifetime of a spent fuel management facility;

(v) incidents significant to safety are reported in a timely manner by the holder of the licence to the regulatory body;

(vi) programmes to collect and analyse relevant operating experience are established and that the results are acted upon, where appropriate;

(vii) decommissioning plans for a spent fuel management facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility, and are reviewed by the regulatory body.

G.6.1 Regulatory requirements

SSM's general regulations (SSMFS 2008:1) concerning safety in nuclear installations establish legally binding requirements relevant to all obligations under Articles 9 and 16. These requirements are summarised below.

G.6.1.1 Licence for facility operation

A comprehensive preliminary safety report shall be prepared by the licensee and assessed by SSM prior to starting construction of a nuclear facility (see section G.5.1.1). Following construction, the safety report shall be updated (FSAR) to reflect the facility as constructed, analysed and verified through inspection and non-active tests before active commissioning and trial operation are permitted. The safety report must subsequently be supplemented as necessary based on experience from a programme of commissioning tests before the facility is permitted to be taken into routine operation. At each of the above steps, the safety report shall be evaluated and approved by SSM.

The safety report must subsequently be held up to date and revised as necessary to reflect modifications or changes to safety standards and practices.

G.6.1.2 Operational limits and conditions (OLCs)

Documented and up-to-date Operational Limits and Conditions (OLCs) are required for all facilities, containing information as specified in an appendix to the regulations. Preliminary OLCs must be defined by the licensee and approved by SSM prior to active commissioning and trial operation of the facility. They must subsequently be updated, alongside the safety report, to reflect experience from commissioning tests and any subsequent operational experience and assessments.

The OLCs must, together with the operating procedures, ensure that the conditions postulated in the safety report are maintained during the operation of the facility. The OLCs must be subjected to a two-fold safety review by the licensee (see section G.5.1.1) and submitted to the regulatory authority for approval. The licensee must notify the regulatory authority about any proposed changes to OLCs after such changes also have been the subject of a two-fold safety review.

G.6.1.3 Programmes for collecting and analysing operating experience

Suitable, verified and documented procedures are required for all operational states, including accidents. The procedures for operability verification and those used in operational states other than normal operation shall be subjected to a two-fold safety review by the licensee. Procedures for maintenance that are important for safety are also covered by this requirement. Maintenance programmes are to be documented. Inspection and testing of mechanical components must be carried out according to qualified methods and verified procedures.

G.6.1.4 Engineering and technical support

The licensee shall ensure that appropriate personnel are available with the competence and suitability necessary to undertake those tasks that are important for safety, and ensure that these qualifications are documented. A long-term staffing plan is required. Use of contractors, as opposed to licensee's personnel, should be carefully considered in relation to developing and sustaining adequate in-house professional skills. The necessary competence should always be available in-house for procuring contractors and for managing and evaluating the results of contractors' work that is of importance for safety.

G.6.1.5 Reporting of incidents in a timely manner

The general regulations (SSMFS 2008:1) concerning safety in nuclear installations include a specific chapter about reporting requirements and a separate appendix specifying these requirements for various types of events. These can be summarised as follows:

- Reporting without delay: emergency alarm events and events and conditions in category 1 (see below).
- Reporting within 16 hours: INES events of Level 2 or higher.
- Reporting within 7 days: a comprehensive investigation report about alarm events or events and conditions in category 1.
- Reporting within 30 days: a comprehensive investigation report of events and conditions in category 2.

In addition, there are requirements for weekly reporting of the operational state and the occurrence of any abnormal events or disturbances, as well as for a comprehensive annual report summarising all experience that is important for the safety of the plant. The regulation specifies the content of the different reports; further general guidance on the fulfilment of reporting requirements, including implementation of a graded approach, is provided in support of the regulations. One of the fundamental regulatory requirements concerns the actions to be taken by the licensee in the event of deficiencies in barriers or in the defence in depth system. These actions include first assessment, adjustment of the operational state, implementation of necessary measures, performance of safety reviews, and reporting to SSM.

In another appendix to the regulations, events and conditions related to deficiencies in barriers and defence in depth are identified that require different responses depending on the category of events. Three categories of incident are defined:

- Category 1: Observed severe deficiency in one or more barriers or in the defence in depth system or an otherwise well-founded suspicion that safety is severely threatened. (In such cases, the facility must be brought to a safe state without delay.)
- Category 2: Observed deficiency in a barrier or in the defence in depth system, considered less severe than that referred to in category 1, or an otherwise well-founded suspicion that safety is threatened. (In such cases, the facility is allowed to continue operation during the period of time when corrective action is being taken and under certain limitations and controls.)
- Category 3: Temporary deficiency in the defence in depth system arising when an event or condition is corrected, which in the absence of such measures could lead to a more severe condition, and is documented in the facility's operational limits and conditions.

In all three cases, corrective measures must be subjected to a two-fold internal safety review by the licensee. The results of these reviews shall be submitted to SSM. There is no requirement to submit a specific report to SSM for category 3 incidents, but only to provide a compilation of these events in the licensee's annual report.

G.6.1.6 Programmes for collecting and analysing operating experience

The licensee shall ensure that experience from its own facilities and from similar activities in other relevant facilities is continuously analysed, used and communicated to the personnel concerned. Furthermore, all events and conditions that are detected and that are important for safety must be investigated in a systematic manner to determine sequences and causes, as well as to establish any actions required to restore safety margins and prevent recurrence. The results of such investigations are to be disseminated within the organisation as well as being submitted to SSM and shall contribute to the continuous improvement of safety at the facility. Furthermore, according to SSM's regulations (SSMFS 2008:21) on the disposal of nuclear material and nuclear waste, it is the responsibility of the licensee, for as long as a disposal facility is in operation, to keep itself and SSM continuously informed of conditions that can be of importance to the assessment of disposal facility safety, including implications for post-closure radiological safety.

G.6.1.7 Decommissioning plans

Decommissioning plans for a radioactive waste management facility other than a disposal facility are prepared and updated as necessary using information obtained during the operating lifetime of that facility. These plans are reviewed by the regulatory body.

Regulations set out specific requirements relating to decommissioning, including:

- a preliminary plan for the future decommissioning of the facility, to be compiled before construction of such facility;
- safety and radiation protection at the time of decommissioning shall be taken into account during the construction of a facility and before changes are made to an existing facility;
- the preliminary plan shall be supplemented and kept up to date for the duration of the facility's operation and shall be reported to SSM every ten years;
- during the operation of a facility, observations and events that have significance for planning and execution of decommissioning shall be documented on an ongoing basis; and
- when a decision has been made on final shutdown of a facility within a certain period of time, an integrated analysis and assessment of how safety is to be maintained during the time remaining until the facility's closure shall be conducted without delay. An analysis and assessment must also be performed of organisational changes during the closure period and personnel requirements during decommissioning. The analyses, assessments and measures emanating from these must be documented and reported to SSM.

See also section F.6.1.

G.6.2 Measures taken by the licence holders

G.6.2.1 Licence for facility operation

SKB anticipates that authorisation to start operations of its planned facilities for the final management of spent fuel (the combined encapsulation plant and spent fuel storage facility, Clink, as well as the spent fuel repository) will follow the requirements specified in SSM's regulations. A full commissioning programme will be developed during the facility's construction and submitted to SSM for approval alongside the safety report for the completed facilities, taking into account results from inspections and non-active tests.

G.6.2.2 Operational limits and conditions (OLCs)

The operational limits and conditions for nuclear facilities are described in the OLC, a document considered to be one of the cornerstones of governing and regulating the operation of nuclear activities in Sweden. Each OLC is facility-specific and subject to approval by SSM as part of the licence conditions. In the case of spent fuel management, this concerns arrangements for the handling of spent fuel at nuclear power plants as well as the Clab interim storage facility.

The original OLC for each facility is derived from the safety analyses in the SAR, in which the behaviour of the facility is described. Corrections and updates take place when new and better knowledge is available, from either research, tests or operational experience. Suggestions for changes in the OLC are reviewed carefully from a safety viewpoint at different levels in the operating organisation and are ultimately approved by the regulatory body before being included in the revised document.

The fact that the OLC is reviewed and revised regularly has contributed to making it a living document. It is also part of the quality and management system and used frequently by the operations staff. An essential general clause of the OLC states "*…should any uncertainty arise concerning the interpretation of the text, the general purpose of the OLC shall provide guidance. This means that the facility, in all indefinite situations, shall be maintained in, or brought to, a safe state.*" Another component of the OLC is the descriptive background to the document. The account of the background is an important means of preserving the knowledge and experience of those who participated in the original production of the OLC and for communicating this information to new staff.

Modified and maintained equipment must pass an operability test to verify that the equipment fulfils specified operational requirements before being accepted for use in continuous operation.

G.6.2.3 Established procedures

All activities that directly affect the operation of the facility are governed by different procedures covering normal operation, emergency operation and functional testing. Maintenance activities, undertaken under a maintenance programme approved by the licence holder, are also largely accomplished according to procedures. These are, however, not always as detailed as the operating procedures, in which activities are described in step-by-step sequences. Signing off the completion of steps carried out under the procedures is mandatory in most cases to confirm the completion and facilitate verification.

The development of procedures follows specified directives, which include reviewing the documents, normally by more than one person other than the author, before being approved by the operations manager or someone else at the corresponding level of authority. The same applies to revision procedures. Revision procedures are to be carried out continuously in particular maintenance procedures when new experience is obtained. Emergency procedures have been developed to deal with anticipated operational occurrences and design basis accidents/disturbances.

G.6.2.4 Engineering and technical support

The principles for staffing are reported in section F.2.1.1. Competencies that might not be completely available within the licensee's own organisation at all plants include, for example, expertise and human resources for materials and chemical assessments, radiation shielding and environmental consequence calculations, expertise and resources for software for safety applications, and also process control and measurement techniques. IT functions are normally outsourced, though are still available onsite. The intention is always to possess purchasing competence within the operating organisation, as well as to have capability to evaluate the results of analyses and calculations, etc. that are performed by consultants.

G.6.2.5 Reporting of incidents in a timely manner

There are two main types of licensee event reports (LER). In the case of the more severe one, called an abnormal event, the facility is required to inform SSM within one hour. A final report must be submitted within ten days from the time of the event, and the analysis of the event and appropriate measures to prevent recurrence are subject to approval by SSM. Only a very limited number of events of this category have occurred at Swedish nuclear facilities over the years; none have occurred at the waste management and spent fuel facilities. These events would typically also be of such a level of severity as to warrant reporting in accordance with the International Nuclear Event Scale (INES).

The other type of LER, called a reportable occurrence (RO), is used for less severe events. This type of event is mentioned in the weekly report, which is sent to the regulatory authorities and followed up by a final report within 30 days. The reports are reviewed at different levels of the operating organisation and approved by the operations or production manager before submission.

The front of the standardised report form describes the event and related circumstances in general: identification number, title, reference to the OLC, date of discovery and length of time until corrective actions were completed, conditions at the time of occurrence, system consequences, a contact person at the plant and activities affected by the event. The reverse side of the form gives an account of the event, using the following headings:

- event sequence and operational impact;
- safety significance;
- direct and root causes;
- planned/decided measures; and
- lessons learned from the event.

If the description of the event is extensive, additional pages may be attached to the form. Reports are also required, in accordance with the OLC, when the permitted levels of activity release from the facility are exceeded, or in the event of unusually high radiation exposure to individuals. These types of non-routine reporting are primarily directed towards SSM.

G.6.2.6 Programmes for collecting and analysing operating experience

The objective of the analysis and feedback programme concerning operating experience is to learn from one's own and others' experience and thus prevent reoccurrence of events, particularly events that might affect the safety of the facility. The operating experience feedback process consists of a wide variety of activities within the plant organisation as well as externally.

G.6.2.7 Decommissioning plans

Before a facility may be constructed, a decommissioning plan is to be drawn up for the future decommissioning of the facility (see also section G.4.2.2). The degree of detail in the plan increases as the time for decommissioning approaches. The plan must be supplemented and kept up to date for as long as the facility is in operation and is submitted to SSM together with the periodic safety reviews.

The decommissioning plan comprises a facility description, a plan for the decommissioning activities, and plans for management and disposal of radioactive waste. Before a dismantling operation may commence, the decommissioning plan must be supplemented and submitted to SSM for approval. The safety analysis report for the facility must be supplemented and revised in accordance with the post-operational activities planned at the facility. The revised safety analysis report is reviewed and approved by SSM.

G.6.3 Regulatory control

G.6.3.1 Operational limits and conditions

SSM routinely reviews applications from licensees for changes to the OLCs at licensed facilities as well as for temporary exemptions from the authorised OLCs. Assessments are made regarding how the proposed changes or exemptions contribute to the risk profile of the facility, based on the application and supporting information provided by the licensees and associated safety analyses.

The most significant modification to OLCs for spent fuel management facilities assessed by SSM in the period covered by the present report relates to SKB's application to start test operation of Clab beyond the previously authorised storage capacity of 8,000 tonnes, in accordance with the Government's revised licence conditions for the facility. These changes were notified to SSM together with the corresponding updated safety report (FSAR) as described in section G.5.3.1. SSM's approval of the PSAR for the start of trial operation was issued in February 2024.

G.6.3.2 Procedures

Operational and maintenance procedures are normally not reviewed by SSM. SSM would only request that a procedure be submitted for review in connection with event investigations.

One specific area of interest continues to be the inspection and maintenance programme in relation to storage pools at the Clab storage facility. SSM has required SKB to develop and implement a control programme to ensure that possible structural changes are detected and evaluated in time. Surveillance of SKB's programme for rock and concrete inspections at Clab is undertaken on an annual basis.

G.6.3.3 Incident reporting

Upon receipt at SSM, each licensee event report (LER) is reviewed by the site inspector in charge, who then asks the facility for clarification if necessary. As a matter of routine, all LERs notified to SSM are screened once a week by a permanent group of inspectors and specialists to assess the event, the analysis and the measures taken by the licensees. If there are any regulatory concerns, the issue is brought up at a management meeting and a decision made about any further measures to be taken by SSM.

G.6.3.4 Experience feedback analysis

Regulatory control in this area is achieved through the processes described in sections E.3.2.6 and F. For example, SSM carries out regular planned surveillance of SKB's routine operations and incident follow-up at the Clab interim storage facility. This enables SSM to monitor how the operations team works to transform experiences and lessons into preventative actions and to be proactive in working with safety. The experience feedback programme is also followed up by SSM in connection with specific event investigations and other inspections and reviews.

G.6.4 Conclusion

Sweden complies with the obligations of Article 9.

G.7 Article 10: Disposal of spent fuel

> If, pursuant to its own legislative and regulatory framework, a Contracting Party has designated spent fuel for disposal, the disposal of such spent fuel shall be in accordance with the obligations of Chapter 3 relating to the disposal of radioactive waste.

G.7.1 Regulatory requirements

According to the Act on Nuclear Activities, the following definitions apply:

- spent nuclear fuel which has not been disposed of in a disposal facility is defined as nuclear material; and
- spent nuclear fuel which has been disposed of in a disposal facility is defined as nuclear waste.

