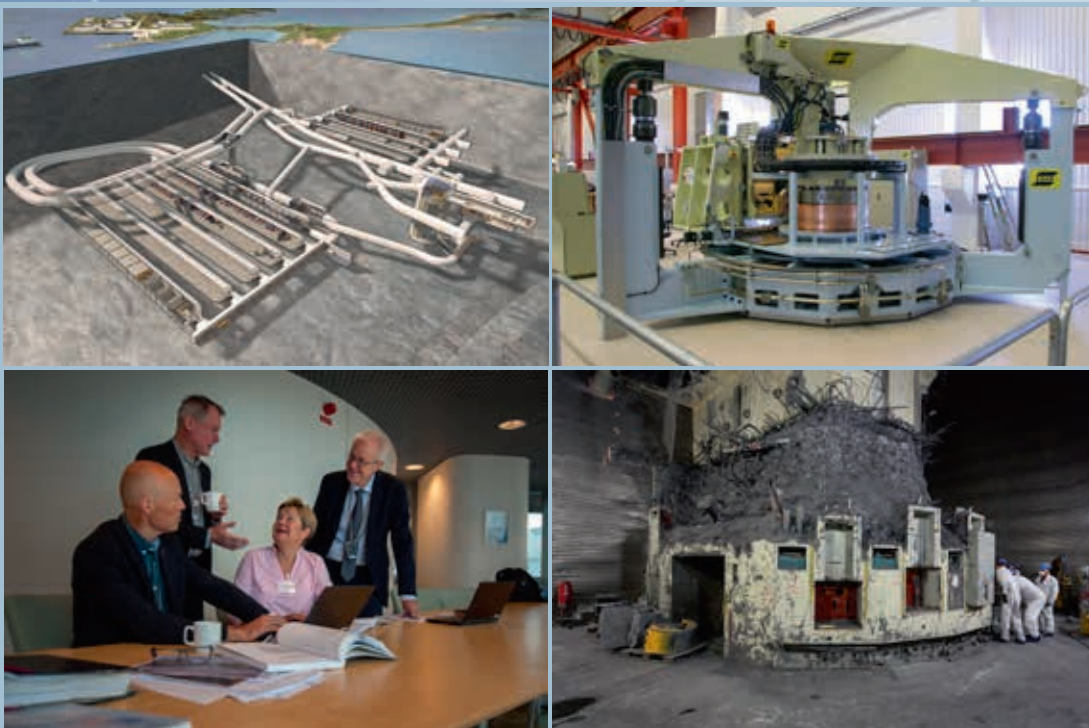


Sweden's sixth national report under the
Joint Convention on the safety of spent
fuel management and on the safety of
radioactive waste management



Sweden's implementation of the obligations
of the Joint Convention



REGERINGSKANSLIET

Ministry of the Environment
Sweden

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Upper left: Illustration of the existing repository for low and intermediate level operational waste (SFR) in Forsmark and the planned extension (the 6 vaults to the lower left) for short-lived low and intermediate level decommissioning waste.

Upper right: The Canister Laboratory equipment for development of friction stir welding of copper lids of spent nuclear fuel copper canisters.

Lower left: Part of the team responsible for writing Sweden's sixth national report under the Joint Convention.

Lower right: Dismantling and decommissioning of the research and materials testing reactor R2 at the Studsvik facilities.

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Foreword

The requirements of the Joint Convention have for a long time been incorporated in the Swedish system for spent fuel and radioactive waste management. The Swedish Government judged at the time of signing the Joint Convention in 1997 that the safety philosophy, legislation and the safety work conducted by the licensees and the authorities in Sweden complied with the obligations of the Convention.

The current report reflects an intensive phase of licensing in the Swedish programme for management of spent nuclear fuel. After six years of review by the Swedish regulator, the Land and Environment Court is now preparing for its main hearings in autumn 2017 on the licence application for a spent nuclear fuel repository at Forsmark and an encapsulation plant at Oskarshamn. The Swedish regulator and the Court expect to submit their final recommendations for a Government decision in 2018. In parallel, the Swedish regulator is also conducting a regulatory review of the nuclear industry's application to extend the existing repository (the SFR facility) for low and intermediate level waste at Forsmark.

A major change in the Swedish nuclear programme since the previous national report is that the power company Vattenfall's planning for new nuclear reactors, for the purpose of replacing existing reactors, has been put on hold since late 2014. This was followed in October 2015 by decisions of the power plant licensees to close down the four oldest reactors at Oskarshamn and at Ringhals before the end of 2020. In June 2016, the Swedish Government and opposition parties agreed on a new long-term energy policy. A goal was set of 100 per cent renewable electricity production by 2040. This was presented as a target, not as a deadline for banning nuclear power; nor does it mean closing nuclear power plants through political decisions. The agreement sets a new baseline for the operation of nuclear facilities in Sweden, with more predictable terms and planning conditions. The current situation is six reactors planned for long-term operation at the Forsmark, Ringhals and Oskarshamn sites, and seven reactors under decommissioning or planned for decommissioning at Ringhals, Oskarshamn, Barsebäck and Ågesta.

This report has been produced by a working group including representatives from the Swedish Radiation Safety Authority (SSM) and the Swedish Nuclear Fuel and Waste Management Company (SKB), see section L3. Other organisations of the nuclear industry have been consulted with and have provided information.

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 about 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 nation 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 a 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 sixth 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 the borders of Sweden. 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 through mid-2017 unless stated otherwise. The report will be subject to review in May 2018 at the Sixth Review Meeting of the Contracting Parties in Vienna.

The report’s format and content follow the guidelines for structure and content of national reports, as agreed at the Second Review Meeting of Contracting Parties to the Joint Convention, held in May 2005 (taking into account 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 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 developments since the last national report. Section A also includes a summary of highlights and issues raised about Sweden during the Fifth Review Meeting, held 11–22 May 2015, and a list of issues Sweden was asked to report on in the sixth national report.

At the Fifth Review Meeting it was agreed to address 4 topics in the National Reports for the next Review Meeting. These topics are discussed as follows in the current report:

- Staffing, staff development, reliability of funding, and other human resource areas, see sections A.6.5, E.3.2.1, E.3.2.4, F.2 and K.1.3
- Maintaining or increasing public involvement and engagement on waste management, to provide public confidence and acceptance, see sections A.6.3.7, E.2.2.2, E.2.2.8, E.3.4, G.3.1.2, K.3.1.5 and K.3.1.6
- Developing and implementing a holistic and sustainable management strategy for radioactive waste and spent fuel at an early stage, see sections A.3, A.5, A.6.3.7, A.6.4, A.7, E.3.2.5, K.2.1 and K.2.2
- Management of disused sealed sources, see section J

A.2 Overview matrix

In order to provide continuity from the second review meeting, the rapporteur's overview matrix has been revised and supplemented with references to explanatory sections of the report in Table A2 below.

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. Strategy in place for disposal.	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.	Licence application for an encapsulation plant and a spent nuclear fuel repository under review.
See section	A.6, A.7, B.1.1, E.2.2.7, K.3.1.3	A.4, A.6.5, E.2.1.4, F.2.1.2, G.1.2.1, G.1.3.1	A.7.3, B.1.2, D.1.2, G.1.2.2	A.7.4, A.8, G.5.2.1, G.5.3.1, K.2.1
Nuclear fuel cycle wastes	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 landfill sites for short-lived VLLW are present at NPP sites. Reviews of the adequacy of funding every three years.	Licence application for extension of the existing repository for short-lived LILW (SFR) under review. Long-lived LILW to be disposed of in the planned repository for long-lived LILW (SFL). Licence application expected in 2030.
See section	A.6, A.7, B.1.1, E.2.2.7, K.3.1.3	A.4, A.6.5, E.2.1.4, F.2.1.2, H.1.2.1, G.1.2.1, G.1.3.1	A.7.3, B.1.2, D.1.3, D.1.4, H.1, H.2	A.7.4, A.8, H.5, K.2.2
Non-power wastes	Disposal at fuel cycle waste facilities when appropriate; further actions ongoing.	Financed by producers/owners of waste. Government funding available for legacy wastes.	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).	Licence application for extension of the existing repository for short-lived LILW (SFR) under review. Long-lived LILW to be disposed of in the planned repository for long-lived LILW (SFL). Licence application expected in 2030.
See section	A.6.5.5, A.7.3.2, D.1.4.2, D.1.4.3, D.1.4.4	A.4, A.6.5.5	D.1.4.2, D.1.4.3, D.1.4.4	A.7.4.2, H.5.2, K.2.2
Decommissioning	Licensee is responsible.	Mainly funded by fees on nuclear energy production (NPPs) or other fees (FCF), 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.	Licence application under review for extension of the existing repository for short-lived LILW (SFR) to accommodate radioactive waste from decommissioning of nuclear facilities. Long-lived LILW to be disposed of in the planned repository for long-lived LILW (SFL). Licence application expected in 2030.
See section	A.6.2, E.2.1.1, F.6.1, G.4.1.2, G.4.2.2	A.4, A.6.5, E.2.1.4, F.2.1.2, H.1.2.1, G.1.2.1, G.1.3.1	A.4, A.7.1, F.6.2, G.6.1.7, G.6.2.7, K.3.2.1	A.7.4, A.8, H.5.2, K.2.2, K.2.4
Disused sealed sources	Returned to manufacturer.	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 wastes, SFR or SFL (if not returned to the manufacturer).
See section	J.1	J.1	J.1	J.1

A.3 Summary of results from the previous review

During the period before the fifth review meeting, Sweden received from 16 countries 89 questions in total on the report. The questions touched upon several articles of the Joint Convention and were mostly requests for clarifications, additional information and reports on experiences with specific practices. All the questions were answered on the Joint Convention website and commented on in a general sense at the review meeting.