Reprocessing is not part of the back end of the nuclear fuel cycle in Sweden (see section C) and the policy and practices for the management of spent nuclear fuel are direct disposal following interim storage for a period of some 30–40 years (see section B).

It is also clearly stated in the general obligations in the Act on Nuclear Activities (section 10) that the holder of a licence for nuclear activities is responsible for ensuring that all measures are taken that are needed for:

- maintaining safety, with reference to the nature of the activities and how they are conducted; and
- ensuring the safe handling and final disposal of nuclear waste arising from the activities or nuclear material arising therein that is not reused.

G.7.2 Measures taken by the licence holders

The practical implication is that spent fuel from Swedish nuclear power plants is treated de facto as high level radioactive waste.

G.7.3 Conclusion

Sweden complies with the obligations of Article 10.

Section H – Safety of Radioactive Waste Management

As stated at the start of section G, the articles of the Joint Convention that specifically relate to the safety of radioactive waste management (Articles 11 to 17, covered in this section) have many similarities to the articles that specifically address the safety of spent fuel management (Articles 4 to 10, covered in section G). To avoid unnecessary duplication, reporting on those matters (primarily regulatory requirements) that are common to both sections G and H is presented in full only in section G. Where appropriate, references are then made from the corresponding parts of section H. Where the Convention's requirements differ between the safety of spent fuel management and safety of radioactive waste management, this is stated in the respective section. The programme for radioactive waste disposal facilities is described in this section, whereas issues relevant to the development of a geological disposal facility for spent nuclear fuel are covered by section G.

H.1 Article 11: General safety requirements

Each Contracting Party shall take the appropriate steps to ensure that at all stages of radioactive waste management individuals, society and the environment are adequately protected against radiological and other hazards.

In so doing, each Contracting Party shall take the appropriate steps to:

(i) ensure that criticality and removal of residual heat generated during radioactive waste management are adequately addressed;

(ii) ensure that the generation of radioactive waste is kept to the minimum practicable;

(iii) take into account interdependencies among the different steps in radioactive waste management;

(iv) provide for effective protection of individuals, society and the environment, by applying at the national level suitable protective methods as approved by the regulatory body, in the framework of its national legislation which has due regard to internationally endorsed criteria and standards;

(v) take into account the biological, chemical and other hazards that may be associated with radioactive waste management;

(vi) strive to avoid actions that impose reasonably predictable impacts on future generations greater than those permitted for the current generation;

(vii) aim to avoid imposing undue burdens on future generations.

H.1.1 Regulatory requirements

H.1.1.1 The general obligations of licence holders

The general legal obligations on licence holders of nuclear power plants and other nuclear facilities regarding the management of radioactive waste are described in section G.1.1.1. As regards other generators of radioactive waste, the Radiation Protection Act (2018:396) stipulates that all those who carry out an activity involving ionising radiation are responsible for ensuring the safe management and final disposal of radioactive waste arising from their activities. The Radiation Protection Act further stipulates that implementation of the polluter pays principle also applies to non-nuclear generators of radioactive waste (such as industry, research and healthcare), in so far as non-public actors may be required to provide financial securities regarding the costs of decommissioning and radioactive waste management from their activities as part of their licence conditions under the Act.

H.1.1.2 Basic provisions and licence obligations

Basic regulatory requirements for the safe management of radioactive waste from nuclear activities are described in section G.1.1.2.

General provisions for the regulation of radiation safety, for activities licensed under both the Act on Nuclear Activities and the Radiation Protection Act (for non-nuclear activities), are specified by SSM (SSMFS 2018:1). By contrast with the more detailed regulations regarding the management of radioactive waste from nuclear facilities (outlined in section G.1.1.2), non-nuclear activities are subject to the general provisions of SSMFS 2018:1 as well as any conditions that may be specified by SSM in relation to licensing under the Radiation Protection Act.

General requirements on all licensed holders or generators of radioactive waste include:

- documentation of a radioactive waste management plan, based on an up-to-date evaluation of alternative management options, indicating how and when the waste will be taken care of;
- segregation at source of waste with different properties so far as is reasonably practicable to enable their effective management;
- documentation and preservation of information regarding waste generation, providing information necessary to support their ongoing management; and
- annual reporting of waste arisings to the Swedish Radiation Safety Authority (SSM) in accordance with a specified schedule.

More detailed requirements that apply only to radioactive waste from nuclear power plants and other facilities include:

- identification of the radionuclide substance content in waste to be transferred to a disposal facility or stored on site for extended periods;
- maintenance of records based on a defined set of information requirements regarding, for example, the origin, quantity, packaging, content and dose rate as well as any treatment performed; and
- formal reporting to SSM per calendar year, including records of waste arisings, transfers and experiences from waste handling.

Discharges to air and water from a facility to the surrounding environment are regulated in accordance with SSMFS 2008:23, see section L.1.4.

Regulations relating to the clearance from regulatory control of nuclear and non-nuclear waste have been issued as SSMFS 2018:3 (see section L.1.6).

H.1.1.3 Criticality and removal of residual heat

See section G.1.1.3.

H.1.1.4 Interdependencies in waste management and minimisation of radioactive waste

As noted in section G, the Radiation Protection Act (2018:396) requires that any party conducting an activity involving ionising radiation (including both nuclear and non-nuclear licensees) must take measures to limit as far as is reasonably practicable the generation of radioactive waste.

The fact that licence holders are responsible under the Act on Nuclear Activities (1984:3) for the safe handling and disposal of the radioactive waste that they generate provides an incentive to consider all steps from generation to disposal. SSM's regulatory provisions regarding radiation safety in the control of radioactive waste from nuclear activities (see also section G.1.1.4) include requirements relating to:

- performance of safety analysis to guide planning and decision making for the management of radioactive waste;
- maintenance of an up-to-date inventory of radioactive waste held on site;
- comprehensive planning for radioactive waste management, including final disposal;
- derivation and use of acceptance criteria relating to safety and radiation protection throughout all steps of the radioactive waste management chain; and
- measures for the management of non-conforming material.

The possibility that limitation of discharges to the environment may imply increased radiation doses to personnel is to be taken into account through optimisation considerations as well as the consequences of other waste management arrangements (SSMFS 2008:23).

Legal obligations on licence holders of nuclear power plants regarding the development and implementation of disposal facilities for radioactive waste from their operation and decommissioning (section G.1.1.1) do not formally require them to provide for the disposal of radioactive waste from nuclear facilities other than their own reactors, or radioactive waste originating from non-nuclear activities. At the time the Act on Nuclear Activities came into force, it was implicitly assumed that the scale of operations relating to the disposal of radioactive waste from nuclear power plants would be such that other waste, including from historic nuclear activities and radioactive waste of industrial and institutional origin, could be accommodated in the nuclear power plant licensees' disposal facilities. Costs for the management and disposal of waste from non-nuclear activities are covered by fees paid by the waste generators under the terms of commercial agreements with Cyclife Sweden AB, which in turn has commercial agreements with SKB regarding capacity at disposal facilities.

H.1.1.5 Protection of individuals, society and the environment

See section G.1.1.5.

H.1.1.6 Account of biological, chemical and other hazards

As noted in section H.1.1.2, SSM requires up-to-date registers to be maintained for all waste and spent nuclear fuel at a nuclear facility. The registers for every waste item (e.g. package or component) must include information on any applied treatment and the physical and chemical form of the waste. Management of the waste must take into account any non-radiological hazards arising, in accordance with the regulation of environmental and workplace safety.

Only packages approved by SSM are allowed to be transported to a disposal facility. This approval presupposes compliance of the methods for waste management, with the conditions and acceptance criteria defined in the safety report of the repository. Acceptance criteria relating to the transfer of wastes to a disposal facility are expected to take into account the implications of their physical and chemical form for the operational and long-term safety performance of the facility.

H.1.1.7 Striving to avoid impacts and undue burdens on future generations

See section G.1.1.7.

H.1.2 Measures taken by the licence holders

H.1.2.1 The general obligations of licence holders

Decisions on the premature closure of four nuclear power reactors have affected the national action plan for low- and intermediate-level waste by bringing forward the need for interim storage of waste from facility dismantling as well as the need for decommissioning planning to be developed and formulated sooner (see also section F.6). The final repositories that SKB plans to establish for low- and intermediate-level waste include an extension of the SFR disposal facility to accommodate short-lived decommissioning waste and the planned SFL deep geological repository for long-lived low- and intermediate-level waste.

RD&D programme 2022

The nuclear industry, through its co-owned company, SKB, has performed research on the long-term management of spent fuel and final disposal of radioactive waste since the mid-1970s. The formal requirement for an RD&D programme to be submitted for regulatory evaluation was established in 1984 when the Act on Nuclear Activities came into force.

In September 2022, SKB submitted the thirteenth RD&D programme to the regulator, SSM, for regulatory review and public consultation, in preparation for the Government's decision concerning the licence holders' fulfilment of their legal obligations (SKB Report TR-22-11, December 2022, can be downloaded at www.skb.se). In the RD&D Programme 2022, SKB presents its plans for research, development and demonstration during the period 2023–2028. The programme consists of three parts:

Part I SKB's activities and plan of action;
Part II Waste and final disposal; and
Part III Decommissioning of nuclear facilities.

The programme for low- and intermediate-level waste includes day-to-day management of waste generated during operation as well as work to realise the remaining parts of the system needed for the safe long-term management and disposal of low- and intermediate-level waste. The overall programme for the waste management system is primarily led by SKB, but also by the nuclear power companies as well as actors such as AB Svafo and Studsvik Nuclear AB.

Licence applications were submitted in late 2014 under the Act on Nuclear Activities and Environmental Code for permission to extend the SFR repository for short-lived waste in order to accommodate decommissioning wastes. In December 2021, the Government approved SKB's applications, enabling a licence according to the Environmental Code to be formally issued by the Land and Environment Court in 2022. In March 2023, SKB submitted to SSM the preliminary safety report (PSAR) for the extended facility, approval of which is required for starting construction of the extension.

An evaluation of post-closure safety issues based on a conceptual design for the proposed SFL repository (the geological repository for long-lived low- and intermediate-level waste) was delivered in autumn 2019. The main results from the study were presented in conjunction with the twelfth RD&D programme. The RD&D programme also presented an analysis of siting factors and a proposed stepwise siting process for SFL.

In the above mentioned work, experience from the operation of SFR constituted an important knowledge base for the development and construction of new repositories for low- and intermediate-level waste.

H.1.2.2 Basic provisions and licence obligations

Measures taken by the licensees regarding general safety requirements are discussed in sections H.3.2 (facility siting), H.4.2 (facility design and construction), H.5.2 (assessment of facility safety) and H.6.2 (facility operation).

Some of the nuclear power companies are arranging for temporary interim storage of short-lived decommissioning waste until the extension of SFR is commissioned. For example, Barsebäck Kraft AB has existing storage facilities that can be used for interim storage, but the capacity needs to be increased to accommodate the short-lived waste that will be produced during decommissioning of Barsebäck Units 1 and 2. It is also expected that existing on-site storage capacity will need to be increased to accommodate short-lived waste from the decommissioning of Oskarshamn Units 1 and 2.

Long-lived waste from decommissioning will be stored at the power plants or at suitable alternative locations, where these can be identified, until SFL is in operation. At Barsebäck, the plan is for the site to be cleared completely before SFL is due to be commissioned, so on-site storage of long-lived waste from dismantling is not currently an option.

AB Svafo currently operates an underground interim storage facility for long-lived low- and intermediate-level waste, which is used for storing not only its own long-lived waste, including legacy waste, but also waste from other licensees such as Studsvik Nuclear AB. This facility does not have capacity to receive more waste. AB Svafo has therefore constructed an extension to an existing storage building to accommodate low- and intermediate-level waste arising from its ongoing decommissioning operations at the Studsvik Tech Park and the former Ågesta PHWR, shut down in 1974. A notification of the modification to operations covered by the existing nuclear licence was submitted to SSM in June 2019. An environmental permit for the extended interim storage facility was granted by the Land and Environment Court in January 2017 and the facility was commissioned in 2022.

AB Svafo is also currently studying the prospects for conditioning and re-packing legacy waste from historical activities within the Swedish nuclear research programme. The study will analyse how different waste fractions are to be handled and what the possibilities are for management and final disposal. However, technical issues concerning how long-lived waste from AB Svafo, Studsvik Nuclear AB and Cyclife Sweden AB is to be treated and packaged for disposal can only be finally resolved when acceptance criteria for long-lived waste at SFL are established.

H.1.3 Regulatory control

H.1.3.1 The general obligations of licence holders

Evaluation of the RD&D programme

See section G.1.3.1 for general information regarding SSM's review of the nuclear licensees' most recent programme for research, development and demonstrating in relation to decommissioning and the provision of safe disposal solutions for nuclear waste arisings in Sweden.

Regarding the nuclear licensees' programme for management of short-lived low- and intermediate-level waste, SSM noted in its review report the ongoing work relating to management of bituminised ion-exchange resins, encouraging SKB to provide a concrete programme for this activity based on clear objectives. SSM also noted the importance of not underestimating the potential inventory of lower-activity waste that is consigned to those parts of the SFR-facility with a simpler barrier design, in order to ensure that there is appropriate capacity for waste of non-nuclear origin.

With regard to the long-term management of long-lived low- and intermediate-level waste, including plans for the development of a geological disposal facility (SFL) for such waste, SSM noted in its review report that such development work had been somewhat de-prioritised compared with other elements of the nuclear power plant licensees' overall programme. SSM further noted that SKB identified a need for further development of suitable technical solutions for the disposal facility design, but provided no clear plans or programme for undertaking such work. In addition, SSM highlighted the importance of an open and transparent process for site selection for the SFL facility, with a clear distinction between necessary and desirable siting factors.

In its decision on the 2022 RD&D programme, published in December 2023, the Government agreed with SSM's overall conclusions, stressing the importance of carefully considering the Authority's observations.

H.1.3.2 Basic provisions and licence obligations

Regulatory control of specific measures taken by the licensees regarding general safety requirements is discussed in sections H.3.3, H.4.3, H.5.3 and H.6.3. Supervision of activities that deal with chemical and biological hazards is primarily exercised by the relevant County Administrative Boards.

See also the description of the outcome of SSM's integrated evaluation of radiation protection and safety for SKB's facilities in section G.1.3.2 (Inspections and Surveillance).

H.1.4 Conclusion

Sweden complies with the obligations of Article 11.

H.2 Article 12: Existing facilities and past practices

Each Contracting Party shall in due course take the appropriate steps to review:

(i) the safety of any radioactive waste management facility existing at the time the Convention enters into force for that Contracting Party and to ensure that, if necessary, all reasonably practicable improvements are made to upgrade the safety of such a facility;

(ii) the results of past practices in order to determine whether any intervention is needed for reasons of radiation protection bearing in mind that the reduction in detriment resulting from the reduction in dose should be sufficient to justify the harm and the costs, including the social costs, of the intervention.

H.2.1 Existing facilities

By the time Sweden became a party to the Joint Convention, the situation was satisfactory with regard to the safety of radioactive waste management facilities. The elements of the Joint Convention have long been implemented in the form of requirements imposed by the Swedish legal and regulatory framework, as well as being implemented in practical arrangements for the management of radioactive waste in Sweden. The conformance of licensees' activities with the legal and regulatory requirements is nevertheless something that constantly needs reaffirming through inspection and review activities.

H.2.2 Past practices

H.2.2.1 Regulatory requirements

As described in section E.2.1.4, a funding mechanism is established in the legislation to cover expenses for liabilities originating from the period prior to the establishment of commercial nuclear power generation in Sweden. This special funding primarily contributes to the decommissioning of the research reactors at Studsvik, the Ågesta reactor and clean-up activities at the former uranium mine in Ranstad. It is also intended to cover the costs of the management and disposal of waste generated from activities that are not covered by licensees' payments into the Nuclear Waste Fund.

H.2.2.2 Measures taken by the licence holders

The utilities operating nuclear power reactors jointly own a special company, AB Svafo, which is charged with the management of legacy waste as well as the decommissioning of the research reactors at Studsvik and the Ågesta reactor.

H.2.2.3 Regulatory control

Decommissioning of the research reactors at Studsvik and the Ågesta reactor as well as management of decommissioning waste is subject to regulatory control. Regulatory reviews of these activities are part of SSM's baseline supervision, which will continue until the facilities have been free-released and the licensee exempted from any further responsibilities.

H.2.3 Conclusion

Sweden complies with the obligations of Article 12.

H.3 Article 13: Siting of proposed facilities

1. Each Contracting Party shall take the appropriate steps to ensure that procedures are established and implemented for a proposed radioactive waste management facility:

(i) to evaluate all relevant site-related factors likely to affect the safety of such a facility during its operating lifetime;

(ii) to evaluate the likely safety impact of such a facility on individuals, society and the environment;

(iii) to make information on the safety of such a facility available to members of the public;

(iv) to consult Contracting Parties in the vicinity of such a facility, insofar as they are likely to be affected by that facility, and provide them, upon their request, with general data relating to the facility to enable them to evaluate the likely safety impact of the facility upon their territory.

2. In so doing, each Contracting Party shall take the appropriate steps to ensure that such facilities shall not have unacceptable effects on other Contracting Parties by being sited in accordance with the general safety requirements of Article 11.

H.3.1 Regulatory requirements

H.3.1.1 Assessment of safety and environmental impact

See section G.3.1.1.

H.3.1.2 Public information and involvement

See section G.3.1.2.

H.3.1.3 Consulting contracting parties

See section G.3.1.3.

Information regarding the extension of the SFR disposal facility will be submitted to the European Commission at the appropriate time in accordance with Article 37 of the Euratom Treaty.

H.3.2 Measures taken by the licence holders

H.3.2.1 Repository for short-lived low- and intermediate-level waste from decommissioning

A summary of the siting process and related consultations undertaken by SKB in respect of the development of a repository for short-lived radioactive waste from decommissioning was provided in Sweden's Fifth National Report, published in 2014. SKB's environmental impact statement in support of its licence applications under the Environmental Code and the Act on Nuclear Activities was submitted in December 2014. As noted in Sweden's Sixth National Report, one consequence of the consultation with the local municipality for the preferred site (as an extension to the existing SFR) was that SKB in May 2017 withdrew from the scope of its licence application a request for permission to temporarily store certain long-lived low- and intermediate-level waste within the proposed facility, pending the final repository for such waste (SFL).

In December 2021, the Government approved SKB's applications relating to the extended facility, enabling a licence under the Environmental Code to be formally issued by the Land and Environment Court in 2022.

H.3.2.2 Repository for long-lived low- and intermediate-level waste (SFL)

As noted above, SKB's RD&D Programme 2019 included not only an evaluation of post-closure safety issues for the proposed SFL repository but also an analysis of siting factors and a proposed stepwise siting process for the facility.

SKB indicated that a future licence application should contain a systematic comparison of available alternative locations, taking account of key factors relevant to siting. The identified key groups of factors for determining a preferred site are based on those adopted in corresponding siting studies for the nuclear fuel repository and SFR. The key groups include:

- safety and radiation protection after repository closure – a robust basis for meeting radiation safety requirements in the long term;
- technical feasibility – necessary conditions to enable technical implementation and operation of the facility;
- environment and health – limited impact on the environment and public health at a reasonable cost;
- societal aspects – societal acceptance at the chosen as well as the alternative site.

SKB then gave an account of the various factors that are included in each group. According to SKB, the requirements relating to safety and radiation protection are similar, though not identical, to those for the spent fuel repository. Key differences are that the total rock volume required for SFL is considerably smaller and that heat generation from the waste does not place any requirements on the potential host rock's thermal properties.

Information gained from investigations supporting siting of the spent fuel repository (but also knowledge from other facilities, including Clab, SFR and the Äspö laboratory, as well as rock cavern storage facilities at Studsvik Tech Park and Oskarshamn) is relevant to building up basic knowledge of geoscientific factors relevant to siting SFL. SKB drew the conclusion that it is unlikely that a meaningful ranking of alternatives can be based on geoscientific information alone, especially given the relatively small size of the planned repository.

SKB also highlighted challenges in achieving societal acceptance – that it takes time to build up acceptance and that it can never be taken for granted. On the basis that several regions are potentially suitable from a geoscientific perspective, but that it is not considered feasible to rank the technical suitability of alternatives in the absence of site-specific geoscientific investigations, SKB suggested that the selection process should in the first instance be based on those factors (e.g. protection of human health and the environment, land use, access to infrastructure, potential to obtain societal support) that are more easily determined at an early stage in siting, on condition that geological prerequisites can be met.

According to this model, the development of a siting process would be undertaken within the scope of an EIA consultation, starting from regions (at Forsmark and Laxemar/Simpevarp) where good geoscientific information already exists and that have previously been identified as being of national interest for geological disposal of radioactive waste. In a first stage, comparative studies would be made with other regions where relevant data have been obtained at appropriate geological depth or that have previously been highlighted as having potential advantages from a radiological safety perspective. Were such areas shown to have obvious benefits, they could then be included in the siting process if it were judged to be reasonably practicable. More detailed site investigations and consultations would then be undertaken to develop the necessary basis for selection of a preferred location.

H.3.3 Regulatory control

H.3.3.1 Repository for short-lived low- and intermediate-level waste from decommissioning

Assessments made by SSM and the Land and Environment Court in relation to the licence applications for the SFR-extension, intended to accommodate short-lived low- and intermediate-level waste from decommissioning, were described in Sweden's Seventh National Report under the Joint Convention, published in 2020. Following the Government's approval in December 2021 of SKB's licence applications for the extended facility according to the Environmental Code and the Act on Nuclear Activities, there is no current siting programme in Sweden for facilities relating to the long-term management of radioactive wastes.

H.3.3.2 Repository for long-lived low- and intermediate-level waste (SFL)

As noted in section H.1.3.1, development work relating to the SFL disposal facility has been de-prioritised by the nuclear power plant licensees relative to other elements of their overall research, development and demonstration programme for the management of spent fuel and nuclear waste. A consequence of this is that there is not currently an active siting programme for the SFL facility. In its review of the nuclear reactor licensees' programme for 2022, SSM underlined the importance of an open and transparent process for site selection for SFL, including the criteria to be used in comparing alternatives.

H.3.4 Conclusion

Sweden complies with the obligations of Article 13.

H.4 Article 14: Design and construction of facilities

Each Contracting Party shall take the appropriate steps to ensure that:

(i) (the design and construction of a radioactive waste management facility provide for suitable measures to limit possible radiological impacts on individuals, society and the environment, including those from discharges or uncontrolled releases;

(ii) at the design stage, conceptual plans and, as necessary, technical provisions for the decommissioning of a radioactive waste management facility other than a disposal facility are taken into account;

(iii) at the design stage, technical provisions for the closure of a disposal facility are prepared;

(iv) the technologies incorporated in the design and construction of a radioactive waste management facility are supported by experience, testing or analysis.

H.4.1 Regulatory requirements

H.4.1.1 Suitable measures to limit radiological impact

See section G.4.1.1.

H.4.1.2 Conceptual plans and provisions for decommissioning

See section G.4.1.2.

H.4.1.3 Technology provisions for closure of repositories

According to section 14 of the Act on Nuclear Activities, licensees retain their obligations to dispose of the nuclear waste and nuclear material in a safe manner until these obligations have been fulfilled. In accordance with section 16 of the Act on Nuclear Activities, SSM determines whether these obligations are fulfilled. With respect to a repository, however. this can be achieved only after the final closure of the repository has been approved by the Government in accordance with the licensing requirements described in Sections 5 g–i of the Act on Nuclear Activities.

In this respect, final closure is defined to entail backfilling of tunnels and shafts up to ground surface level in a manner consistent with the safety analysis which, according to SSM's regulations (SSMFS 2008:21) concerning safety in connection with the disposal of nuclear material and nuclear waste, must demonstrate how safety after closure is maintained through a system of passive barriers. This in turn means that technology provisions for closure need to be developed at the design stage, as part of a comprehensive design for the repository facility.

H.4.1.4 Technology supported by experience

See section G.4.1.3.

H.4.2 Measures by the licence holders

H.4.2.1 Suitable measures to limit radiological impact

The safety philosophy applied in the design of all Swedish nuclear facilities is based on the principles of defence in depth and of using multiple barriers to prevent the unplanned release of radioactive material to the environment. Facilities are designed to ensure that releases of radioactive material in normal operation are limited as far as is reasonably practicable.

This safety philosophy underpins the design and planned construction of the extension to SFR to accommodate short-lived low- and intermediate- level waste from decommissioning as well as the conceptual designs under development for the SFL repository for long-live low- and intermediate-level waste. A specific example of how design and construction measures to limit radiological impact have been informed by experience from related facilities is provided in section H.4.2.4.

H.4.2.2 Conceptual plans and provisions for decommissioning of radioactive waste management facilities

Current planning relating to new waste management facilities in Sweden is focused mainly on alternative storage and disposal solutions for long-lived wastes, including those arising from decommissioning of nuclear power plants as well as legacy waste from past practices. Conceptual plans for decommissioning are taken into account in facility design and in accordance with SSM's regulation (SSMFS 2008:1; see also G.4.1.2). These plans will be assessed by the regulator at the appropriate time when the relevant permissions are sought.

The development of decommissioning plans for the new interim storage facility for low- and intermediate-level waste on the Studsvik Tech Park was a relatively simple process (see section H.1.2.2). An outline description of decommissioning plans was originally submitted together with the licence application for the facility under the Environmental Code, which was approved in January 2017. Plans for decommissioning, dismantling and demolition of the facility, consistent with regulatory requirements, were subsequently examined as part of the PSAR for the proposed facility change in June 2019, when the licensee sought permission from SSM to begin construction.

In this particular case, since the new store was classed as an extension to an existing storage facility, the plans for decommissioning were addressed as a modification to the SAR for the combined facility. The simple nature of the facility means that there are no radiological safety challenges associated with planning for decommissioning at the design stage. This in turn will be reflected in an update to the overall decommissioning strategy for Svafo's operations on the Studsvik Tech Park.

H.4.2.3 Technology provisions for closure of repositories

An account of the status of SKB's technological development programme relating to plans for closure of the spent nuclear fuel repository and SFR was provided in Sweden's Fifth National Report published in 2014.

Activities relating to the design, development and verification of plugs for closure of deposition tunnels in the spent fuel repository, including full-scale tests at the Äspö laboratory, are summarised in SKB's RD&D Programme 2019. SKB noted that the purpose of the plugs is to keep the backfill in the deposition tunnels in place while minimising leakage of oxygen from access tunnels during the repository operating period until the adjoining main tunnel can be closed. The full-scale tests were conducted over a period of three years, demonstrating the feasibility of constructing the plug system to withstand pressurisation using materials that conform to performance requirements for the repository barrier system as a whole. Reporting on gas transmissivity testing was published in 2018. Lessons learned from evaluating the construction and dismantling of the plugs will be compiled as a basis for further studies on materials and methods for plug design and construction.

A simplified design for the overall closure of the spent fuel repository has been proposed based on completed sensitivity analyses. It is noted that the size and function of closure components may ultimately have an impact on the details of the repository design, which means that continued efforts are needed in this area. SKB's forward RD&D programme therefore incorporates the drawing up of an overall closure plan to yield more details with respect to the closure sequence as well as the required function and potential size of closure plugs.

Analyses in support of the proposed extension of SFR to accommodate short-lived waste from decommissioning have resulted in updated requirements on the closure components for SFR as well as the development of a coordinated closure plan for the extended facility. Closure is currently described on the conceptual level, with the intention that knowledge concerning materials, design and installation should be improved prior to the completion of the PSAR. Separate studies of individual closure components (e.g. modelling of concrete plugs) have been carried out to develop an understanding of how properties are expected to evolve over time, with the aim of defining requirements in more detail. SKB is planning for the continued technological development of concrete plugs with the aim of achieving a robust design that meets the requirements and practical conditions for the repository.

H.4.2.4 Technology supported by experience

The principle of proven technology is broadly accepted and implemented in the design and construction procedures for Swedish nuclear facilities. The use of properly environmentally qualified equipment ensures the functioning of safety-related systems and components under emergency conditions.

The development of engineered barrier designs for the planned extension to the SFR-facility reflects experience gained from design and operation of the existing facility. In particular, the vault for intermediate-level waste, known as 1BMA, has been demonstrated to exhibit design flaws that have given rise to cracks in the concrete structures that form the base and walls of the vault. SKB has since demonstrated, through modelling studies undertaken in response to an enforcement notice, that such cracks may not ultimately have a significant impact on the flow of groundwater through the waste. Nevertheless, lessons learned from the causes of the cracking have been taken into account in the design and construction methods for the corresponding vault in the extended facility. A prototype for the revised vault design has been installed at the Äspö laboratory to test the revised methods.

H.4.3 Regulatory control

SSM performed its scrutiny of SKB's licence application for the proposed extension of the SFR disposal facility to accommodate short-lived low- and intermediate-level waste from decommissioning and made its recommendation for approval based on consideration of SKB's reference designs, including plans and provisions for final closure. Following the Government's decision in December 2021 to approve SKB's licence applications for the extended facility, and the Land and Environment Court's subsequent granting of a licence under the Environmental Code in November 2022, SSM received SKB's application for approval of the preliminary safety report (PSAR) for the extended facility in March 2023. Approval by SSM of the PSAR, which includes more detailed descriptions of the different structures, systems and components relevant for safety, is a licence condition under the Act on Nuclear Activities for the start of construction of the extension. SSM's review of SKB's application was ongoing at the time of preparing this report.