During the discussion at the review meeting, it was agreed that Sweden seems to comply well with the obligations of the Joint Convention. It was concluded that Sweden has a comprehensive waste management programme with necessary funding mechanisms in place, an open licensing process involving extensive public consultation and engagement, and a regulatory framework encompassing clearly defined and separated responsibilities.

The review meeting identified a good practice related to Sweden's development of a spent nuclear fuel repository: 'Real progress towards a fully-operational deep geological repository for spent fuel involving the Äspö deep geological research facility, site selection for the repository, public engagement, international cooperation and concomitant development of the necessary safety case and regulatory processes.'

A number of challenges were discussed for future development as regards management of spent fuel and radioactive waste, including:

- Updating regulations
- Managing stakeholder interactions and maintaining public confidence
- Resolution of scientific issues in the licensing review of the SF repository programme
- Transition in the RW management programme from the R&D phase to licensing and implementation
- Maintaining knowledge and adequate resources of competent staff over long time periods.

Sweden was asked to report in particular at the next review meeting on the following planned measures to improve safety:

- Licensing of an encapsulation plant and a disposal facility for spent fuel
- Licensing of an extension to the existing LILW repository to also accommodate decommissioning wastes
- Development of waste acceptance criteria for long-lived waste
- Implementation of recommendations from the IRRS mission
- Implementation of Directive 2011/70/Euratom (Waste Directive) and Directive 2013/59/Euratom (BSS)
- Review and updating of regulations
- Periodic safety reviews of nuclear installations
- Periodic updating of the safety case for waste facilities
- Actions to enhance openness and transparency.

A.4 Summary of developments since the previous report

This section briefly summarises key developments in Sweden's waste management programme since the fifth review meeting under the Joint Convention. Relevant decisions regarding Sweden's nuclear power programme are also included.

Application for new nuclear reactors

The application received in 2012 from the power company Vattenfall for the replacement of one or two reactors at the existing sites in operation was put on hold by Vattenfall in 2014 due to difficult market conditions with weak demand, a surplus of generation capacity and historically low electricity prices.

Nuclear decommissioning

In October 2015 the nuclear power plant licensees decided to permanently close down the four oldest reactors at Oskarshamn (BWR units 1 and 2) in 2017 and at Ringhals (BWR unit 1 and PWR unit 2) before the end of 2020. Decommissioning activities at the two BWR units at Barsebäck, which were shut down in 1999 and 2005, have started with an interim storage facility established on the site in 2015. Dismantling and segmentation of internal reactor parts from reactor 2 commenced in 2016. The Ågesta PHWR has been in service operation since 1974. Preparations are now being made for the start of dismantling in 2020. The dismantling of Studsvik's R2 materials testing reactors started in February 2015 and is planned to continue until 2019, aiming for free-release of the facility. The decommissioning of the Ranstad uranium mining and milling facility that started in 2010 is nearing completion, with dismantling of the processing plant taking place in 2017 and subsequent radiological controls and preparations for site release. See sections A.7.1 and K.3.2.1.

New Studsvik licensee – Cyclife Sweden AB

On 1 July 2016, the radioactive waste and materials technology company Studsvik Nuclear AB (SNAB) formed a new subsidiary, Studsvik Nuclear Environmental AB (SNEAB), responsible for Studsvik's waste treatment assets and facilities for metal recycling, incineration and pyrolysis. The new licence and transfer of responsibilities were decided on by the Government in accordance with the Act on Nuclear Activities. The licence applications were reviewed by SSM. SSM also authorised the start of operations. Shortly thereafter, SNEAB was acquired by French EDF and renamed Cyclife Sweden AB, aimed at offering decommissioning and waste management services.

Licensing review of a spent nuclear fuel repository

Owing to the extended timescales of the licensing review and their implications for the predicted date of the possible launch of fuel encapsulation operations, and since it is not permitted to have two separate licensing processes ongoing simultaneously that relate to the same facility, the Swedish Nuclear Fuel and Waste Management Company (SKB) extended the scope of its licence application in March 2015 to include augmentation of the capacity of the interim storage facility for spent fuel from 8,000 tonnes of uranium to 11,000 tonnes.

Public notification of SKB's parallel licence applications under both the Environmental Code and the Act on Nuclear Activities took place in January 2016. The announcements

followed decisions by the Land and Environment Court and by the Swedish Radiation Safety Authority (SSM) that the applications were sufficiently complete to be subject to formal assessment on their merits. In June 2016, SSM submitted a statement to the Land and Environment Court based on the outcome of the Authority's review of SKB's licence applications under the Act on Nuclear Activities. In its statement, SSM presented its conclusion that both the proposed encapsulation facility and the geological repository have the potential to comply with radiation safety requirements in compliance with pertinent regulations. In addition, SSM considered that SKB's application satisfied the requirements of the general rules of consideration set out in the Environmental Code, insofar as they are applicable to protection of human health and the environment from the harmful effects of ionising radiation. In support of its statement to the Court, SSM submitted preliminary versions of its detailed review reports based on SKB's safety analyses for the two facilities. At the time of preparing this report, it is expected that the main hearings of the Land and Environment Court in assessing SKB's licence application under the Environmental Code will be conducted in September and October of 2017. Both the Court and SSM are expected to submit their final recommendations to the Swedish Government by early 2018. See also sections A.8.1, G.5.3.1 and K.2.1.

Licence application for extension of the SFR disposal facility

In 2014, SSM received a licence application for an extension of the final repository for short-lived low and intermediate level waste at Forsmark (SFR) so that it can also accommodate decommissioning waste. SSM's review is ongoing and SKB has submitted complementary information upon request by SSM. SKB has also withdrawn the part of the licence application related to interim storage of long-lived waste in the extended facility. See sections A.8.2, H.5.3 and K.2.2.

Review of SKB's eleventh RD&D programme

In September 2016, the Swedish Nuclear Fuel and Waste Management Company (SKB) submitted its eleventh tri-annual research, development and demonstration programme (RD&D Programme 2016) to SSM for evaluation and review, including a public consultation process. Based on its review, SSM concluded that RD&D Programme 2016 fulfils statutory requirements. In its statement of March 2017, the Authority recommended that the Government approve the programme's reporting. See sections A.6.4, G.1.2.1, G.1.3.1, H.1.2.1, H.1.3.1 and K.2.4.

Proposal for a revised funding system reducing the state's financial risk

In June 2013, following a Government assignment, SSM submitted proposals concerning revision of the Financing Act. The assignment was carried out in consultation with the Nuclear Waste Fund and National Debt Office. The proposal resulted in a Government bill to Parliament in June 2017 clarifying the principles for how the nuclear waste fee is calculated and how the funds in the Nuclear Waste Fund are managed in order to reduce the state's financial risk.

Overview of the Studsvik Act

In a report to the Government in 2016, SSM proposed that the special fee levied on the nuclear power utilities under the so-called ‘Studsvik Act’, for the cleanup of legacy waste from historic nuclear activities, should not be extended after expiring at the end of 2017. The Government agrees with this, which means that future contributions from the fund will be regulated through the Financing Act. If the fund’s assets are insufficient to cover future liabilities for facilities that are still in operation, these licensees of these facilities are required to pay the additional fees necessary according to the provisions of the Financing Act. See also section E.2.1.4.

Review of SKB’s estimation of costs of the future programme

SKB submitted cost estimates in January 2016 on the future management and disposal of spent nuclear fuel and nuclear waste, and decommissioning and dismantling of nuclear facilities. SSM is reviewing the cost estimates and will submit an evaluation to the Government in October 2016 as a basis for a Government decision on the guarantees to be set and the fees per delivered kilowatt-hour of electricity generated to be paid by the nuclear power plant owners to the Nuclear Waste Fund for the years 2018 through 2020. SSM’s recommendation to the Government will be based on the new principles set out in the government bill for a revised Financing Act. See also sections A.6.5.1, A.6.5.4 and G.1.3.1.

Orphan sources control

In 2016, the annual funding for enabling control and safe management of orphan sources and certain legacy waste from non-nuclear activities was increased from SEK 2.0 million to SEK 3.0 million. In addition, for the period 2016 to 2018, SEK 11 million in campaign funding has been allocated to SSM for treatment and storage of radiation sources from disused smoke detectors that have been incorrectly delivered to recycling centres. See also section J.

Implementation of the Euratom BSS directive

On 1 July 2016, after consultation with stakeholders, SSM submitted a proposal to the Government for a new act and ordinance on radiation protection for fulfilment of necessary amendments to the legislation owing to Council Directive 2013/59/Euratom (BSS). Pending Government and Parliament decisions, a review of SSM’s regulations is ongoing, with the overall aim of having all legislative changes that apply to the BSS implemented by 6 February 2018. See section K.1.1.

Implementation of Euratom directive on management of spent fuel and radioactive waste

On 20 August 2015, Sweden submitted a report to the European Commission on implementation of Council Directive 2011/70/Euratom establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste. On the same date, Sweden also provided notification of a national programme under the Directive for the management of spent fuel and radioactive waste, see also section A.9.1.

Under the Ordinance with instructions for the Swedish Radiation Safety Authority (2008:452), SSM must ensure that there is a current national plan in place for management of spent fuel and radioactive waste which corresponds to the content required under Article 12

of the directive. The Swedish National Programme, submitted to the European Commission in 2015, is an up-to-date national plan accounting for the origin, management, treatment, transport, interim storage and final disposal of spent nuclear fuel and other radioactive waste in Sweden. The National Programme gives an account of the quantities of spent nuclear fuel and radioactive waste produced, as well as estimates of future quantities. This programme was prepared by SSM following consultation with stakeholders. See section K.5.

Implementation of the Euratom nuclear safety directive

Parliament (the Riksdag) has decided to amend the Act on Nuclear Activities in order to implement the EU's revised nuclear safety directive, 2009/71/Euratom. The changes clarify the licensee's responsibility for safety and that safety must be continuously evaluated and verified. New provisions are also introduced to give the supervisory authority insight into how the licensee ensures that contractors and suppliers meet the safety requirements. The amendments will enter into force on 1 August 2017.

IRRS mission

In May 2016, SSM underwent an international review of Sweden's compliance with IAEA standards in the form of an IRRS (Integrated Regulatory Review Service) review mission. The review was a follow-up of the full scope IRRS mission that took place in February 2012. The follow-up mission concluded that the Swedish system for nuclear safety and radiation protection is solid and continues to show good progress. The Authority has taken into consideration and dealt with the recommendations and suggestions made during the 2012 review. New areas for improvement were identified as well as good practices, including a regulatory risk management approach and a comprehensive and integrated development of revised regulations. See sections A.9.4.1 and K.4.

Revising and updating regulations

In 2012 SSM initiated a major multi-objective revision of its regulatory framework. The revision addresses IRRS recommendations regarding consistency of the Swedish regulatory framework with IAEA Safety Standards. It takes into account the above-mentioned implementation of the EU directives on nuclear safety, waste management and the BSS, as well as implementing WENRA's applicable safety reference levels. Another important goal of the regulatory revision is to create greater predictability for licensees as well as to improve the regulatory support for SSM in its supervisory activities. See section K.1.1.

European Spallation Source

The Swedish Radiation Safety Authority decided on 30 June 2017 to grant the European Spallation Source ERIC (ESS) authorisation to begin installation of the ESS research accelerator in Lund. Further permission will be required from the Authority before this facility may be commissioned. The Authority has now granted the company a licence to begin installations at the facility. This means that ESS is allowed to import, acquire, install and own technical devices and other components for generation of ionising radiation. The ESS application has also been reviewed by the Land and Environment Court under the Environmental Code. On 12 June 2014, the Court gave ESS conditional approval, see section A.10.

A.5 Development of a national policy for spent fuel and radioactive waste management

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

The legal framework corresponds very well to the objectives of the Joint Convention. An overview is given in sections A.6 and E.

A.5.1 Past practices

In Sweden, nuclear engineering was launched in 1947, when AB Atomenergi was established to realise a development programme resolved by Parliament. The first research reactor, R1, went critical in 1954 at the Royal Institute of Technology in Stockholm (KTH), and was in operation until 1970. The R1 reactor was followed by the first prototype nuclear power plant (PHWR) in Ågesta, which was mainly used for district heating in a suburb of Stockholm from 1964 to 1974, when it was permanently shut down. Two steam generators were dismantled and waste treated at Studsvik in the early 1990s. Currently, preparations are being made for radiological characterisation and planning of future decommissioning.

The first commercial nuclear power plant, Oskarshamn 1, was commissioned in 1972, and was followed by an additional eleven units at four sites in southern Sweden: at Barsebäck, Oskarshamn, Ringhals and Forsmark until 1985, see Figure A1. The twelve commercial reactors constructed in Sweden comprise nine BWRs (ASEA ATOM design) and three PWRs (Westinghouse design). As a result of political decisions, the twin BWR units Barsebäck 1 and 2 were shut down permanently in 1999 and 2005, respectively. In 2015, the utilities decided for commercial reasons to shut down the four oldest reactors at Oskarshamn (BWR units 1 and 2) in 2017, and at Ringhals (BWR unit 1 and PWR unit 2) before the end of 2020.

Other early activities that generated spent fuel and radioactive waste in Sweden include work that took place at the Studsvik site, with two materials testing reactors (R2 and R2-0) in operation between 1958 and 2005. Dismantling of the permanently closed down reactors is ongoing.

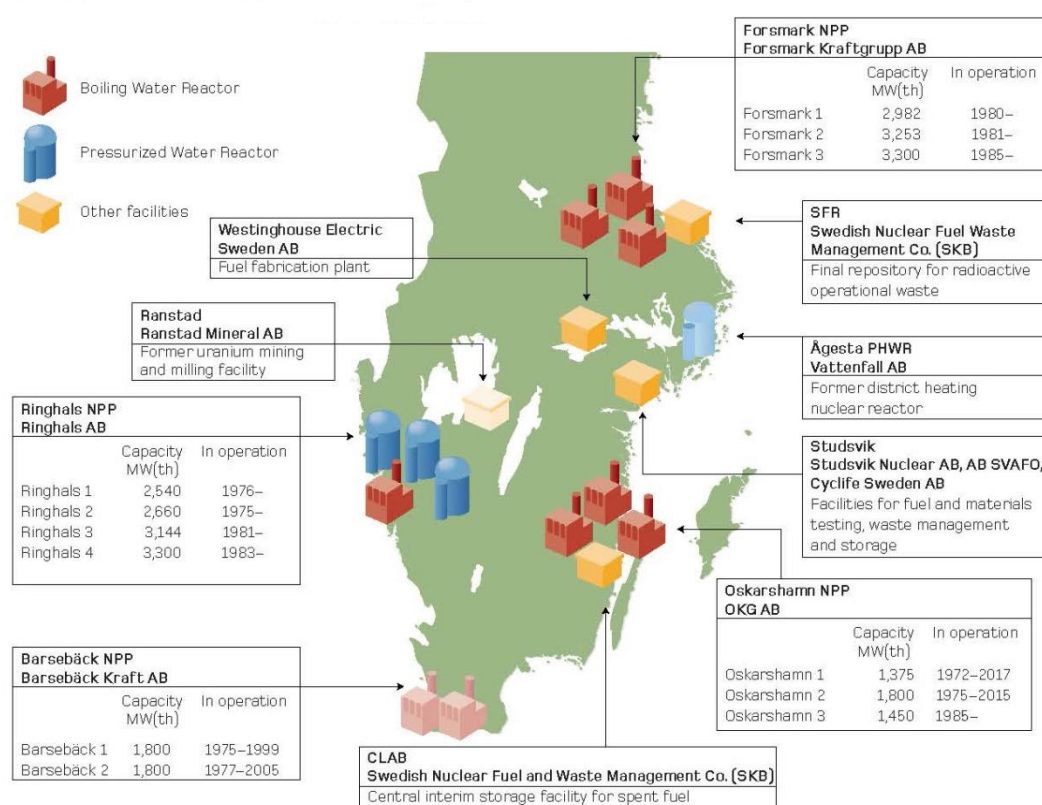
The uranium mining and milling facilities in Ranstad were constructed and operated in the 1960s. In total about 200 tonnes of uranium were produced. The uranium open-cast mine and the mill-tailings deposits were restored and covered in the 1990s. Currently, decommissioning of the remaining facility is ongoing and is planned to continue until 2018.

Sea dumping of radioactive waste was limited to low-level waste and occurred in Swedish territorial waters as well as in the Atlantic. The last dumping occurred in the late 1960s. Sea dumping has been prohibited by Swedish legislation since 1971.¹

In 1985, the Swedish Nuclear Fuel and Waste Management Company (SKB) commissioned Clab, an interim storage facility for spent nuclear fuel at Oskarshamn. A repository for low and intermediate level waste, SFR, was commissioned in 1988 at Forsmark in Östhammar Municipality. In 2009, SKB also selected Forsmark as the proposed site for a spent nuclear fuel repository, and in 2011, the company submitted its licence applications for this. In 2014, SKB also applied for permission to extend the SFR facility to accommodate decommissioning waste from Swedish nuclear reactors.

¹ For more information, see IAEA-TECDOC-1105, available at www.iaea.org, and SKI Report 96:78/SSI Report 96:18 (in Swedish only) available at www.ssm.se

Figure A1 Nuclear facilities in Sweden



A.5.2 Milestones in the development of the legal framework

Sweden's first legislation on radiation protection was enacted in 1941 to regulate the risks associated with ionising radiation. Initially, the act referred mainly to medical applications, but the legislation was also applied in 1954 to the licensing of Sweden's first nuclear reactor, R1, located at the Royal Institute of Technology in Stockholm.