SSM will subsequently be engaged in further formal reviews of safety reports relating to the "as-built" construction of the extension prior to active trial operation as well as any subsequent modifications prior to the start of routine operation, in order to verify continued compliance with regulatory requirements and with the Government's licence conditions under the Act on Nuclear Activities. A condition of the licences, under both the Environmental Code and the Act on Nuclear Activities, is that the extension should be constructed substantially in accordance with the documentation submitted as a basis for the licence applications.

The status of SSM's assessment of the design for the proposed SFL disposal facility for long-lived low- and intermediate-level waste is summarised in Sweden's Seventh National Report under the Joint Convention, published in 2020, see section H.1.3.1.

H.4.4 Conclusion

Sweden complies with the obligations of Article 14.

H.5 Article 15: Assessment of safety of facilities

Each Contracting Party shall take the appropriate steps to ensure that:

(i) before construction of a radioactive waste management facility, a systematic safety assessment and an environmental assessment appropriate to the hazard presented by the facility and covering its operating lifetime shall be carried out;

(ii) in addition, before construction of a disposal facility, a systematic safety assessment and an environmental assessment for the period following closure shall be carried out and the results evaluated against the criteria established by the regulatory body;

(iii) before the operation of a radioactive waste management facility, updated and detailed versions of the safety assessment and of the environmental assessment shall be prepared when deemed necessary to complement the assessments referred to in paragraph (i).

H.5.1 Regulatory requirements

H.5.1.1 Assessment of safety, including post-closure safety

See section G.5.1.1.

H.5.1.2 Environmental assessment

See section G.5.1.2.

H.5.1.3 The licensing procedure

See section G.5.1.3.

H.5.2 Measures taken by the licence holders

Waste storage facilities

In 2016, AB Svafo submitted an environmental impact assessment to the Land and Environment Court in support of its licence application under the Environmental Code to construct a new interim storage building for low- and intermediate-level waste at Studsvik Tech Park. Subsequently, in June 2019, AB Svafo submitted a preliminary safety report (PSAR) to SSM, describing the radiological safety implications of the store in terms of an extension to the licensee's existing above-ground storage arrangements on site. Both the environmental assessment and the PSAR were comparatively simple

documents, appropriate to the nature of the hazard and reflecting the nature and purpose of the store, where the primary focus is on shielding to protect the workforce and ventilation to maintain a suitable environment for long-term storage of metallic waste containers. The facility was commissioned in 2022.

Short-lived operational and decommissioning waste
In December 2014, SKB submitted parallel applications to SSM and the Land and Environment Court for permission to develop an extension of SFR. The purpose of the extension is to accommodate disposal of additional short-lived LILW, including those generated by decommissioning of Swedish nuclear reactors. The licence applications included an environmental impact assessment and a comprehensive preliminary safety assessment report for the extended SFR facility as a whole.

The first preliminary safety analysis report (F-PSAR) was submitted in support of SKB's licence application according to the Act on Nuclear Activities. Following the Government's approval of the application, the safety analysis was updated and submitted to SSM in March 2023 in support of the PSAR, which needs to be approved by the regulator prior to starting construction of the extension.

The safety report reflects a systematic analysis of both operational and post-closure safety considerations for the disposal facility. An updated safety analysis report that is meant to reflect the as-built facility will then be prepared prior to trial operation. In the case of SFR, this means that the safety analysis report for the present disposal facility for operational LILW will, at this point, be replaced by the updated safety analysis report describing trial operation of the extended facility. The safety analysis report will be supplemented with experience gained from trial operation before the extended facility is allowed to begin routine operation.

Long-lived operational and decommissioning waste
A comparison of different design concepts for the repository for long-lived waste (SFL), including a qualitative assessment of alternative barriers and their long-term safety function, was published by SKB in 2013. In the autumn of 2019, SKB completed an updated safety evaluation, based on the preferred conceptual design for SFL. The safety analysis was not yet considered to provide sufficient support for granting a licence for siting and construction. This was, however, not SKB's purpose of the safety evaluation.

H.5.3 Regulatory control

Short-lived operational and decommissioning waste
Key aspects of the regulatory review activities undertaken by SSM, including an account of the parallel processes for licensing under the Swedish Environmental Code and the Act on Nuclear Activities, were described in previous national reports under the Joint Convention, published in 2017 and 2020. Following the Government's decision in December 2021 to approve SKB's licence applications for the extended SFR facility, and the Land and Environment Court's subsequent granting of a licence under the Environmental Code in November 2022, SSM received SKB's application for approval of the preliminary safety report (PSAR) for the extended facility in March 2023. Approval by SSM of the PSAR, which includes more detailed descriptions of the different structures, systems and components relevant for safety, is a licence condition under the Act on Nuclear Activities for the start of construction of the extension. SSM's review of SKB's application was ongoing at the time of preparing this report.

SSM will be engaged in further formal reviews of safety reports relating to the "as-built" construction of the extension prior to active test operation as well as any subsequent modifications prior to the start of routine operation, in order to verify continued compliance with regulatory requirements and with the Government's licence conditions under the Act on Nuclear Activities. A condition of the licences under both the Environmental Code and the Act on Nuclear Activities is that the extension must be constructed substantially in accordance with the documentation submitted as part of the licence applications.

Long-lived operational and decommissioning waste
SSM has not conducted any further regulatory review of the developing safety case for the SFL geological disposal facility since that reported in Sweden's Seventh National Report under the Joint Convention, published in 2020.

H.5.4 Conclusion

Sweden complies with the obligations of Article 15.

H.6 Article 16: Operation of facilities

Each Contracting Party shall take the appropriate steps to ensure that:

(i) the licence to operate a radioactive waste management facility is based upon appropriate assessments as specified in Article 15 and is conditional on the completion of a commissioning programme demonstrating that the facility, as constructed, is consistent with design and safety requirements;

(ii) operational limits and conditions, derived from tests, operational experience and the assessments as specified in Article 15, are defined and revised as necessary;

(iii) operation, maintenance, monitoring, inspection and testing of a radioactive waste management facility are conducted in accordance with established procedures. For a disposal facility the results thus obtained shall be used to verify and to review the validity of assumptions made and to update the assessments as specified in Article 15 for the period after closure;

(iv) engineering and technical support in all safety-related fields are available throughout the operating lifetime of a radioactive waste management facility;

(v) procedures for characterisation and segregation of radioactive waste are applied;

(vi) incidents significant to safety are reported in a timely manner by the holder of the licence to the regulatory body;

(vii) programmes to collect and analyse relevant operating experience are established and that the results are acted upon, where appropriate;

(viii) decommissioning plans for a radioactive waste management facility other than a disposal facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility, and are reviewed by the regulatory body;

(ix) plans for the closure of a disposal facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility and are reviewed by the regulatory body.

H.6.1 Regulatory requirements

See section G.6.1.

H.6.1.1 Initial authorisation

See section G.6.1.1.

H.6.1.2 Operational limits and conditions

See section G.6.1.2.

H.6.1.3 Established procedures

See section G.6.1.3.

H.6.1.4 Engineering and technical support

See section G.6.1.4.

H.6.1.5 Procedure for characterisation and segregation of waste

All waste to be disposed of in SFR must conform to predefined waste acceptance criteria relevant to the facility (see section D.1.4.2). The characteristics of each waste type are documented in a Waste Type Description (WTD). The WTD is prepared by the waste producer in close contact with the licensed operator of SFR (SKB). The completed WTD is submitted to SSM for approval. SSM reviews the WTD and may issue specific conditions for the disposal of a particular waste type. To ensure consistent and comparable WTDs, guidelines have been issued for the structure and content of the WTD.

Waste that is to be disposed of in shallow land burials are specified and described in the licences (see section D.1.4.3). The licensee must notify SSM at least three months in advance of each such disposal campaign and must then provide information about each waste package.

H.6.1.6 Reporting of incidents in a timely manner

See section G.6.1.5.

H.6.1.7 Programmes for collecting and analysing operating experience

See section G.6.1.6.

H.6.1.8 Decommissioning plans

See section G.6.1.7.

H.6.1.9 Plans for closure of disposal facilities

SSM's regulations establish several requirements relating to assurance of safety and radiation protection after the closure of disposal facilities (see sections G.3.1 and G.4.1). As noted earlier (section H.4.1), licensees retain their legal obligations for safe management until they are judged to have been fulfilled, which in practice is linked to authorisation of the final closure of the repository by the Government in accordance with the Act on Nuclear Activities (Sections 5 g–i). This, in turn, means that plans and technical provisions for closure need to be developed at the design stage and updated during the operational lifetime of the disposal facility. Furthermore, any authorisation decision regarding final closure is expected to be linked to licensing conditions, which means that the disposal facility will only be considered to have been finally closed when the licensee has demonstrated that such conditions have been fulfilled.

In the case of the SFR disposal facility, requirements relating to closure planning are issued as a licence condition. According to this licence condition, SKB is required to have a developed a plan for closure of the facility. The requirement is important as future closure could ultimately entail the imposition of restrictions on the operation of the facility, such as the mechanical performance, physical dimensions or chemical characteristics of the waste and waste containers. The closure plan should be continuously reviewed and may be modified as long as all requirements continue to be met.

H.6.2 Measures taken by the licence holders

No radioactive waste disposal facilities have been commissioned in Sweden since 1988, when the repository for radioactive operational waste (SFR) was licensed for operation. As noted previously, in addition to the repository for spent fuel, two additional final disposal facilities need to be constructed and taken into operation: a repository for short-lived low- and intermediate-level decommissioning waste (extension of SFR), and a repository for the disposal of long-lived low- and intermediate-level waste.

The general regulations (SSMFS 2008:1) concerning safety in nuclear installations define legally binding requirements relevant for all obligations of Article 9. These requirements are summarised in section G.6.2.

H.6.2.1 Initial authorisation

SKB anticipates that authorisation to start operations of its planned disposal for low- and intermediate-level waste will follow the process specified in SSM's regulations. A full commissioning programme will be developed during the facility's construction and will be submitted to SSM for approval alongside the safety report for the completed facilities, taking into account results from inspections and any non-active tests.

SKB submitted parallel applications to SSM and the Land and Environment Court in December 2014 regarding the development of an extension to SFR, see sections A.4 and A.7.2. The purpose of the extension is to accommodate disposal of additional short-lived wastes, including those generated during decommissioning of Swedish nuclear reactors.

Wastes that will ultimately be consigned to SFL are either currently stored at Studsvik Tech Park, or produced via the decommissioning of nuclear power plants and other facilities, or in some cases stored as in the fuel storage pools at Clab. Conditioning and packaging facilities will need to be developed to meet identified waste acceptance criteria for SFL before disposal can take place. Additional interim storage arrangements are also likely to be required, for example to accommodate long-lived waste from reactor decommissioning (including core and other internal components) as well as future waste arising from research, industry and medical applications.

H.6.2.2 Operational limits and conditions (OLCs)

See section G.6.2.2.

H.6.2.3 Established procedures

See section G.6.2.3.

H.6.2.4 Engineering and technical support

See section G.6.2.4.

H.6.2.5 Procedure for characterisation and segregation of waste

See section H.6.1.5.

H.6.2.6 Reporting of incidents in a timely manner

In late 2012, SKB informed SSM that it was suspected that errors could have been made in the documentation relating to the material contents of a specific type of waste package from Studsvik that had been accepted at the SFR disposal facility for short-lived low- and intermediate-level waste. Regulatory consent for disposal of this type of waste package was originally granted in 1994. The ISO waste containers contain concrete-grouted waste in 200 litre drums, where the content of individual drums varies considerably depending on the original source, which included institutional waste producers (both civil and military) as well as nuclear licensed activities.

In total 75 waste containers of this type were disposed of between 1994 and 2005, containing an estimated 2,800 waste drums. After their disposal, non-destructive examination of similar, though mostly older (and therefore not fully representative) drummed waste remaining in storage at Studsvik Tech Park had given rise to suspicions that the content of a significant fraction of those drums might not comply with conditions for acceptance at the disposal facility. SKB reported its intention in 2013 to retrieve the waste at an appropriate time but noted that a decision would be taken only after further investigations had been undertaken. At first it was considered that the liquid content of the waste drums might be the most significant anomaly and that non-compliance was the primary consideration, rather than a significant hazard to the workforce or the environment. However, subsequent analyses, ordered by the regulator to guide the analysis of available options, revealed that a fraction of the drums were likely to contain very large numbers of small Ra-226 sources (night sights from former military weapons).

The presence of such sources, and possibly other long-lived radionuclides, in the waste has potentially significant implications for long-term radiation protection, both in terms of the slow release of radionuclides from the undisturbed repository and the possible consequences to those directly exposed in the event of human intrusion. For more information on recent developments regarding the above non-conformities see section K.1.3.

More general information regarding incident reporting in provided in section G.6.2.5.

H.6.2.7 Programmes for collecting and analysing operating experience

The objective of the analysis and feedback programme concerning operating experience is to learn from one's own and others' experience and thus prevent recurrences of events, particularly those that might affect the safety of a facility. The operating experience feedback process consists of a wide variety of activities within the plant organisation as well as externally.

When SFR was built, the intention was that the facility would receive waste up until 2010. Due to the prolonged operating time of the nuclear power plants, SFR's operating phase will also be prolonged, which imposes new demands on the maintenance of the facility. The maintenance programme includes remedial and preventive maintenance, as well as the identification, handling and prevention of age-related deterioration and damage. In recent years, maintenance projects have been carried out in SFR. These have included measures to minimise water dripping by installing a suspended ceiling in the silo, 1BLA and 1BMA as well as the addition of a sprinkler in the operations building. The suspended ceiling will be dismantled before the repository is closed and a waterproofing membrane installed to protect barriers and waste in the rock vault for intermediate-level waste (1BMA) and the silo.

Renovation projects continue related to the replacement of fire alarms, evacuation alarms, fibre-optic networks, systems for monitoring and control (SCADA systems), and gates and doors in the underground area of the repository.

H.6.2.8 Decommissioning plans

As described in section G.6.1.7, the general regulations (SSMFS 2008:1) concerning safety in nuclear installations comprise requirements for preparation of decommissioning plans for all nuclear facilities. The degree of detail in such a plan increases as the time for decommissioning approaches.

A preliminary decommissioning plan for the extended SFR facility has been prepared for applications under the Act and the Environmental Code for authorising the extension and continued operation of SFR.

H.6.2.9 Plans for closure of disposal facilities

According to the current plans, closure of repositories will not take place for at least 30 to 60 years. Closure is thus still part of SKB's RD&D programme and an issue for analysis in future safety assessments. Planning for closure has been undertaken for SFR and was included in the licence applications to extend the facility.

H.6.3 Regulatory control

H.6.3.1 Operational limits and conditions

SSM routinely reviews applications from licensees for changes in the OLCs at licensed facilities as well as for temporary exemptions from the authorised OLCs. Assessments are made regarding how the proposed changes or exemptions contribute to the risk profile of the facility, based on the application and supporting information provided by the licensees, together with associated safety analyses.

H.6.3.2 Procedures

Operational and maintenance procedures are normally not reviewed by SSM. SSM would only request that a procedure be submitted for review in connection with event investigations.

H.6.3.3 Engineering and technical support

SSM continues to carry out follow-up reviews of SKB's plans for engineering countermeasures relating to the degradation of the structural concrete in the 1BMA vault at SFR but has yet to take a final decision regarding the proposals that have been submitted.

H.6.3.4 Characterisation and segregation of waste

As described in section H.6.1.5, all waste types must be approved by the regulator before disposal. Compliance with regulations is verified by inspections carried out both at the waste producer and the operator of the disposal facility, e.g. SFR or shallow land burials. These inspections for instance cover administrative routines, documentation, equipment and radiological measurements.

The disposal of certain operational waste streams to the 1BMA vault for intermediate-level waste at SFR has been a particular focus for regulatory attention. SSM has raised concerns regarding the swelling of bitumen-solidified ion-exchange resin and its potential implication for the integrity of the engineered barrier. It is important to know how large the swelling pressure of the waste may be if the waste swells. Experiments conducted at the Äspö underground laboratory have shown that the matrix associated with the bituminised waste form is not sufficiently tight to prevent the ion-exchange resin from swelling. SSM has underlined in an enforcement notice the importance of updating and harmonising the definition of waste acceptance criteria for SFR, with particular emphasis on the disposal of bituminised waste. As part of the response to the enforcement notice, SKB has set up an action plan to further investigate ion-exchange-resin swelling.

H.6.3.5 Incident reporting

As described in section H.6.2.6, SKB informed SSM in 2012 about potential errors in documenting the content of specific waste packages from Studsvik that were accepted for disposal in the SFR. A description of the regulatory supervision of this situation up to 2019 has been provided in previous national reports under the Joint Convention. Additional background information relating to the challenges associated with this issue is provided in section K.1.3.

In October 2022, SSM issued a further injunction to SKB requiring the SFR licence holder to retrieve the improperly disposed waste as soon as possible or, at the latest, prior to the disposal of further waste in the planned extension to the SFR facility. The basis for the injunction was that SKB is legally responsible for ensuring the long-term safety of the facility and that, according to the presumed content of the incorrectly documented waste packages, this would be incompatible with leaving them in place. SKB, in turn, accepted that retrieval is necessary but considers that a prerequisite for safe handling of the waste packages is that necessary handling and storage capacity exists on the site of the responsible waste consignor. Because no waste consignor currently accepts responsibility for financing the retrieval and subsequent handling of the waste packages, SKB appealed SSM's injunction claiming that it could result in unfavourable radiation safety outcomes. At the time of preparing this report, the appeal remains to be decided by the Government.

H.6.3.6 Experience feedback analysis
See section G.6.3.4.

H.6.3.7 Decommissioning plans
Regulatory requirements (section G.6.1.7) specify that updates of the decommissioning plan for a nuclear facility must be submitted to SSM for review alongside related updates of the facility's safety analysis report. Once the facility has been taken out of operation, and any nuclear materials removed, the revised safety analysis report must be reviewed and approved by SSM before dismantling and demolition are allowed to commence. It should be noted, however, that no final decision on dismantling and demolition is expected for several decades in respect of SKB's disposal facilities or other waste management facilities.

H.6.4 Conclusion
Sweden complies with the obligations of Article 16.

H.7 Article 17: Institutional measures after closure

Each Contracting Party shall take the appropriate steps to ensure that after closure of a disposal facility:

(i) records of the location, design and inventory of that facility required by the regulatory body are preserved;

(ii) active or passive institutional controls such as monitoring or access restrictions are carried out, if required; and

(iii) if, during any period of active institutional control, an unplanned release of radioactive materials into the environment is detected, intervention measures are implemented, if necessary.

H.7.1 Record keeping
The regulations (SSMFS 2008:38) on information archiving at nuclear facilities establish requirements for record management, under which specified documents concerning location, design and inventory of waste held any such facility are required to be kept in archives for more than 100 years. Moreover, the general advice to the regulations SSMFS 2008:37, concerning protection of human health and the environment in connection with the final management of spent nuclear fuel and nuclear waste, states that the implementer of a disposal facility should produce a strategy for preservation of information so that appropriate measures are developed and in place prior to its closure. From a radiation safety perspective, this involves consideration of the purpose of such record-keeping in contributing to safety and radiological protection after closure, as opposed to, for example, a more general desire simply to convey information to future generations. Examples of information that should be taken into consideration include the location of the repository, its radioactive substances content and its design. Records are to be transferred to the national or regional official archive when facilities are decommissioned or closed.

H.7.2 Measures taken by the licence holders
Generally, licence holder organisations are responsible for the development and management of records, including related RD&D. The RD&D activities performed by SKB for the design of repositories are based on the fact that the safety of a closed repository is not dependent on surveillance or monitoring, even though some institutional controls may need to be in place after closure, e.g. safeguards for nuclear materials.

Monitoring programmes, covering both geoscientific and ecological parameters, were initiated at the time of the site investigations for the proposed site of the geological disposal facility for spent fuel and at the SFR site. A similar programme is envisaged for the planned repository for long-lived low- and intermediate-level waste (SFL). With a few exceptions, these programmes have continued after the completion of the surface-based site investigations and will continue both during construction and operation of the repositories.

As construction and operation of the disposal facilities proceed, there will be a need to regularly re-assess the selection of monitoring parameters, monitoring objects and measurement frequencies. Long-term experiments may be carried out underground to explore impacts on key barrier functions.

A quality control programme will be developed prior to excavation with the objective of ensuring fulfilment of the design premises and other requirements for the construction and operation of the facilities. Safeguards control will be implemented as needed. The control programme, including its quality documentation, forms the basis for assessing whether construction and operation conforms to the safety-related requirements as expressed in stated design premises and requirements for efficiency and quality. The objectives and content of the control programme will be defined prior to the underground construction work but will evolve and be adjusted in response to experience gained.

Repository closure is a stepwise process, from consecutively closing a deposition tunnel to closing one or several deposition areas before the entire repository is closed. Monitoring is planned to continue until all waste has been emplaced and closure of the repository facility is commenced. At closure, monitoring systems that are only accessible from underground will be decommissioned. The extent to which the closure process itself needs to be monitored will be considered at that time.

A surface-based monitoring system may, in principle, be in operation even after repository closure. The extent of the post-closure monitoring programme will be determined at, or shortly before, closure. Any decisions on requirements for post-closure monitoring will be taken at the time of closure with full consideration of their wider implications. If, as part of the authorisation conditions, monitoring after closure is prescribed, or any other measure to facilitate the retrieval of disposed materials or to make access to the repository difficult, then their potential implications for disposal system performance must be considered (SSMFS 2008:21).

H.7.3 Institutional control

Requirements for institutional control after closure of a waste repository are not established in the current Swedish legal system or regulatory provisions. However, geological disposal of radioactive waste is authorised on the basis that the protection of people and the environment from the harmful effects of radiation will be achieved through the design of the facility, in such a way that neither maintenance nor monitoring will be required following its final closure. Furthermore, according to the Act on Nuclear Activities and the Environmental Code, the State will assume responsibility for a geological disposal facility and the waste it contains following a determination that conditions attached to the authorisation of final closure have been fulfilled. Any subsequent measures relating to control over the site will then be the responsibility of a public authority appointed by the Government.

Other considerations relate to the shallow land burial of short-lived very low-level waste. The four sites for shallow land burial facilities (at Oskarshamn, Forsmark, Ringhals and Studsvik Tech Park) are located on the premises of either a nuclear power plant or licensed industrial facility. Access restrictions for these disposal sites will be maintained as long as restrictions apply for the entire facility. Control after closure of the burial facility remains the responsibility of the licence holder for a period of up to 50 years, primarily to minimise the potential for inadvertent disturbance of the burials while their activity content remains above general clearance levels. It is the duty of the owner and operator of the disposal facility to demonstrate how the requirement for institutional control can be maintained over that period. For longer periods, it is foreseen that the environmental hazard and risk are principally of a non-radiological nature, and therefore subject to the same control arrangements as landfills for non-radioactive waste. Prolonged requirements for institutional control may therefore be issued by county or municipal administrations, but these are no longer within the scope of the nuclear facility licence. The municipalities' detailed development plans are also of importance, by providing conditions concerning future use of the land. All nuclear facilities, including shallow land disposal facilities, are within areas where detailed development plans have been established.

H.7.4 Intervention measures

As described above, SSM's regulations stipulate that a facility for disposal of nuclear waste must be designed so that safety after its final closure will be provided by a system of passive barriers, free from any need for inspection and maintenance. Prior to final closure of the facility, any identified need for intervention measures is the responsibility of the licence holder and must be notified to SSM. If intervention measures are needed after the licence has been surrendered, these will be the responsibility of the State and the public authority appointed by the Government with responsibility for control over the closed facility site.

H.7.5 Conclusion

Sweden complies with the obligations of Article 17.

Section I – Transboundary Movement

I.1 Article 27: Transboundary movement

1. Each Contracting Party involved in transboundary movement shall take the appropriate steps to ensure that such movement is undertaken in a manner consistent with the provisions of this Convention and relevant binding international instruments.

In so doing:

(i) a Contracting Party which is a State of origin shall take the appropriate steps to ensure that transboundary movement is authorized and takes place only with the prior notification and consent of the State of destination;

(ii) transboundary movement through States of transit shall be subject to those international obligations which are relevant to the particular modes of transport utilized;

(iii) a Contracting Party which is a State of destination shall consent to a transboundary movement only if it has the administrative and technical capacity, as well as the regulatory structure, needed to manage the spent fuel or the radioactive waste in a manner consistent with this Convention;

(iv) a Contracting Party which is a State of origin shall authorize a transboundary movement only if it can satisfy itself in accordance with the consent of the State of destination that the requirements of subparagraph (iii) are met prior to transboundary movement;

(v) a Contracting Party which is a State of origin shall take the appropriate steps to permit re-entry into its territory, if a transboundary movement is not or cannot be completed in conformity with this Article, unless an alternative safe arrangement can be made.

2. A Contracting Party shall not licence the shipment of its spent fuel or radioactive waste to a destination south of latitude 60 degrees South for storage or disposal.

3. Nothing in this Convention prejudices or affects:

(i) the exercise, by ships and aircraft of all States, of maritime, river and air navigation rights and freedoms, as provided for in international law;

(ii) rights of a Contracting Party to which radioactive waste is exported for processing to return, or provide for the return of, the radioactive waste and other products after treatment to the State of origin;

(iii) the right of a Contracting Party to export its spent fuel for reprocessing;

(iv) rights of a Contracting Party to which spent fuel is exported for reprocessing to return, or provide for the return of, radioactive waste and other products resulting from reprocessing operations to the State of origin.

I.1.1 Regulatory requirements

There are four different legal instruments that must be considered to obtain an overview of the Swedish regulatory requirements regarding transboundary movement of spent nuclear fuel and radioactive waste:

- the Radiation Protection Act (2018:396);
- the Act (1984:3) on Nuclear Activities;
- Council Regulation (EC) No 428/2009; and
- the Act (2000:1064) on the Control of Dual-use items and Technical Assistance.

Sweden implemented two Directives in its national legislation, i.e. the Radiation Protection Act and the Act on Nuclear Activities: the Council Directive 2006/117/Euratom of 20 November 2006 on the supervision and control of shipments of radioactive waste and spent fuel; and the 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.

In summary, and as specified in the Radiation Protection Act, a licence to export spent nuclear fuel or radioactive waste from Sweden cannot be granted if the destination is:

(i) south of latitude 60 degrees south;
(ii) a State party to the Fourth ACP-EEC Convention that is not a member of the European Union;
(iii) a State that has forbidden the import of spent nuclear fuel or radioactive waste; or
(iv) a State that, in the opinion of the responsible Swedish authorities, does not have the technical, legal or administrative resources to safely manage the spent nuclear fuel, or administrative resources to safely manage the spent nuclear fuel or radioactive waste. This also applies to the Swedish consignee when importing spent nuclear fuel or radioactive waste to Sweden.

As specified in the Ordinance (1984:14) on Nuclear Activities, a licence to import or export spent nuclear fuel or radioactive waste to or from Sweden can only be granted when the following requirements are met:

– an application to import spent nuclear fuel or radioactive waste from a nuclear facility in another country must specify how long the material will be in Sweden and where it will be sent after processing. A licence can only be granted if it is clarified that the material will be returned from Sweden within a specific timeframe or if an authorisation for final disposal has been given in accordance with the Act (1984:3) on Nuclear Activities; or.
– an application to export radioactive waste from Sweden must specify about how the material will finally be taken care of. Regarding material originating from a nuclear facility in Sweden the application must contain a statement from the exporter that the material will be reclaimed if it cannot be processed as planned.

I.1.2 Regulatory control

Sweden follows the provisions set forth in Directive 2006/117/ Euratom to ensure that states of destination and states of transit have the opportunity to give their prior consent and are notified, as stated in the Directive.

I.1.3 Experience of transboundary movements

The major enterprises that conduct operations within transboundary movements in Sweden are Cyclife Sweden AB and Studsvik Nuclear AB. Cyclife Sweden AB carries out volume reduction of radioactive waste on a commercial basis by incinerating combustible waste and melting scrap metal. Studsvik Nuclear AB carries out testing and analysis of spent nuclear fuel and radioactive waste. Foreign spent nuclear fuel or radioactive that has been brought into Sweden must be returned to the original owner after completed processing, unless an authorisation for intermediate storage or final disposal has been authorised according to section 5 a of the Act (1984:3) on Nuclear Activities(1984:3).

I.1.4 Conclusion

The Swedish party complies with Article 27.

Section J – Disused Sealed Sources

J.1 Article 28: Disused sealed sources

1. Each Contracting Party shall, in the framework of its national law, take the appropriate steps to ensure that the possession, remanufacturing or disposal of disused sealed sources takes place in a safe manner.

2. A Contracting Party shall allow for re-entry into its territory of disused sealed sources if, in the framework of its national law, it has accepted that they be returned to a manufacturer qualified to receive and possess the disused sealed sources.

J.1.1 Regulatory requirements

The management of disused sealed sources is covered by the Radiation Protection Act (2018:396). According to the Act, anyone who conducts or has conducted activities involving sealed sources must ensure the safe management, including disposal if needed, of the disused sealed sources. The Radiation Protection Act allows the re-entry of disused sealed sources into Sweden.

Detailed requirements for the management of disused sealed sources are found in the regulations issued by SSM, see Annex L.1.1. SSMFS 2018:1 that incorporate the provisions on high activity sealed sources set in the Basic Safety Standards Directive 2013/59/Euratom. Before issuing an authorisation for practices involving high-activity sealed sources, SSM must ensure that adequate arrangements exist for the safe management of sources, including when they become disused sources. This may provide for the return of disused sources to the supplier or to the recognised waste management facility Cyclife Sweden AB. Financial provisions must have been made to cover the cost of management of the disused sources safely if the licence holder becomes insolvent or goes out of business.