In 1956 the Riksdag (Swedish parliament) passed the first act specifically regulating nuclear activities. This act contained basic requirements for construction and operation of a nuclear reactor. The act was the forerunner to the current Act on Nuclear Activities from 1984.

In the late 1970s, the first requirements were issued concerning the operator's responsibility to safely manage and dispose of nuclear waste as well as ensuring the financing of any costs incurred. At that time it was also stated that an operator must be responsible for research and development programmes in order to safely manage the nuclear waste generated and to safely decommission and dismantle plants no longer to be used.

In 1977 the Parliament promulgated the Stipulation Act, which required a government permit for loading nuclear fuel into a new reactor. A permit could only be issued if the utility presented either an agreement for reprocessing of the spent fuel, or a plan for the safe disposal of the highly radioactive waste. As a result, the nuclear industry initiated a joint project on nuclear fuel safety (KBS) that included the development of disposal methods as well as a wide-ranging siting programme. The first summary report of the KBS project (KBS-1) published in 1977 described a method for the disposal of high-activity reprocessed vitrified waste. The report formed the basis of the subsequent Government permission granted in 1979–1980 for loading fuel into newly established reactors. A second summary report (KBS-2) dealing with the disposal of spent non-reprocessed nuclear fuel was issued in 1978. A revised version of the second report, focusing on direct geological disposal (KBS-3), was published in 1983.

In 1981, the Act on Financing of Management of Residual Products from Nuclear Activities laid down the principles for the reactor operators' financing of expenses for decommissioning and disposal of spent nuclear fuel and nuclear waste. In 1984, the Stipulation Act was replaced by the Act on Nuclear Activities, which required reactor operators to develop a final disposal system in the framework of a research and development programme for the safe handling and disposal of spent fuel and nuclear waste, as described in sections A.6 and E.2.

A.5.3 Fundamental principles

Fundamental principles for the management of spent fuel and radioactive waste have evolved in stages since the 1970s through public debate and a number of policy decisions taken by both the Government and Parliament. These principles are reflected in the Swedish legislation, which is further described in sections A.6 and E.2.

The most important fundamental principles of the national policy are:

1. Costs for the treatment and disposal of spent fuel and radioactive waste from nuclear activities shall be covered by fees that licensees are required to pay.
2. The licensees are to safely dispose of spent nuclear fuel and radioactive waste from nuclear activities.
3. The state has the ultimate responsibility for final management of spent nuclear fuel and radioactive waste from nuclear activities.
4. Each country is to be responsible for the spent nuclear fuel and radioactive waste generated by nuclear activities in that country.

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

The Swedish policy was originally based on the assumption that reprocessing and plutonium recycling would form attractive and desirable elements of the nuclear fuel cycle. As commercial reactors were built in the early 1970s, arrangements were also made to send spent fuel abroad for reprocessing. In the late 1970s, attitudes changed, mainly due to non-proliferation concerns. Since then, the strategy has been direct disposal without reprocessing. In practice, this means that spent nuclear fuel is treated as waste, although it is not legally defined as waste until disposed of in a repository.

A.6 Current legislative and regulatory framework

A.6.1 General requirements

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
- The Act on Financing of Management of Residual Products from Nuclear Activities

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

The Environmental Code contains 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 selection of the most appropriate location where the purpose of the activity can be achieved with a minimum of damage and detriment to human health and the environment. The Code also contains rules on 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 disposal of spent nuclear fuel and nuclear waste.

Detailed regulations issued by SSM supplement the general requirements. If needed, the Authority may specify licence conditions in individual cases.

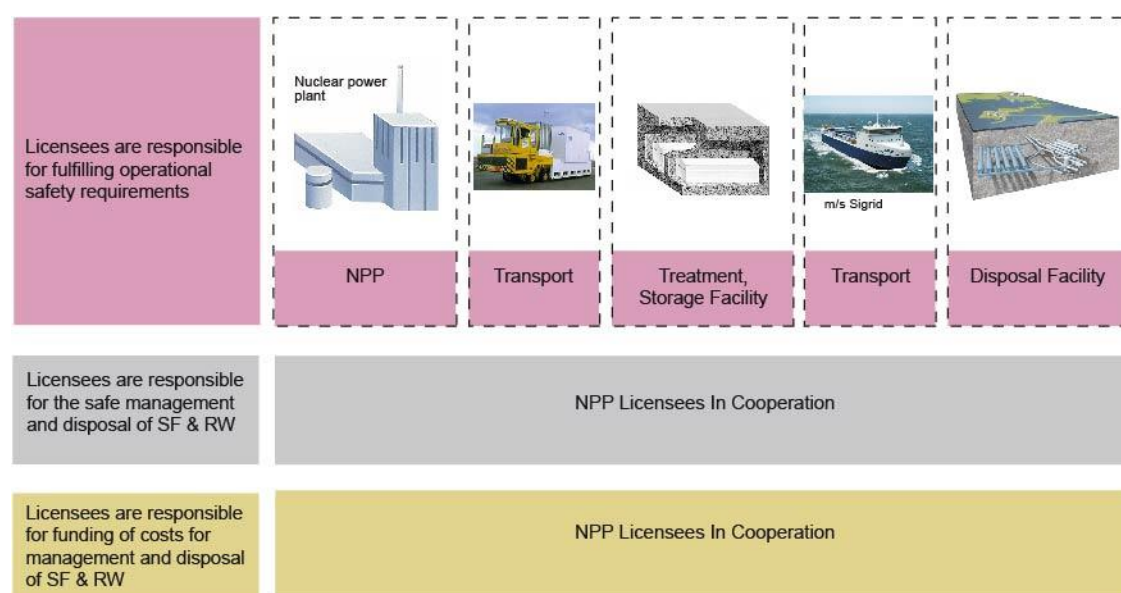
A.6.2 Licence holder responsibilities

The holder of a licence 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 in which the activities will cease.

Swedish nuclear power plant licensees also have some important shared obligations. They must in cooperation:

- establish and carry out a research and development (RD&D) programme for the safe handling and disposal of spent fuel and nuclear waste, see also sections A.6.4 and E.2.1.1, and
- carry out cost estimates for management and disposal of spent fuel and nuclear waste as a basis for payments to be made to the Swedish Nuclear Waste Fund, see also section E.2.1.4.

Figure A2 illustrates licensees' responsibilities.

Figure A2 Basic requirements and general obligations of licensees

The four utilities operating nuclear power reactors have joint ownership of the Swedish Nuclear Fuel and Waste Management Company, SKB, which fulfils the utilities' above-mentioned shared obligations and assists them in executing their responsibilities.

SKB is also responsible for the planning and construction of facilities required for the management of spent nuclear fuel and radioactive wastes, and the research and development work associated with these facilities. SKB is also responsible for calculating the costs associated with the management of spent fuel and radioactive waste, as well as for the costs for future decommissioning of the nuclear power plants and other nuclear facilities.

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

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: medicine, industry, agriculture, research and education, see sections E.2.1.4 and J.

A.6.3 Regulatory control and supervision

A.6.3.1 Licensing

All new 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 the competent authority.

A key element of the regulatory framework is the clearly defined stepwise licensing process, see section E.2.4.1.

A.6.3.2 Roles and responsibilities

The Swedish Radiation Safety Authority (SSM) is the competent authority that supervises licensees of nuclear activities in fulfilling their responsibilities for safe operation of facilities and transports as well as in planning for decommissioning and disposal, see section E.2.2.5.

SSM has the adequate levels of authority, competence and financial and human resources to fulfil its assigned responsibilities, see sections E.3.2 and K.1.3.

A.6.3.3 Independence of the regulatory authority

The regulatory body's independence is of fundamental importance in the Swedish constitution. As a central administrative authority, SSM receives its budget appropriations and instructions on its general direction of operations from the Swedish Government. SSM is at the same time independent in its decision-making under Swedish legislation.

Although the independence of the regulator is stated in Swedish legislation, it is also a matter of public service culture and values. A strong, independent and fully accountable national authority is also confident and trustworthy in upholding high safety standards. As an example, the integrity of SSM has become increasingly vital with the progression of the licensing review of SKB's application for a spent fuel repository. Strict internal rules apply to interaction with an applicant and to the regulator's independence in relation to the nuclear industry, see sections E.3.3 and K.3.1.4.

A.6.3.4 Regulatory inspections

In accordance with its legal authorisation and its mandate defined by the Government, the regulatory authority conducts regular inspections and assessments of nuclear and other facilities whose work involves radiation in order to ascertain compliance with regulations and licence conditions, see section E.2.2.5.

A.6.3.5 Documentation and reporting

Extensive reporting from licence holders is required. Annual reports are to be submitted to SSM on activities at the facility, 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, and that can lead to deterioration in safety in addition to what is anticipated in the safety analysis report, must be reported to SSM without unnecessary delay, see section E.2.2.5.

The licensee of a nuclear facility must also 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.2.2.5.

At least once every ten years, licensees are required to perform a periodic safety review (PSR), i.e. an integrated analysis and assessment of the safety of a facility, see sections E.2.1.1 and E.2.2.5.

A.6.3.6 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 so required in the specific case to ensure compliance, see section E.2.2.3.