In addition to the regulations, SSM can also issue licence conditions concerning the management of disused sealed sources. For sealed sources incorporated into electrical or electronic equipment, responsibility of the producer is established through the Ordinance (2022:1276) on Producer Responsibility for Electrical Equipment.

J.1.2 Measures taken by the licence holders

J.1.2.1 Disused sealed sources

Licence holders are required to keep records of all sources in their possession and report to SSM when a practice involving sealed sources ceases, when the ownership of a particular sealed source has been transferred to another licensee and when a disused sealed source is either returned to a manufacturer or supplier or sent for disposal.

Since one of the fundamental principles of radioactive waste management is that radioactive waste generated in Sweden shall be disposed of in Sweden, disused sealed sources that are to be disposed of can be sent to the only recognised radioactive waste management facility in Sweden, Cyclife Sweden AB, for treatment and storage before disposal. However, Cyclife Sweden AB is not required to accept disused sealed sources. The company operates on a commercial basis. If Cyclife Sweden AB does not accept the disused sealed sources for treatment, the licence holder will have to store the source on site or, if possible, return the source to the supplier or send it for reuse or recycling.

When Cyclife Sweden AB accepts to receive a disused sealed source for treatment and disposal, the company also assumes the ownership of the sealed source, which includes the financial liability. Cyclife Sweden AB receives approximately 200-300 disused sealed sources per year, not counting discarded ionising smoke detectors. These numbers include orphan sources (see section J.1.2.2).

At Cyclife Sweden AB, the disused sealed sources are treated, conditioned and stored pending disposal. During storage, the sources are retrievable. Short-lived disused sealed sources can be disposed of in SFR if they meet the waste acceptance criteria. Most disused sealed sources are long-lived. These sources are stored until SKB's planned disposal facility for long-lived low- and intermediate-level waste, SFL, is in operation. Should Cyclife Sweden AB not accept to manage a disused source, the source must be stored by the finder pending a solution.

J.1.2.2 Orphan sources

Licence holders are required to take all necessary measures not to allow sealed sources to fall outside of regulatory control. Nevertheless, orphan sources are found on rare occasions, usually at scrap metal recycling facilities. If the licence holder responsible cannot be identified, the State will provide financial resources for the management and disposal of the orphan source. A special governmental funding arrangement allows SSM to cover the costs, up to a certain amount, for the management and disposal of orphan sources and legacy radioactive waste. The current funding is SEK 3.0 million/year.

Several orphan sources are recovered every year, using the financial resources provided by the State. To date, no high activity orphan sealed sources have been found. The finder of an orphan source is required to contact SSM and apply for funding for the safe management and disposal of the source. SSM commissions Cyclife Sweden AB to manage and dispose of the orphan source. When Cyclife Sweden AB accepts the responsibility to manage and dispose of orphan sources, the company also assumes ownership of the sources. The orphan sources are then managed the same way as any disused sources: they are transported to the Studsvik Tech Park where they are treated, conditioned and stored pending disposal. Short-lived orphan sources can be disposed of in SFR if they meet the waste acceptance criteria. Long-lived orphan sources are stored until SKB's planned disposal facility for long-lived low- and intermediate-level waste, SFL, is in operation. SKB is however not legally obligated to accept the sources. This is subject to commercial agreements and requires that disposal of sources will be within the scope of their licence. Should Cyclife Sweden AB not accept to manage an orphan source, the source must be stored by the finder pending a solution.

J.1.3 Regulatory control

SSM plans and performs inspections regularly at establishments in the non-nuclear sector. When it comes to research centres and hospitals, the entire practice is inspected, including routines for treatment of waste and the facilities where radioactive waste and disused sealed sources are stored. Handling of disused sealed sources and back-end issues are usually brought to the attention of SSM in connection with inquiries made by licence holders.

J.1.4 Conclusion

Sweden complies with the obligations of Article 28.

Section K – General Efforts to Improve Safety

K.1 Measures taken to address suggestions and challenges at previous review meeting

K.1.1 Establish a strategy for the management of all non-fuel cycle waste arising in Sweden

At the Seventh Review Meeting, one of the Challenges discussed was the need to improve the management of radioactive waste from outside of the nuclear fuel cycle (as noted elsewhere SKB is not legally obligated to accept waste from others than the nuclear power operators) and centralised storage depends on the acceptance of one commercial company. This Challenge is closely related to the Suggestion included in the rapporteur's report for Sweden: "To establish a strategy for the management of all non-fuel cycle waste arising in Sweden".

IAEA carried out an ARTEMIS mission on Sweden's waste management programme in spring 2023 (see section A.4). The ARTEMIS Review Team's observations partly coincided with the discussions at the Seventh Review Meeting that improvements could be brought to some aspects of the national policy and strategies for waste management, particularly concerning non-nuclear radioactive waste. The Review Team recommended that the Swedish Government:

- supplements its policy and strategy so that responsibilities and resources are allocated to ensure safe and sustainable management of all non-nuclear radioactive waste;
- ensures that safe management routes are made available for all radioactive waste, including disused sealed radioactive sources; and
- ensures that the responsibilities and obligations in respect of securing financial provisions allow for the sustainable management of all legacy waste and non-nuclear radioactive waste.

As a first measure, the Government has commissioned SSM to carry out a situation analysis, including the issue of identifying the non-nuclear waste streams that do not currently have a management route. The authority will report to the Government at the end of 2024. In parallel, the Government continues to prepare for an inquiry to propose suggestions to reach safe and sustainable management of radioactive waste, using the report from SSM as a starting point. The Government has proposed in the spring 2024 budget's amendment to the Parliament, that the State should provide a contribution to part of the cost of the historical non-nuclear waste in possession by AB SVAFO (see section K.1.3). As a result, there are ongoing discussion on how the grant will be organised, where the industry and National Dept Office are included.

K.1.2 Continue reinforcing a sustainable management of human resources and knowledge

K.1.2.1 Long-term national competence provision

In 2018, SSM finalised a governmental assignment on long-term competence provision in the field of radiation safety. In 2020, SSM reported on another assignment to the Government on the description and specification of the research SSM believes is needed for Sweden to maintain a national competence in the supply areas, with proposals for funding sources.

Based on these two assignments, SSM produced a proposal for national strategic direction for Sweden's competence supply in the field of radiation safety, which was delivered to the Government in 2022.

The proposal was also based on the conclusions from the SSM's previous government mission on national competence provision, whose vision was: "Ensured national competence provision in the field of radiation safety enables socially beneficial use of radiation and contributes to protecting people and the environment from unwanted effects now and in the future".

The strategy contains 21 prioritised actions within the following five strategic focus areas:
– national coordination;
– research policy for viable research environments;
– international research collaboration;
– training for society's skills needs; and
– the attractiveness of the radiation safety area.

SSM's proposal has been widely anchored through meetings and referrals to national actors with responsibility or interest in the field of radiation safety (universities, industry, other authorities, etc.). These actors were part of a collaborative platform used for several years in the authority's strategic work with national competence provision. SSM believes that the proposed efforts are an important first step in creating national coordination between the parties concerned, which provides the strategic prerequisites for the development of action plans to maintain and develop the national competence supply in the field of radiation safety.

K.1.2.2 Measures taken by SSM to improve competence provision

SSM has gathered these national actors, using the collaboration platform (see above), on several occasions to secure the support and develop the national strategic direction for the supply of skills in the field of radiation safety. SSM has also expanded its participation with existing networks, such as Swedish Centre for Nuclear Technology (SKC), and in the development of a new skills council.

In its appropriation directions for 2023, SSM was commissioned by the Government to work with strengthened competence for radiation-safe nuclear power. SSM must strengthen its competence in the field of radiation safety in order to have the expertise to review and develop the regulations and licencing processes for existing and new nuclear power, based on known as well as new technology.

SSM must also strengthen the national competence provision in the field of radiation safety, which is one prerequisite for existing and new nuclear power. As of 2024, SSM has received substantial increased funding to strengthen its support to national research. The objective is to meet the long-term national competence demand that follows from the development of new nuclear power.

SSM's Director General has decided to set up a project to support the authority's work in 2023. The project will coordinate the work that is required for the authority to strengthen its internal competence to be ready to handle an application for new nuclear power in 2025 and to strengthen national competence to ensure radiation safety in the country for existing and new nuclear power in the short and long term. The final report shall be submitted to the Government on 20 December 2025.

Currently, SSM is carrying out an investigation to map important issues in the handling and final disposal of spent nuclear fuel and radioactive waste from LW-SMR (Light Water Small Modular Reactors). The investigation is expected to develop knowledge needed to support an assessment of these issues from LW-SMR in connection with possible licensing processes.

SSM will need to develop and strengthen both its staff numbers and its competence in the coming years to be able to handle any applications for new nuclear power. To succeed in recruiting new employees, SSM will have to broaden its recruitment in different ways and increase cooperation with other actors in the field of radiation safety. Work is underway to streamline SSM's processes linked to competence provision.

A limited organisational review and adjustment has been carried out to provide the authority better working conditions to be able to manage more employees and to perform more operations. For example, a new unit for radioactive waste will be established.

K.1.2.3 Technical support organisation (TSO) in Sweden

SSM is responsible for radiation protection and nuclear safety and must maintain competence to anticipate and meet future needs in these areas. However, there is a lack of clarity of the existing support and expert organisation's possibilities to secure their expertise in the long term and provide the authority with appropriate support. The nuclear power industry has also an interest in a well-defined organisation that can provide support and advice in the design, construction and operation of facilities. In March 2024, the Government has, decided to give the Swedish Agency for Public Management the task of investigating the need for an expedient and efficient organisation for the technical support in nuclear safety and radiation protection. The Agency shall report it conclusions to the Government in January 2025. The aim is to create a technical support organisation that meets these needs.

K.1.3 Measures taken to address non-conformities at the SFR facility

As described in sections H.6.1.5 and F.3.2, all waste types must be approved by the regulatory function before disposal. Compliance with regulations is verified by inspections carried out both at the waste producer and the operator of the disposal facility. These inspections for instance cover administrative routines, documentation, equipment and radiological measurements.

In the commonly called Studsvik Act (1988:1597), the licence holders of the NPPs were obligated to pay a fee that, in addition to other costs, would cover the expenses for the management and disposal of the legacy waste from nuclear facilities stored at the Studsvik site. The licence holders formed a company, AB Svafo, and in 1992 AB Svafo applied to the Government for transferring the responsibility of the nuclear legacy waste stored at the Studsvik site to AB Svafo. It was known at the time that the legacy waste also included some non-nuclear waste, although the full extent was not known at the time. The Government approved AB Svafos' application in 1993. The Studsvik Act was later extended to cover also non-nuclear waste.

In late 2012, SKB informed SSM that the documentation for a certain type of waste disposed of in SFR might not be accurate. The waste (up to 2,800 drums placed in containers) could significantly affect long-term (post-closure) radiation protection if the non-conformities could be confirmed. A significant portion of the drums consists of legacy waste. SKB has reported its intention to retrieve the waste at an appropriate time as the waste is still accessible, although logistically complicated.

AB Svafo disclaims responsibility for parts of the nuclear and non-nuclear legacy waste in a letter to the Government in 2020. This includes waste generated at the Studsvik site, hospitals, research institutions and by the State (military origin etc.). Because of this letter, SSM received an assignment from the Government to investigate the issue of responsibility for the legacy waste and to submit proposals for measures to be taken by the Government. In 2022, SSM reported its analysis of both technical and financial responsibilities for the waste and concluded that AB Svafo is fully responsible for the vast majority of the legacy waste, including legacy waste disposed of at the SFR facility.

In October 2022, SSM decided that SKB must retrieve the waste from the SFR-facility as soon as possible, or at the latest, prior to the disposal of further waste in the expanded repository. SKB has appealed SSM's decision. SKB is not opposed to retrieving the waste but argues that the responsibility for the legacy waste is yet to be established by the Government and that conducting the retrieval before the responsibility has been established may be unfavourable from a radiation safety viewpoint since SKB will have to seek interim storage solutions until it is determined who will be responsible for reconditioning or handling the waste. The appeal is yet to be decided by the Government and processing is underway.

SSM and the National Debt Office suggested that the Government gives financial support to cover the expenses for managing these non-nuclear legacy waste and nuclear legacy waste from military research. In 2024, the Government decided to provide financial support.

K.2 Other measures taken to improve safety

K.2.1 Development of regulations on geological disposal facilities

SSM is developing new regulations for nuclear facilities (other than nuclear power plants) and geological disposal facilities. These regulations will follow the same structure that is used for regulations for nuclear power plant, i.e. (1) design, (2) assessment of safety and security; and (3) operation and decommissioning/closure. For geological disposal facilities, the requirements on design and assessments cover the phases both before and after closure. In general, the requirements use a performance-based approach complemented with more detailed prescriptive requirements. Safety and nuclear security are regulated together, often in joint requirements. During the IRRS mission in 2022, Sweden received a Recommendation to align the regulations with IAEA safety requirements on disposal of radioactive waste. This recommendation has being taken into account by SSM in its on-going work. The new regulations are planned to enter into force in 2026.

K.2.2 Ageing management for facilities operated by SKB

Both SFR and Clab were commissioned in the late 1980s (Clab 1985 and SFR 1988). As discussed in sections A.7 (spent fuel and radioactive waste) and in F.6 (decommissioning) both facilities won't be in operation until the later part of the 2000s. Managing ageing components specifically and facilities in general are therefore vital for a radiologically safe and efficient operation. Ageing management includes activities like changing vital components according to a predefined plan or inspections of the rock to avoid fall-out (in the case of an underground repository like SFR).

Regulatory requirements on ageing management are presented in SSMFS 2008:1 Chapter 5 Section 3, which includes reporting its status to SSM as part of the formal annual reporting that a licensee of a nuclear facility is required to provide.

SKB's work on ageing is governed by requirements in the management system ("Operate and Maintain a nuclear facility"), as further discussed in section F.3.2.2. This includes routines, instructions, roles and responsibilities etc. Plans for activities related to managing ageing issues are developed for five years at a time and is regularly being followed-up.

K.3 Strong features, major challenges and areas for improvement identified by the Contracting Party

K.3.1 Strong features

K.3.1.1 Good Practices

In its National Report for the Seventh Review Meeting under the Joint Convention (section K.3.1), Sweden reported on several strong features relating to the progress and continuity of the waste management programme, allocation of responsibilities, the functions of the regulatory authority and the licensing process with provisions for stakeholder involvement. These strong features have been central for Sweden's progress in the development and licensing of a deep geological repository for spent nuclear fuel and have been identified as Good Practices at the Fifth and Seventh Review Meetings of the Joint Convention as well as in the ARTEMIS mission held in Sweden 2023.

Since the Seventh Review Meeting, Sweden's waste management programme has moved further towards a real implementation of disposal facilities:

- On 22 December 2021, the Government granted a licence for extension of the existing repository for LILW in Forsmark to receive waste from decommissioning of nuclear power reactors.
- On 27 January 2022, the Government granted a licence for the KBS-3 system for disposal of spent nuclear fuel, including an encapsulation plant in Oskarshamn and a deep geological repository in Forsmark.