A.6.3.7 Provisions for public engagement and transparency

Building public confidence and acceptance in the management system for spent nuclear fuel and radioactive waste strongly benefits from a national system based on consistent and long-term strategies and planning. As stated above, the financial arrangements have long been in place in Sweden and performing successfully over nearly three decades now, plus a research and development programme for waste management and disposal has been continually in progress for more than 30 years, with its long-term strategies being implemented nationally on an ongoing basis. The respective Clab and SFR storage and disposal facilities have been in operation since the 1980s. An application for a spent fuel repository has been undergoing review since 2011, and in 2014 an application for extension of the SFR facility to accommodate decommissioning waste was submitted to the authorities.

The legal framework for licensing of nuclear activities also 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.

Through the mandatory review of RD&D programmes and cost estimate reports, SSM supervises the development of management and disposal systems in the pre-licensing process. In addition to the regulatory involvement and strategic Government decisions, the review process also includes opportunities for broad public participation in the development of a Swedish management system for spent fuel and radioactive waste.

For example, SKB's siting process for a spent fuel repository involved local communities on a voluntary basis, with the possibility to end participation during all stages. To enable active participation in formal consultations during the licensing process, host municipalities, regional authorities and certain environmental organisations receive financial support through the Nuclear Waste Fund. Preceding the Government's licensing decision, the host municipality concerned has a right to veto and is to formally declare its support or rejection of the decision. In practice, these arrangements have thus far been very beneficial to the overall quality and public acceptance of the repository licensing process.

SSM has taken several measures to support the engagement of municipalities, NGOs, the public and other stakeholders in the ongoing licensing review of the spent nuclear fuel repository. Firstly, SSM has distributed SKB's application as part of a broad national consultation in order to gather review comments from stakeholders. Secondly, SSM successively publishes all relevant documents on its website, including consultants' review reports, preliminary review statements and all dialogue with SKB.

The Swedish approach to building trust in the high-level waste management system as well as to regulator integrity was awarded a good practice in the 2011 IAEA IRRS review. See also sections E.2.2.8, E.3.4, K.3.1.6 and K.5.

A.6.4 National RD&D programme

The Act on Nuclear Activities requires from the power plant operators an R&D programme (since 1992 denoted as the programme for Research, Development and Demonstration, the ‘RD&D programme’) needed for the safe management and disposal of spent nuclear fuel and nuclear waste, and safe decommissioning and dismantling of nuclear power plants.

Every three years, on the behalf of the operators, SKB submits a report on this programme to the regulatory authority for review and for a public consultation. The report is to include an overview of all measures that may be necessary and must specify the actions to be taken within a period of at least six years. Based on SSM’s review recommendations, the Government approves or rejects the general direction of the continued programme. In connection with the decision, the Government may also issue conditions on the content of future research and development work.

Since 1986, SKB has carried out and reported on ten research programmes with the KBS-3 method being the main alternative for the geological disposal of spent fuel. An important goal of the programme was fulfilled when an application for a licence to construct a disposal facility for spent nuclear fuel was submitted to SSM and the Land and Environment Court on 16 March 2011, see section A.8.1.

The most recent RD&D programme was published by SKB and submitted to SSM in September 2016. From its review and evaluation, SSM concluded that the programme fulfils statutory requirements. SSM also concluded that the licensees of nuclear power reactors complied with the conditions imposed by the Swedish Government in the decision on the RD&D Programme 2013, as regards improved clarity and structure as well as consultations with SSM in matters relating to development of decommissioning plans and dismantling studies.

The overall system for managing spent fuel and nuclear waste including future plans for its implementation, as presented in SKB’s RD&D Programme 2016, is described in section A.7. This includes e.g. decommissioning of nuclear facilities, extension of the disposal facility for short-lived low and intermediate level operational waste (SFR) to accommodate decommissioning waste, as well as planning for realisation of a future disposal facility for long-lived radioactive waste (SFL).

A.6.5 The financing system

A.6.5.1 Nuclear power plants

The purpose of the financing system (section E.2.1.4), 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.² The objective is to minimize the risk of the state and future generations being forced to bear costs considered to be the liability of the licensees. The licensees pay a fee to the Nuclear Waste Fund. If there is insufficient money in the Fund to pay for the costs, the nuclear companies will nevertheless still be liable.

SKB coordinates the nuclear power utilities’ cost estimates and submits these to the regulator, SSM, every three years. SSM reviews the cost estimates and calculates the fees and guarantees to be set individually for each utility. The fees are calculated on the assumption that each reactor will generate electricity for 40 years (50 years is suggested in a government bill and applicable to fees payable during the period 2018–2020, but this is not yet decided), though always with a minimum remaining operating time of six years. Based on SSM’s pronouncement, the Government sets the nuclear waste fees and guarantees for a period of three years. Management of the assets of the nuclear waste fund is the mandate of a separate

² Costs for management of operational radioactive waste are payable directly by the nuclear power utilities.

government agency bearing the same name (Nuclear Waste Fund). The Swedish National Debt Office authorises the guarantees provided.

The power plant utilities must provide two separate guarantees as security to cover:

- the shortfall if a reactor is closed before the end of its licensed operating time, and
- costs in connection with unexpected events.

To date, the Nuclear Waste Fund has covered SKB's expenses for the central interim storage facility for spent nuclear fuel (Clab), for the transport system and for the research and development activities, laboratories, siting and feasibility studies included. Future expenses should cover the encapsulation plant for spent fuel, repositories for spent fuel and long-lived low and intermediate level waste, the decommissioning and dismantling of nuclear power plants, the disposal facility for decommissioning waste and the continued research and development work. The waste fund also finances regulatory control and supervision following closure of reactors.

The Government decided in 2011 to increase the fee from an average of SEK 0.01 per kWh of produced nuclear electricity (approx. EUR 1.0 per MWh) to an average of SEK 0.022 (approx. EUR 2.2 per MWh) for the period 2012–2014. In 2014, the Government decided to raise the fee to an average of SEK 0.04 per kWh (approx. EUR 4.0 per MWh) for the period 2015–2017. In October 2017, SSM is to submit the review results of SKB's 2016 cost estimates to the Government, with an updated proposal for fees and guarantees to be decided for the period 2018–2020. A substantial increase in the fees is expected, as two reactors will be taken out of operation at Oskarshamn in 2017, and another two reactors at Ringhals before 2020, resulting in fewer production units paying for the liabilities.

A.6.5.2 Other nuclear facilities

Licensees other than nuclear power reactor operators must also pay fees to the Nuclear Waste Fund. Cost estimates and the buildup of adequate financial resources are based on the expected remaining period of operation. The licensees of nuclear facilities other than nuclear power reactors must also provide a guarantee to cover the discrepancy between funded means and estimated costs.

The regulatory authority, SSM, decides on the nuclear waste fees and guarantees for other nuclear facilities for a period of three years.

The licensees of nuclear facilities other than nuclear power reactors paid a total of SEK 54.6 million per year during the period 2014–2016 in accordance with SSM's decision. In 2017, SSM will issue a new decision for the period 2017–2019.

A.6.5.3 Legacy waste

There is also a funding mechanism for legacy waste from historic nuclear activities. A special fee is levied on the nuclear power utilities according to what is referred to as the 'Studsvik Act'. The fee is intended to cover expenses for decommissioning of the research reactors at Studsvik, the Ågesta reactor and the uranium mine at Ranstad.

The Studsvik Act stipulates a set fee of SEK 0.003 per kWh of produced nuclear electricity (approx. EUR 0.3 per MWh). The Act is in effect until the end of 2017, when the fund should be complete. SSM reviews the fee on a yearly basis and can propose legislative changes to the Government if needed.

In a report to the Government in 2016, SSM proposed that the Act should not be extended. The Government agreed, which means that future contributions from the fund for cleanup activities will be regulated through the Financing Act. If the fund's assets are insufficient to cover future liabilities for facilities that are still in operation, and which were previously recipients of the fund, then these licensees are required to pay the additional fees necessary according to the provisions of the Financing Act.

There is also a state financing scheme administered by SSM for the cleanup of orphan sources and other legacy waste.

A.6.5.4 Financing system supervision

In 2011, the Swedish Government assigned SSM to review the Act (2006:647) and the Ordinance (2008:715) on Financing of Management of Residual Products from Nuclear Activities. This review was to be carried out in consultation with the Nuclear Waste Fund and Swedish National Debt Office. The purpose was to clarify the principles for calculating nuclear waste fees and managing the assets in the Nuclear Waste Fund, while also reviewing the provisions concerning use of guarantees for improving the level of financial security on the part of the state.

Significant material changes proposed by the authorities in their June 2014 report were:

- Broadening the investment opportunities of the Nuclear Waste Fund,
- Linking the discount rate curve to the Nuclear Waste Fund's anticipated yield and stipulating the calculation principles in the Act and Ordinance,
- Basing the computation of fees on 50 years of operation on the part of nuclear power reactors in operation,
- Broadening the guarantee for contingencies in order to cover risks in terms of both assets and liabilities, in addition to their being computed by the state, and
- Implementing an option to claim guarantees provided in cases where the fund assets of a fee-labile licensee cannot be expected to cover the expenses and this licensee undertakes no other measures.

Other changes proposed in the authorities' report mainly served to provide clarifications and to increase the level of precision in the regulatory framework. In addition to the proposed statutory amendments, the authorities identified a need for continued development of analysis methods for the computation of fees and guarantees.

The Government has proposed in a bill to Parliament that these changes be implemented in the Financing Act in due time for the Government's decision to be made on fees and guarantees for the period 2018–2020.

A.6.5.5 Non-nuclear activities

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: medicine, industry, agriculture, research and education. Radioactive waste that is to be disposed of is sent to Cyclife Sweden AB for treatment and storage prior to disposal, for which the waste producer must pay a fee. Institutional waste is, as appropriate, disposed of in disposal facilities for nuclear waste. In 1984, the Government agreed on 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. When radioactive waste is to be disposed of in SFL, the fee to Cyclife Sweden AB includes the cost for this disposal.

A.7 The management system for spent nuclear fuel and radioactive waste

A.7.1 Decommissioning plans

In the 1970s and 1980s, twelve nuclear reactors were built at four sites in southern Sweden: Forsmark, Ringhals, Oskarshamn and Barsebäck, see Figure A.1.

The Barsebäck reactors (BWR units 1 and 2) were shut down in 1999 and 2005, respectively. In October 2015 the nuclear power plant licensees decided to permanently shut down the four oldest reactors in operation in Sweden: at Oskarshamn (BWR units 1 and 2) in 2017 and at Ringhals (BWR unit 1 and PWR unit 2) by 2020. In practice, Oskarshamn 2 was never restarted following an extended period of shutdown, and Oskarshamn 1 was permanently shut down in June 2017. Ringhals units 1 and 2 will be permanently shut down in conjunction with the maintenance outages in 2020 and 2019, respectively.

The remaining six operating reactors are undergoing preparations for long-term operation of at least 60 years, which means that three reactors at Forsmark, two at Ringhals and one reactor at Oskarshamn will be shut down between 2040 and 2045. For details on the licensees' decommissioning planning, see section F.6.2.

The decisions on early permanent shutdown of four nuclear power reactors mean a decrease in the total amount of fuel to be managed within the framework of the programme. However, a larger quantity of fuel will arrive earlier to Clab when the final fuel cores from the four reactors are transported there.

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 that waste type descriptions for example be devised 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 the radioactive material that will not be disposed of by SKB, such as a licence for landfill disposal of very low-level decommissioning waste in near-surface repositories at the nuclear power plants.

Decommissioning activities have started at Barsebäck after many years of service operation. In 2015 an interim storage facility was established on the site, and in 2016, the dismantling and segmentation of internal reactor parts from unit B2 commenced. The final dismantling work is planned for 2021. Dismantling is scheduled to begin in 2020 for the Oskarshamn reactors and during the period 2021–2022 for the Ringhals reactors.

According to the operator Vattenfall's planning, dismantling of the Ågesta reactor (PHWR), shut down in 1974, will commence no later than 2020. The final dismantling of Studsvik's R2 materials testing reactor, which began in February 2015, will continue until 2019, with the facility undergoing preparations for free release. A new storage building for low and intermediate level decommissioning waste from R2 and eventually Ågesta will be established and operational on the Studsvik site from 2018. The decommissioning of the Ranstad uranium mining and milling facility that started in 2010 is nearing completion, with the dismantling of the processing plant taking place in 2017 and subsequent radiological controls and preparations for site release.

The general timetable for the nuclear power companies' and SKB's planned decommissioning of their facilities is presented in Figure A3. Here, the current period is dominated by activities at the nuclear power reactors Barsebäck 1 and 2, Oskarshamn 1 and 2, Ringhals 1

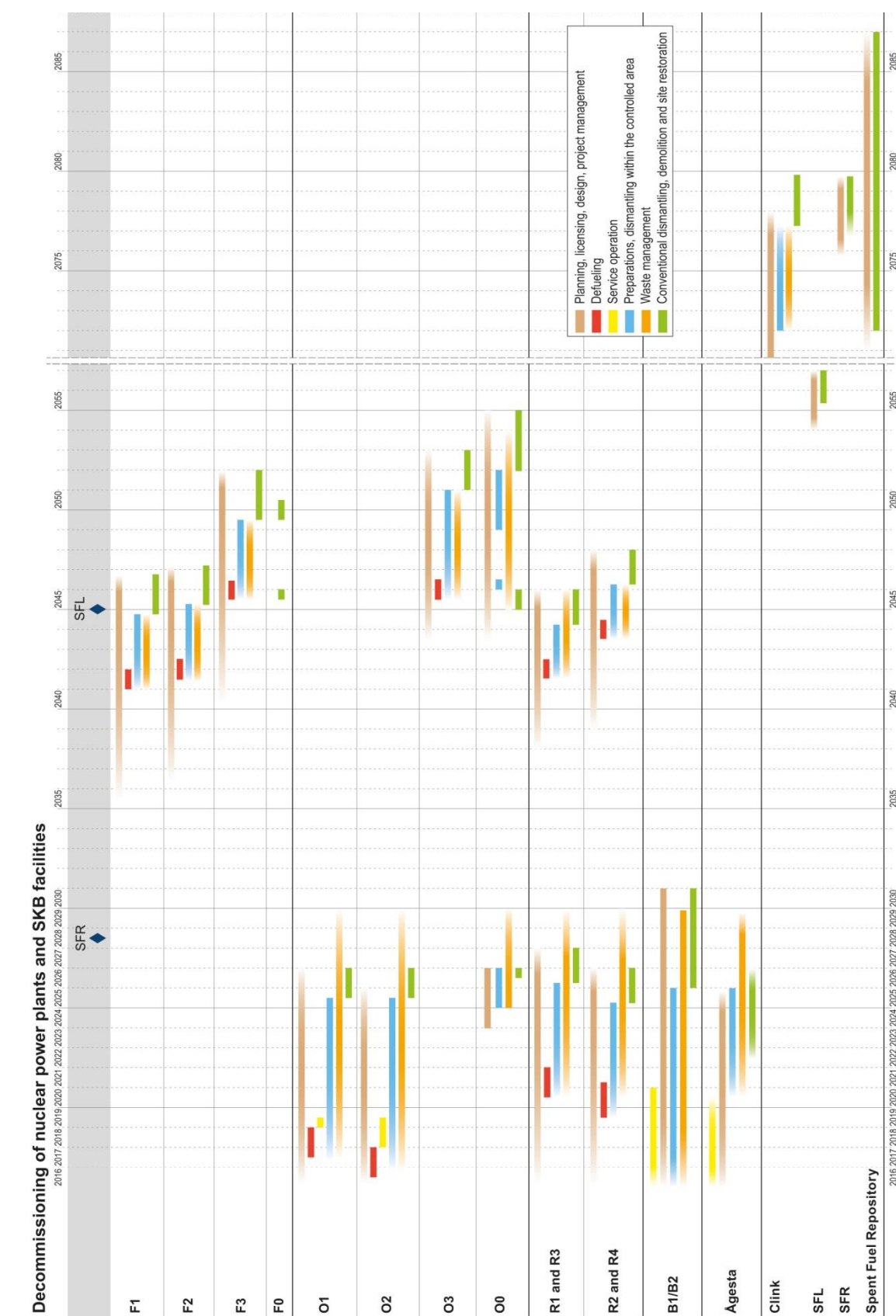
and 2, and the Ågesta reactor. The ongoing decommissioning of the materials testing reactors at Studsvik and the Ranstad uranium facilities is not included in the figure.

Decommissioning of the first nuclear power reactors has started before the expanded SFR repository will be available for the disposal of shorter-lived decommissioning wastes and before the construction of the SFL repository for long-lived decommissioning wastes. For this reason, the radioactive waste must be placed in interim storage prior to final deposition. The load on the transportation system will increase when the expanded SFR and SFL repositories are commissioned, and the interim stored wastes can be transferred for final disposal.

As regards radioactive waste materials arising from the decommissioning of the Barsebäck reactors, this means planning for additional interim storage capacity for low-level waste on site in addition to the recently constructed interim storage facility for long-lived medium-level waste. Waste produced during decommissioning of the reactors at Oskarshamn and Ringhals will need to be stored on site in existing facilities until these wastes can be transferred to the expanded SFR or SFL repository. Radioactive wastes produced during decommissioning of the Ågesta reactor may need to be transferred to another site for storage pending final disposal. Some of these licensees are also investigating the possibilities for near-surface disposal on site for very low level decommissioning wastes.

When it comes to handling of long-lived waste, approximately half of this waste will arise before the planned commissioning of SFL. Since the waste cannot be finally conditioned before the set of requirements for SFL is determined, which presupposes that the repository site is known, the long-lived waste needs to be placed in waste containers without final conditioning until final conditioning becomes possible. According to the current timetable, final conditioning can commence at the earliest in conjunction with SKB obtaining a licence to build SFL, which is planned for the late 2030s.

Figure A3 Schematic overview of the nuclear power companies' and SKB's timetables for decommissioning (F0 and O0 are shared facilities on the sites reported separately)



A.7.2 Generation of spent fuel and radioactive waste

The national strategy for spent nuclear fuel is direct disposal without reprocessing, i.e. spent fuel is managed as waste and not as a resource in the Swedish programme. The spent fuel, after cooling on the reactor site, is transported by ship to the central interim storage facility, Clab, located next to the Oskarshamn nuclear power plant.