In conclusion, the Good Practice recognised at the Seventh Review Meeting is still considered valid.

K.3.1.2 Areas of good performance

Sweden has taken comprehensive measures to strengthen competence in the areas of nuclear safety and radiological protection both at the national level and at SSM (see section K.1.2), which is considered as an Area of Good Performance.

Another proposal for an Area of Good Performance is the measures taken to ensure transparency and stakeholder involvement in the new phase of construction of disposal facilities, see section K.5.

K.3.2 Challenges and areas of improvement

K.3.2.1 Management of radioactive waste from outside of the nuclear fuel cycle

The licence holders of nuclear power reactors are required by law to develop the infrastructure for safe management of their spent fuel and nuclear waste. The widely accepted understanding over time has been that the disposal facilities managed by SKB, on behalf of the licence holders, also should be accessible for any other radioactive waste generated from outside the nuclear fuel cycle. However, SKB is not legally required to manage any other waste than what is generated by the power reactors. By and large, other waste from both nuclear facilities other than nuclear power plants and from the use of radionuclides in medicine, industry, research and education has been so far managed within this system. Nevertheless, there are challenges with the management of radioactive waste from outside of the nuclear fuel cycle, which differ somewhat depending on the origin of the waste, as described below. The Government has started to investigate these issues with the aim to reach safe and sustainable management of radioactive waste, see section K.1.1.

Radioactive waste generated at nuclear facilities other than nuclear power plants

The waste generated at the nuclear facilities at Studsvik Tech Park differs from the power plants' waste in certain important aspects. Large parts of the low- and intermediate-level waste are long-lived and therefore cannot be disposed of in the existing SFR repository or the planned extension of SFR. The development of a concept for the final disposal facility for long-lived waste, SFL, is still in its early stages. The licence holders at Studsvik Tech Park have made agreements with SKB to consider their long-lived waste when developing and dimensioning SFL. However, there are no legal requirements for SKB to develop disposal facilities; the legal requirements on waste management rest on the waste generators. SKB has recently chosen to prioritise other parts of their waste management program and plans to postpone the start of operation of the SFL for about five to 10 years after the last nuclear power plant ceases to operate. This affects the conditions for the waste generators at Studsvik Tech Park and makes it difficult to develop suitable methods for treatment and characterization of the long-lived waste. Furthermore, the lack of preliminary waste acceptance criteria leads to greater uncertainty regarding the future costs and need for funding. The postponement will also increase the need for interim storage capacity, with potential impacts related to the costs.

A large parts of the long-lived low- and intermediate-level waste at Studsvik Tech Park is nuclear waste from the operation of the facilities, or non-nuclear radioactive waste, and are therefore not covered by the requirements of the Financing Act for funding. In order to limit the risk that some long-lived waste will not have adequate funding for its disposal in the future, an oversight of the Financing Act, overseen by the National Debt Office, has recently been evaluated and reported to the Government. However, the current waste management system may continue to cause difficulties for some of the waste generators and in the long term introduce additional uncertainties concerning the waste management and the associated costs.

Radioactive waste arising from the use of radionuclides in medicine, industry, research and education

The management of radioactive waste arising from the use of radionuclides in medicine, industry, research and education relies on commercial solutions where waste management companies agree on a voluntary basis to manage and dispose of the waste. The waste generator pays Cyclife Sweden AB to treat, store and dispose of radioactive waste. As Cyclife Sweden AB accepts to manage the waste and also assumes the responsibility for it. Cyclife Sweden AB has agreements with SKB for the disposal of radioactive waste in SFR, in the planned extended SFR and in the planned SFL. By and large, this system has worked over the years. However, there are shortcomings, which can make it a challenge for waste generators to fulfil their statutory responsibilities, both currently and in the future, as described below:

- Cyclife Sweden AB is the only radioactive waste management facility in Sweden that provides the service of managing radioactive waste from medicine, industry, research and education. The company operates on a commercial basis and is not legally obligated to accept waste from others for management. If Cyclife Sweden AB refuses to manage that other radioactive waste, the waste generator has no other waste management company to turn to. Because there are no designated storage facilities available for this kind of waste, the waste generator must store the waste on-site until further notice.
- Long-lived radioactive waste cannot typically be disposed of in SFR, thus it must be stored until SFL is in operation. Because SFL is not yet sited, designed nor constructed, the costs for disposal are difficult to determine today. Cyclife Sweden AB has indicated that it might be too much of a financial risk for them to take on the responsibility for long-lived waste generated by others. In addition, although SKB has entered, or plans to enter, into agreements on disposal of radioactive waste with waste generators, e.g. European Spallation Source ERIC (ESS), these agreements do not mean that SKB will accept waste for disposal without reservation. As stated earlier, SKB is only required to manage spent fuel and waste generated by the power reactors.
- Radioactive waste will be generated from the use of radionuclides in medicine, industry, research and education for many years to come, including after both SFR and SFL have been closed. This is a challenge that has become particularly evident with the planning and construction of the ESS facility, see sections A.4 and A.5.1. The ESS facility is expected to generate considerable amounts of radioactive waste from both operation and decommissioning, which is planned to be disposed of in SFL.

K.3.2.2 Management of radioactive waste from new nuclear reactors

A prerequisite for the establishment of new nuclear reactors is that the generated spent fuel and radioactive waste can be safely managed. According to the Act on Nuclear Activities, the licensee for the operation of a nuclear power reactor – in liaison with the other licensees for the operation of nuclear power reactors – is responsible for ensuring that facilities are in place for the safe handling and disposal of spent fuel and nuclear waste produced by their power plants (see section E2.1.1). The nuclear industry in Sweden, through its co-owned company, SKB, has for many years performed research on the long-term management of spent fuel and radioactive waste. The current nuclear waste and spent fuel management programme is designed to manage waste from existing nuclear power facilities, where the actors involved and the overall scope have been largely unchanged for several decades. The programme is thus based on specific planning assumptions about the quantities as well as the type of waste and spent nuclear fuel.

If new nuclear build is to take place, and if new actors are to be able to establish themselves in the market, these existing arrangements will need to be adjusted to enable the scope of the programme to be changed and to enable new licensees to effectively bear their responsibility for research and development activities to ensure that their spent fuel and nuclear waste are accommodated. As part of the Government's ongoing inquiry into legal and regulatory structures for enabling new nuclear build, proposals will therefore be developed regarding policy for the management of new types and amounts of spent fuel and nuclear waste. According to the Government's schedule, the inquiry's recommendations relating to governance of the nuclear waste programme are to be submitted by the end of August 2025.

K.4 Policy and plans for international peer review missions

As a Member State of the European Union, Sweden is required to periodically, and at least every 10 years, arrange for self-assessments to be made and invite international peer reviews of its national framework, competent regulatory authority, and/or national programme to ensure that high safety standards are achieved in the safe management of spent fuel and radioactive waste. SSM has the task of submitting proposals to the Government on the appropriate time schedule for such assessments and international peer reviews. As described in section A.4 a full-scope IRRS mission and an ARTEMIS mission were conducted in 2022 and 2023, respectively. A follow-up IRRS mission is planned in 2027.

K.5 Actions to enhance openness and transparency in the implementation of the obligations under the Convention

The legal framework in Sweden for licensing nuclear activities contains provisions governing transparency, openness and public participation. The licensing reviews of nuclear waste disposal facilities benefit from the provisions for a transparent and predictable siting and licensing process, with an active involvement of stakeholders. More detailed information on public engagement during the pre-licensing phase is given in Sweden's Seventh National Report (sections K.3.1.5 and K.5).

Sweden has been successful in the siting and licensing of an encapsulation plant and a spent nuclear fuel repository (the Government granted a licence in 2022) and the extension of the existing SFR repository for LILW in Forsmark (Government licence granted in 2021).

The progress of Sweden's spent nuclear fuel disposal programme has been acknowledged as Good Practices at the Fifth and Seventh Review Meetings of the Joint Convention and by the ARTEMIS mission held in Sweden 2023.

Sweden is now committed to continue the good work on transparency and public involvement as the nuclear waste system is transitioning into industrial projects with construction and subsequently operation.

The legal provisions for continued stakeholder involvement include:

- The Government has set as a licence condition for the spent nuclear fuel repository, under the Environmental Code, whereby SKB shall meet at least once a year with the municipalities (Östhammar, Oskarshamn), other stakeholders proposed by the municipalities and competent supervisory authorities to address local environmental issues; and
- The Act on Nuclear Activities states that the Government shall establish Local Safety Boards in municipalities hosting nuclear facilities. These boards shall be informed by the licence holder on the safety and radiation protection work at the facility.

The Local Safety Boards administer the safety and security issues concerning nuclear facilities within three municipalities: Östhammar (nuclear power plants as well as final repositories), Oskarshamn (nuclear power plants as well as the intermediate storage of spent nuclear fuel) and Varberg (nuclear power plants). Their task is to oversee and invite the different actors (implementer, authorities and others) to explain and describe their daily operational and long-term work with assuring safety and security. The Boards hold internal meetings as well as meetings open to the public. The minutes from the meetings are published on the websites of the municipalities. The Local Safety Boards also initiate study visits and produce brochures about their work. Finally, the three municipalities often join together as one part in receiving and answering for consultations from authorities and the Government concerning for example changes in legislation. These municipalities are also part of a greater network on a European level (Group of European Municipalities with Nuclear Facilities) to share experiences as well as to influence European institutions.

SSM participates regularly at Local Safety Board meetings to inform about e.g. recent initiatives and development of regulations related to nuclear waste disposal. In addition, SSM hosts annual meetings with stakeholders, including environmental NGOs. SSM's Director General also attends annual meetings with the municipal boards in the municipalities with spent nuclear fuel facilities, i.e. Östhammar and Oskarshamn.

There has been limited scope of legal provisions relating to regulatory engagement with stakeholders as disposal facility projects move from siting and licensing to construction and operation. As a result, SSM initiated in 2022 an independently-led research project (known as INCLUDE) to provide guidance to the development of the Authority's public outreach and transparency strategy in relation to its continuing regulatory activities with respect to these facilities. As part of this work, the researchers consulted with a range of different stakeholders regarding their experiences from engaging with SSM during earlier stages in the programme as well as their hopes and expectations for the future. At the time of preparing this report to the Joint Convention, the results of the project had not been finalised. Nevertheless, it is SSM's intention that the research report will provide input to the formulation of an appropriate and effective engagement policy that will continues to respect the principles of openness and integrity, while at the same time meeting practical constraints in relation to SSM's regulatory role.

SSM publishes the Swedish National Reports of the Joint Convention on SSM's official website, www.stralsakerhetsmyndigheten.se. SSM also publishes questions and comments received from other contracting parties, including the responses to these questions.

Section L – Annexes

L.1 Summary of applicable regulations

A brief description of the Swedish Radiation Safety Authority's (SSM) regulations is provided below, with relevance to the safe management of spent fuel and radioactive waste, presented by main areas of application. Considerable work has been carried out on revising the content and overall structure of SSM's Regulatory Code.

L.1.1 General regulations on safety and nuclear security

Regulations on basic requirements on activities involving ionising radiation requiring permit (SSMFS 2018:1)

These regulations contains all basic and common requirements for activities with ionising radiation requiring a licence (in medicine, research, industry, and in the nuclear area). The regulations specifies requirements in the Radiation Protection Act and the Act on Nuclear Activities and considers other international requirements and documents published by the International Commission on Radiological Protection (ICRP), the European Union (EU), the International Atomic Energy Agency (IAEA) and the Western European Nuclear Regulators Association (WENRA).

For each of the paragraphs, there is a guidance explaining the purpose, background, considerations, application of the provision and references to the provisions.

The regulations contain basic provisions on e.g.:

- risk analysis;
- defence in depth;
- physical protection system;
- emergency preparedness and response;
- management system;
- protection of workers against radiation risks;
- protection of the public and the environment against radiation risks;
- radioactive sources intended for exposure;
- radioactive waste;
- discharge of radioactive substances; and
- decommissioning.

Regulations on activities requiring notification (SSMFS 2018:2)

These regulations includes activities that only need to be notified. The regulations implements the principle of graded approach according to art. 24.1 Council Directive 2013/59/Euratom.

The regulations applies to the following activities: sealed and unsealed sources below certain activity levels, orthodontic and veterinary x-ray diagnostics, cabinet x-ray equipment, technical devices for measurement, control, analysis and laboratory use, microwave drying, medical solariums and professional trade in radiation sources, etc.

Basically, the regulations have the same requirements as in SSMFS 2018: 1, but in a less extensive application.

Regulations and general advice concerning safety in certain nuclear facilities (SSMFS 2008:1)

These general regulations are applicable to all licensed nuclear facilities except power plants in operation. This is regardless of the size or type of facility, i.e. research or materials testing reactors, fuel fabrication plants, facilities for handling and storage of spent nuclear fuel, and facilities for handling, storage or disposal of nuclear waste.

The purpose of the regulations is to specify the measures needed for preventing and mitigating radiological accidents, preventing illegal access to nuclear material and nuclear waste, and conducting efficient supervision. The regulations covers the following areas:

- application of multiple barriers and defence in depth;
- response to detected deficiencies in barriers and the defence in depth;
- organisation, management and control of activities significant for safety;
- actions and resources for maintaining and developing safety;
- physical protection and emergency preparedness;
- basic design principles;
- assessment, review and reporting of safety;
- operations of the facility;
- reporting to SSM of deficiencies, incidents and accidents;
- documentation and archiving of safety documents;
- final closure and decommissioning; and
- for most of the requirements, general advice on their interpretation has been issued.

Regulations on design, assessment and operation of nuclear power plants (SSMFS 2021:4, SSMFS 2021:5 and SSMFS 2021:6)

These regulations entered into force in 2022 to replace the earlier SSMFS regulations for nuclear power plants. The regulations consist of three close- related sets that together cover requirements in more detail than specified in SSMFS 2018:1 for design, assessment and operation of nuclear power plants.

Regarding spent fuel and radioactive waste, in addition to requirements on management system and procedures, these regulations contain requirements of design and operation to minimise waste and provisions for waste management of spent fuel and radioactive waste at the facility. The regulations cover the following areas:

- designing work and commissioning;
- basic principles for design and operation;
- design basis and basis for emergency preparedness and response (incl. methods);
- safety and security objectives;
- general design requirements;
- more detailed design requirements for specific functions;
- safety and security assessment (incl. DSA and PSA);
- content of SAR, OLCs, emergency response plan, contingency plan;
- periodic safety review;
- management system;
- competence and training;
- radiation protection;
- environmental monitoring;
- operations;
- maintaining equipment availability;
- physical protection;
- emergency preparedness and response; and
- reporting to the regulatory body.

Regulations on radiation protection managers at nuclear facilities (SSMFS 2008:24)

According to these regulations, a licence holder must appoint a radiation protection manager at the facility to implement radiation protection conditions issued by the authorities and to supervise compliance with these conditions.