A final repository for short-lived low and intermediate level operational waste, the SFR facility, is located next to the Forsmark nuclear power plant.

The nuclear power plants at Ringhals, Forsmark and Oskarshamn, and the Studsvik site, also have shallow landfill facilities on site for solid short-lived low-level operational waste.

Other Swedish fuel cycle facilities include:

- The Westinghouse fuel fabrication plant in Västerås, central Sweden.
- The Studsvik site, with waste management and treatment facilities for both nuclear and non-nuclear waste, as well as closed down materials testing reactors that are currently under decommissioning.
- The closed down uranium extraction facility in Ranstad that is under decommissioning.
- The Ågesta nuclear power station that was in operation between 1964 and 1974. This was the first commercial NPP in Sweden.

Operational radioactive waste is produced by the nuclear reactors and fuel cycle facilities. Radioactive waste also originates from medical and research institutions, industry and consumer products. Past research activities also generated some waste, which is either stored or has already been disposed of.

The spent nuclear fuel is interim stored in Clab. During the time it takes to construct and commission the encapsulation section, the quantity of spent nuclear fuel that needs to be interim stored in the facility will exceed the current licence of 8,000 tonnes. SKB has therefore, as part of the application for construction and operation of Clink, also applied to increase the interim storage capacity to 11,000 tonnes.

Short-lived waste is deposited in SFR or in near-surface repositories. The near-surface repositories, where waste with very low-level radioactivity is deposited, are operated by the nuclear power companies, whereas SFR is operated by SKB. Under the current licence, about 37,000 cubic metres of short-lived operational waste will be disposed of in near-surface repositories at the Forsmark, Oskarshamn and Ringhals nuclear power plants. According to current projections, about 170,000 cubic metres of waste plus nine segmented reactor pressure vessels from BWRs will be disposed of in SFR. Most of the short-lived waste originates from the nuclear power plants. Other waste originates from Clab (a central interim storage facility for spent nuclear fuel) and from Cyclife AB, Studsvik Nuclear AB and AB SVAFO.

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). Long-lived radionuclides are formed from stable elements in (for example) steel when they are exposed to strong neutron radiation from the reactor core. The total quantity of long-lived low and intermediate level waste is estimated at about 16,000 cubic metres, about one-third of which comes from the NPPs. The rest comes from facilities operated by Studsvik Nuclear AB and AB SVAFO. SKB plans to dispose of the long-lived waste in SFL.

The facilities in the KBS-3 system are designed for a total amount of spent nuclear fuel equivalent to about 6,000 canisters. One canister contains approximately two tonnes of fuel. The amount of spent nuclear fuel is given as the weight of the uranium that was originally present in the fuel.

In addition to all the spent nuclear fuel from Swedish nuclear power plants (including fuel from the Ågesta reactor), the amount of spent nuclear fuel to be deposited in the spent fuel

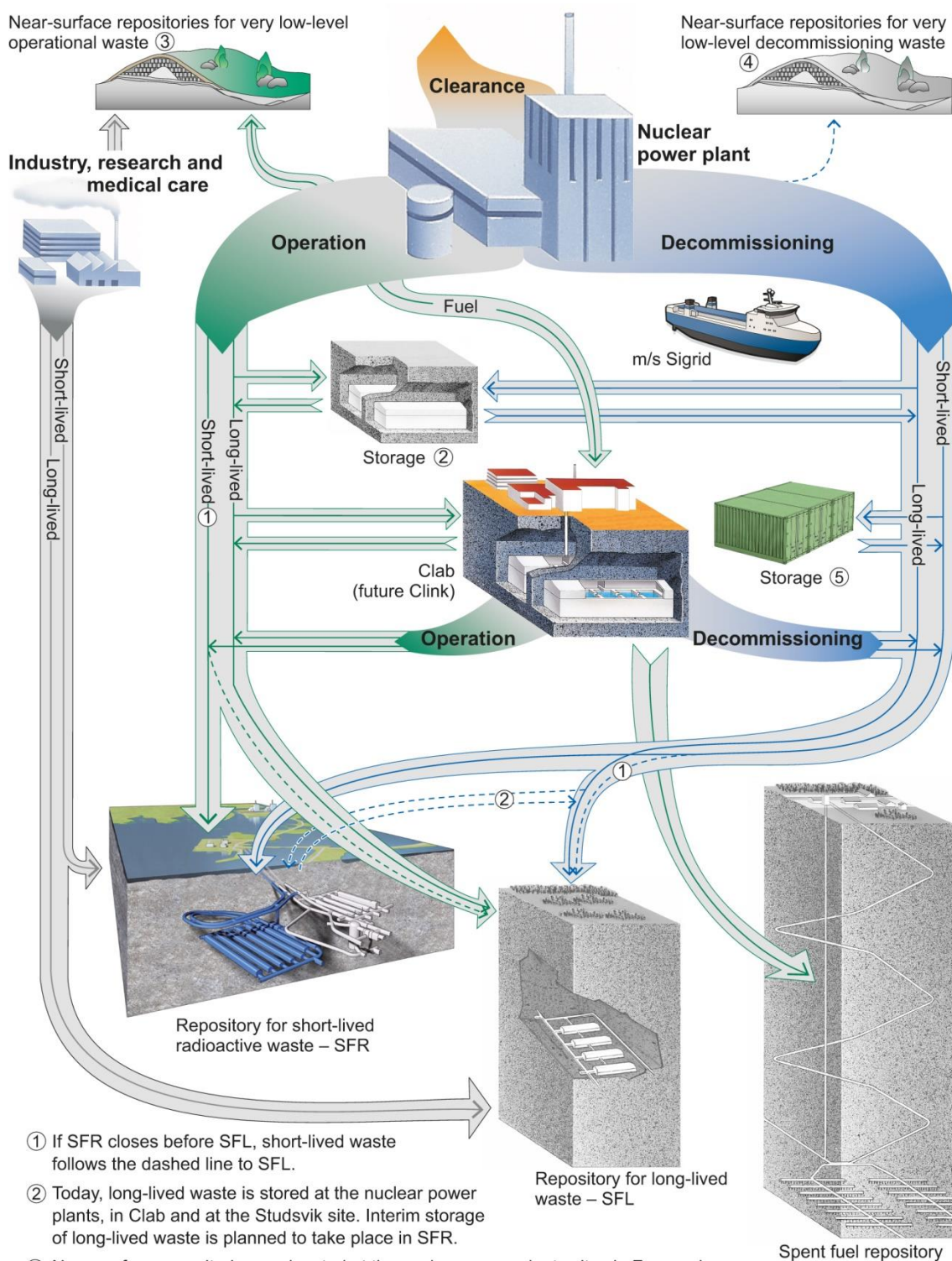
repository also includes fuel residues from testing programmes at Studsvik, as well as MOX fuel (mixed oxide fuel). These fuel types comprise a very small fraction of the total. Approximately 20 tonnes of spent nuclear fuel from Ågesta and approximately two tonnes of spent nuclear fuel from Studsvik 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. Sweden has also sent a small amount of spent nuclear fuel from the first reactor at Oskarshamn to be reprocessed in Sellafield, England. No fuel or radioactive waste from that processing will be returned to Sweden.

All transportation of spent nuclear fuel and radioactive waste from the four nuclear power plant sites to SKB's facilities is by sea, since all the nuclear facilities are situated on the coast. The transportation system has been in operation since 1982 and consists of a dedicated ship, transport casks and containers, and terminal vehicles for loading and unloading. Figure A4 provides a schematic illustration of the management system for spent nuclear fuel and radioactive waste.

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

Research and demonstration facilities 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 Bentonite Laboratory 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.

Figure A4 Management system for spent nuclear fuel and radioactive waste as presented in SKB's RD&D Programme 2016



A.7.3 Facilities overview

A.7.3.1 Spent nuclear fuel management practices and facilities

Management practices at the NPP sites

Spent nuclear fuel from the nuclear power reactors is temporarily stored in water-filled fuel pools for at least nine months before being transported to the central interim storage facility for spent nuclear fuel (Clab).

The central interim storage facility for spent fuel, Clab

Spent nuclear fuel from all Swedish nuclear power reactors is stored in a central interim storage facility, Clab, situated adjacent to the Oskarshamn nuclear power plant. The facility has been in operation since 1985. The facility has around 100 employees.

The facility consists of two parts: one building above ground for unloading spent fuel assemblies from transport casks, and one underground section for storage with a rock cover of about 25–30 metres. The spent fuel is stored for at least 30 years before being encapsulated and deposited in the repository.

SKB has a licence to store 8,000 tonnes of spent fuel. At the end of 2016, 6,266 tonnes U (31,817 fuel elements) were in storage. One of the storage pools is shown in Figure A5. Principal data as well as information on inventories are contained in section D.1.2.3.

Figure A5 Storage pool in Clab



A.7.3.2 Radioactive waste management practices and facilities

Management practices at the Westinghouse fuel fabrication plant

Westinghouse Electric Sweden AB (WSE) operates a facility in Västerås for fabrication of nuclear fuel, which is located approximately 100 km west of Stockholm. Its annual production is approximately 500–600 tonnes of UO₂ fuel for PWRs and BWRs, mainly for customers abroad.