Regulations on filing at nuclear facilities (SSMFS 2008:38)

These regulations applies to filing of documentation in connection with the operation of nuclear facilities. Certain documentation must be filed. If the practice ceases, the licensee's archived documentation must be transferred to SSM.

L.1.2 Regulations on final management of spent fuel and radioactive waste

Regulations concerning safety in connection with the disposal of nuclear material and nuclear waste (SSMFS 2008:21)
These regulations, in force since 2002, contains specific requirements for design, construction, safety analysis and safety reporting of disposal facilities in view of the period after closure of the facility. For the period before closure, the general safety regulations (SSMFS 2008:1) applies.

The regulations concerning long-term safety for disposal of spent nuclear fuel and nuclear waste specifically covers:

- qualitative requirements for the barrier system;
- scenario definitions and classifications;
- timescales for the safety assessment (as long as barrier functions are needed to isolate and/or to retard dispersion of radionuclides, but for at least 10,000 years); and
- topics to be covered in the safety report.

Regulations and general advice on the protection of human health and the environment in connection with the final management of spent nuclear fuel and nuclear waste (SSMFS 2008:37)
These regulations applies to the disposal of spent nuclear fuel and nuclear waste, but are not applicable to landfills for low-level nuclear waste. The basic requirement is that human health and the environment shall be protected from detrimental effects of ionising radiation, during operation as well as after closure. Another important requirement is that impacts on human health and the environment outside Sweden's borders are not permitted to be more severe than those accepted in Sweden.

The regulations contains provisions on areas such as BAT and optimisation, the risk criterion and most exposed group, time periods for the risk analysis and demonstration of compliance for different time periods.

Regulations on predisposal management of radioactive waste from nuclear facilities (SSMFS 2021:7)
These regulations have been in force since 2022 and contains requirements on the management of spent fuel and radioactive waste from nuclear facilities and must be mainly used in parallel with SSMFS 2018:1 but also with SSMFS 2021:5 and SSMFS 2021:6.

The regulations specifically covers requirements for documented plans based on an evaluation of alternative management options; the derivation of acceptance criteria stating the properties of spent fuel and radioactive waste that can be received for storage, disposal or any other treatment; control measures of waste items to ensure that they meet the acceptance criteria; waste type descriptions and verification of waste items; and an up-to-date inventory of all spent fuel and radioactive waste at the facility.

L.1.3 Regulations on or related to non-nuclear radioactive waste

Regulations on smoke detectors for domestic use containing radioactive sources (SSMFS 2008:47)
These regulations stipulates that the discarded units must be collected and shipped for disassembly.

Regulations on smoke detectors for industrial use containing radioactive sources (SSMFS 2008:44)
These regulations stipulates that the disused units must be handled as radioactive waste and returned to the supplier or manufacturer.

L.1.4 Regulations on discharges and protection of workers and the public

Regulations on the protection of human health and the environment from discharges of radioactive substances from certain nuclear facilities (SSMFS 2008:23)
These regulations contains provisions on releases of radioactive substances from nuclear facilities, except power plants in operation (which is regulated in SSMFS 2021:4-6, see above), during normal operation based on optimisation of radiation protection. Compliance is to be achieved by using the best available technique (BAT). The optimisation of radiation protection shall include all facilities located within the same geographically delimited area. The effective dose to an individual in the critical group of one year of releases of radioactive substances to air and water from all facilities located in the same geographically delimited area shall not exceed 0.1 millisievert (mSv).

Regulations on radiation protection of workers exposed to ionising radiation at nuclear facilities (SSMFS 2008:26)
These regulation contains provisions on limitation of exposures as far as reasonably achievable while having considered societal and economic factors and are applicable to all licensed nuclear facilities except power plants in operation (which is regulated in SSMFS 2021:4–6, see above). For this purpose, the licence holder must ensure that the goals and needed actions for control are established and documented and that the needed resources are available.

L.1.5 Regulations on emergency preparedness, nuclear security and safeguards

Regulations on emergency preparedness at certain nuclear facilities (SSMFS 2014:2)
These regulations applies to the planning of emergency preparedness and radiation protection measures in the event of an emergency or a threat of an emergency at nuclear facilities other than power plants in operation (which is regulated in SSMFS 2021:4–6, see above).

The regulations contains provisions on planning of emergency preparedness, alarm criteria and alarms, premises, assembly stations, iodine tablets, personal protection equipment, evacuation, education and training, radiation surveillance, filtration, meteorology data, etc.

Additional provisions on emergency preparedness are stipulated in the regulations SSMFS 2008:1 of the Swedish Radiation Safety Authority concerning safety in nuclear facilities.

Regulations on physical protection of nuclear facilities (SSMFS 2008:12)
These regulations applies to nuclear facilities other than power plants in operation, which is regulated in SSMFS 2021:4–6 (see above) and contains requirements on organisation of physical protection, clearance of staff, tasks for security staff, central alarm station, perimeter protection, protection of buildings, protection of compartments vital for safety, access control for persons and vehicles, protection of control rooms, communication equipment, searching for illegal items, handling of information about the physical protection, and IT security. Design details about the physical protection must be reported in a classified attachment to the SAR of the facility.

Regulations on nuclear safeguards (SSMFS 2008:3)
These regulations applies to the measures required to meet the obligations resulting from Sweden's agreements to prevent proliferation and unauthorised dealing with nuclear fuel, spent nuclear fuel placed in the final repository, nuclear equipment and related software and technology.

L.1.6 Regulations on clearance and exemption

Regulations on exemptions from the Radiation Protection Act and on clearance of materials, building structures and areas (SSMFS 2018:3)
These regulations contains provisions on the clearance of materials, rooms, buildings and land that have been used in practices involving ionising radiation.

L.1.7 Regulations on shipments and reporting

Regulations on the control of transboundary shipments of radioactive waste and spent nuclear fuel (SSMFS 2009:1)
These regulations applies to transboundary shipments of radioactive waste and spent nuclear fuel within the European Union as well as from or to the EU, provided that Sweden is the country of origin, country of destination or country of transit.

The regulations, which implements the Council Directive 2006/117/Euratom, requires prior authorisation for moving radioactive waste and spent fuel across its borders if the item is being sent from, through or to an EU country.

L.1.8 Regulations on discharges and protection of workers and the public

Regulations on the protection of human health and the environment from discharges of radioactive substances from certain nuclear facilities (SSMFS 2008:23)
These regulations contains provisions on releases of radioactive substances from nuclear facilities during normal operation based on optimisation of radiation protection. Compliance is to be achieved by using the best available technique (BAT). The optimisation of radiation protection shall include all facilities located within the same geographically delimited area. The effective dose to an individual in the critical group of one year of releases of radioactive substances to air and water from all facilities located in the same geographically delimited area shall not exceed 0.1 millisievert (mSv).

Regulations on radiation protection of workers exposed to ionising radiation at nuclear power plants (SSMFS 2008:26)
These regulations contains provisions on limitation of exposures as far as reasonably achievable while having considered societal and economic factors. For this purpose, the licence holder must ensure that goals and needed actions for control are established and documented and that the needed resources are available.

L.1.9 Regulations on emergency preparedness, physical protection and safeguards

Regulations on emergency preparedness at certain nuclear facilities (SSMFS 2014:2)
These regulations applies to the planning of emergency preparedness and radiation protection measures in the event of an emergency or a threat of an emergency at nuclear facilities.

The regulations contains provisions on planning of emergency preparedness, alarm criteria and alarms, premises, assembly stations, iodine tablets, personal protection equipment, evacuation, education and training, radiation surveillance, filtration, meteorology data, etc.

Additional provisions on emergency preparedness are stipulated in the regulations SSMFS 2008:1 of the Swedish Radiation Safety Authority concerning safety in nuclear facilities.

Regulations on physical protection of nuclear facilities (SSMFS 2008:12)
These regulations contains requirements on organisation of physical protection, clearance of staff, tasks for security staff, central alarm station, perimeter protection, protection of buildings, protection of compartments vital for safety, access control for persons and vehicles, protection of control rooms, communication equipment, searching for illegal items, handling of information about the physical protection, and IT security. Design details about the physical protection must be reported in a classified attachment to the SAR of the facility.

Regulations on the control of nuclear material, etc. (SSMFS 2008:3)
These regulations applies to the measures required to meet the obligations resulting from Sweden's agreements to prevent proliferation and unauthorised dealing with nuclear fuel, spent nuclear fuel placed in the final repository, nuclear equipment and related software and technology.

L.1.10 Regulations on clearance and exemption

Regulations on exemptions from the Radiation Protection Act and on clearance of materials, building structures and areas (SSMFS 2018:3)
These regulations contains provisions on the clearance of materials, rooms, buildings and land that have been used in practices involving ionising radiation.

L.1.11 Regulations on shipments and reporting

Regulations on the control of transboundary shipments of radioactive waste and spent nuclear fuel (SSMFS 2009:1)
These regulations applies to transboundary shipments of radioactive waste and spent nuclear fuel within the European Union as well as from or to the European Union, provided that Sweden is the country of origin, country of destination or country of transit.

The regulations, which implements the Council Directive 2006/117/Euratom, requires prior authorisation for moving radioactive waste and spent fuel across borders if the item is being sent from, through, or to an EU country.

L.2 List of acronyms

ACP-ECC	African Caribbean and Pacific (ACP) countries and the European Economic Community (EEC)
ALARA	As Low As Reasonable Achievable (a principle applied in radiation protection)
ATB 1T	Waste container for transportation of long-lived low- and intermediate-level waste
AM	Interim storage for low- and intermediate-level waste (Studsvik Tech Park)
AU	Storage facility for radioactive waste (Studsvik Tech Park)
1BAT	Best Available Technique
1BLA	Rock vault for low level waste (part of the SFR facility)
BMA	Rock vault for intermediate level waste (part of the SFR facility)
BSS	Basic Safety Standards
BTF	Rock vault for concrete tanks (part of the SFR facility)
BWR	Boiling Water Reactor
Clab	Centralt Lager för Använt Bränsle (central interim storage facility for spent fuel)
Clink	Integrated central interim storage facility and encapsulation plant
ConvEx	IAEA Convention Exercises
CSS	Commission on Safety Standards
DGRRF	Deep Geological Repository - Regulatory Forum
ECURIE	European Community Urgent Radiological Information Exchange
EIA	Environmental Impact Assessment
ENSRA	European Nuclear Security Regulators Association
ENSREG	European Nuclear Safety Regulators Group
EPReSC	Emergency Preparedness and Response Standards Committee
ESS	European Spallation Source
EU	European Union
FOI	Swedish Defence Research Agency
FR0-A	Treatment facility for radioactive non-nuclear waste (Studsvik Tech Park)
HA	Incineration facility (Studsvik Tech Park)
HCL	Hot Cell Laboratory (Studsvik Tech Park)
HELCOM	The Helsinki Commission
HERCA	Heads of European Radiation Control Authorities
HRL	Hard Rock Laboratory
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IGD-TP	Implementing Geological Disposal of radioactive waste Technology Platform
INES	International Nuclear Event Scale
INEX	OECD/NEA International Nuclear Emergency Exercises
INRA	International Nuclear Regulators Association
IRRS	Integrated Regulatory Review Service
ISO	International Standard Organisation
KBS-3	SKB's method for disposal of spent nuclear fuel
LER	Licensee Event Report
LILW	Low- and Intermediate-Level Waste
LLW	Low-Level Waste
MOX	Mixed Oxide Fuel
MSB	Swedish Civil Contingencies Agency
NBHW	National Board of Health and Welfare
NEA	Nuclear Energy Agency within the OECD
NESA	National Expert Council on Remediation
NGO	Non-Governmental Organisation
NORM	Naturally Occurring Radioactive Materials
NORMAN	Nordic manual for cooperation between the respective regulators in the five Nordic countries of Denmark, Finland, Iceland, Norway and Sweden in response to, and preparedness for, nuclear and radiological emergencies and incidents
NPP	Nuclear Power Plant (including all nuclear power units at one site)
NSGC	Nuclear Security Guidance Committee
NUSSC	Nuclear Safety Standards Committee
NUWARD	A subsidiary of EDF that develops the small modular reactor of the same name
OECD	Organisation for Economic Cooperation and Development
OKG	Oskarshamns Kraftgrupp AB
OLC	Operational Limits and Conditions
ONR	Office for Nuclear Regulation, UK
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic

PHWR	Pressurised Heavy Water Reactor
PSAR	Preliminary Safety Analysis Report/Preliminary Safety Report
PSR	Periodic Safety Review
PWR	Pressurised Water Reactor
R0-A	Treatment facility for radioactive non-nuclear waste (Studsvik Tech Park)
RadGIS	Radiation Geographical Information System software for reporting, storing, extracting and visualising radiation monitoring data and environmental samples collected during an emergency
RANET	Response and Assistance Network
RASSC	Radiation Safety Standards Committee
RD&D	Programme for Research, Development and Demonstration
RN-MEG	Nuclear Medical Expert Group
SAR	Safety Analysis Report/Safety Report
SFA	Swedish Food Agency
SFL	Disposal facility for long-lived low- and intermediate-level waste
SFR	Disposal facility for short-lived low- and intermediate-level waste
SJV	The Swedish Board of Agriculture
SKB	Svensk Kärnbränslehantering AB (Swedish Nuclear Fuel and Waste Management Company)
SMA	Melting facility (Studsvik Tech Park)
SMHI	Swedish Meteorological and Hydrological Institute
SR-Site	SKB's long-term safety assessment for the spent fuel repository in support of F-PSAR
SSM	Strålsäkerhetsmyndigheten (Swedish Radiation Safety Authority)
SSMFS	SSM's Regulatory Code
STUK	Finnish Nuclear and Radiation Safety Authority
TRANSSC	Transport Safety Standards Committee
TSO	Technical Support Organisation
USIE	Unified System for Information Exchange in Incidents and Emergencies
WASSC	Waste Safety Standards Committee
WENRA	Western European Nuclear Regulators Association
VLLW	Very Low Level Waste
WSE	Westinghouse Electric Sweden AB
WTD	Waste Type Description

L.3 National Report Preparation Team

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In addition, a team of experts at SSM and SKB have contributed with text, illustrations and factual review.

Departementsserien 2024

Kronologisk förteckning

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12. Pensionärernas levnadsstandard då och nu. En studie av pensionärernas levnadsstandard 2003–2024. S.
13. Bättre förutsättningar för att utveckla en kunskapsbaserad socialtjänst. S.
14. Ändamålsenlig styrning av äldreomsorgen via riktade statsbidrag. S.
15. Underlätta, utbilda, uppskatta – så erkänns ungas ideella engagemang. S.
16. Ett fritidskort för barn och unga – en aktiv och meningsfull fritid i gemenskap med andra. S.
17. Sweden's eighth national report under the Joint Convention on the safety of spent fuel management and on the safety of radioactive waste management – Sweden's implementation of the obligations of the Joint Convention. KN.

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Systematisk förteckning

Government Offices of Sweden
Ministry of Climate and Enterprise