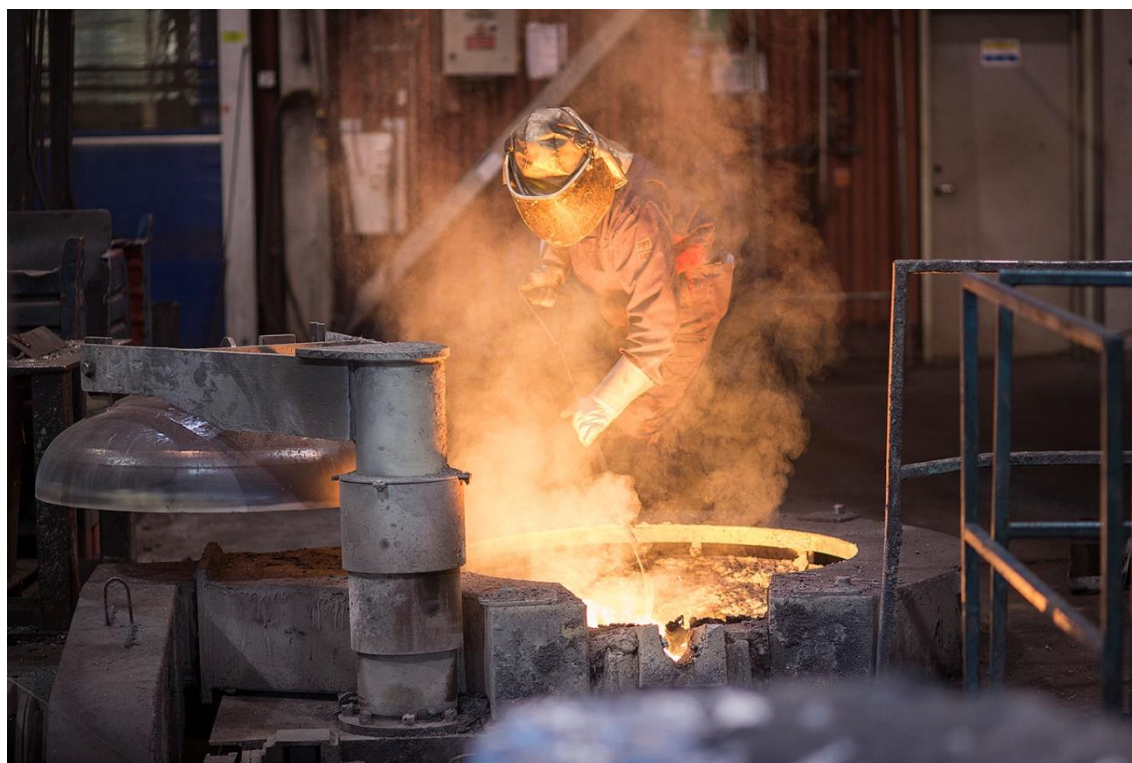
Residual uranium from production is recovered and reprocessed at the plant. WSE disposes of waste with very low uranium content, typically CaF₂, metal and construction wastes at municipal landfills as permitted by the Swedish Radiation Safety Authority (SSM). A minor proportion of the remaining waste can be considered for future storage in a disposal facility.

Management practices at the Studsvik site

Three nuclear licensees, Cyclife Sweden AB, Studsvik Nuclear AB (SNAB) and AB SVAFO, conduct nuclear activities and operate facilities at the Studsvik site in Nyköping Municipality. The radioactive waste treatment and management facilities at Studsvik are described in more detail in section D.1.4.

Cyclife Sweden AB, owned by French EDF and previously (before 1 July 2016) a part of SNAB, manages Studsvik's waste treatment facilities. These include the incineration facility (HA) used for incineration or pyrolysis of low-level waste from NPPs, fuel fabrication plants, hospitals, research institutions and facilities at Studsvik. The melting facility (SMA) is used for volume reduction of contaminated metal, see Figure A6. Disused sealed sources and radioactive waste from medical use, research and industry are mainly managed in the treatment facilities for radioactive non-nuclear waste (FR0-A and R0-A).

Figure A6 The melting facility (SMA) at Cyclife Sweden AB

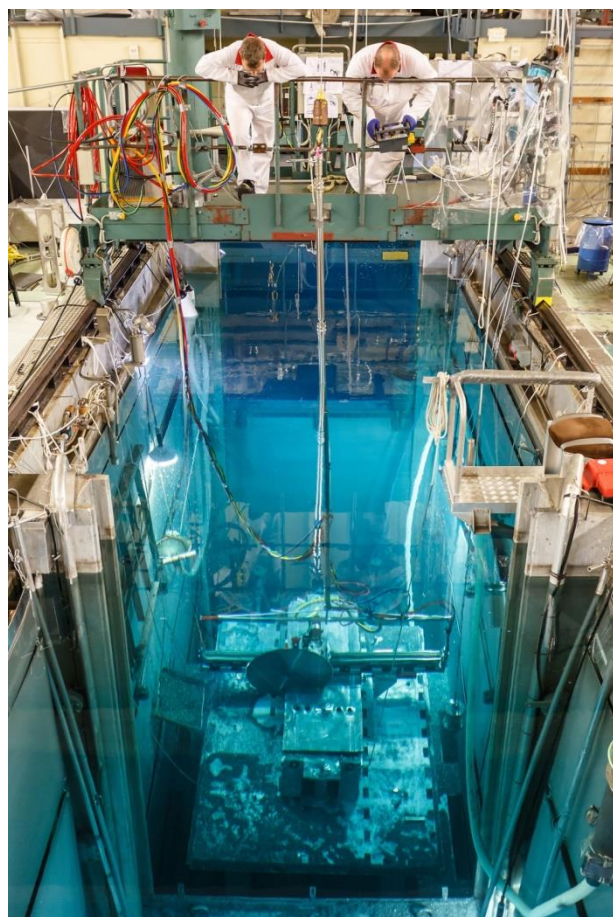


SNAB provides services in fuel and materials technologies to the nuclear power industry. Testing of materials and reactor fuel is performed in its own laboratories on site. The facilities include the hot cell laboratory (HCL) and the active metal laboratory (AML) that are primarily used to investigate irradiated nuclear fuel and irradiated metallic materials. A storage facility (FA) was built in 1965 for interim storage of spent nuclear fuel from the Ågesta nuclear power reactor. As all fuel from Ågesta has been transferred to Clab, the pools are presently used for temporary storage of spent fuel prior to examinations performed in HCL. Small quantities of spent nuclear fuel that have been examined at Studsvik are transported to Clab, the interim storage facility for spent nuclear fuel.

SVAFO is owned by the companies operating Swedish nuclear power plants. At Studsvik, the company treats and stores radioactive legacy waste from former research and development operations conducted in Sweden. SVAFO also manages liquid radioactive waste generated at the Studsvik facilities. SVAFO is responsible for decommissioning the R2/R2-0 research and materials testing reactor at Studsvik that was shut down in 2005, see Figure A7. Decommissioning of the reactor is ongoing and expected to be finished in 2019.

SVAFO's treatment facility for intermediate waste (HM) is used for solid and liquid waste from facilities at Studsvik. The interim storage facility for low and intermediate level waste (AM) is used for operational waste from the Studsvik facilities, primarily the R2 research reactor, irradiated and contaminated material from the production of isotopes and fuel testing, and operational waste from waste handling. There are also some externally produced types of waste currently being stored at AM, mainly residual products from incinerated waste from nuclear power plants, hospitals and industry; residual products from the use of isotopes in industry and hospitals; decommissioning waste from old nuclear facilities; and waste from treatment of steam generators from Ringhals.

Figure A7 Decommissioning of the R2 research and materials testing reactor at Studsvik



Management practices at the nuclear power plant sites

Most of the low and intermediate level radioactive wastes (LILW) are conditioned (solidified, compacted, etc.) at the point of origin, i.e. at the reactor sites. Some wastes are sent to Studsvik's waste treatment facilities for incineration or melting down.

Repository for radioactive operational waste, SFR

SFR is designed for the disposal of short-lived low and intermediate level radioactive waste from Swedish nuclear power plants and Clab, and for disposal of similar waste from other usage in industry, research and medicine. SFR is situated approximately 140 kilometres north of Stockholm, close to the Forsmark nuclear power plant. Approximately 40 people work at the facility.

SFR consists of four rock caverns and a silo. The facility is situated in crystalline bedrock, approximately 50 m below the seabed. The facility was taken into operation in 1988. Its total capacity is 63,000 m³ and about 38,000 m³ had been used by the end of 2015. The silo is shown in Figure A8. Principal data as well as information on inventories are contained in section D.1.4.5.

SKB is planning an extension of SFR in order to dispose of additional operational waste and waste from future decommissioning of nuclear power plants and other nuclear facilities, see section A.8.2. SKB submitted a licence application in 2014. Operations are planned to commence in 2028.

Figure A8 Photo from the top of the silo in SFR



Shallow landfill facilities

The nuclear power plants at Ringhals, Forsmark and Oskarshamn, as well as the Studsvik site, have shallow landfill facilities for solid short-lived low-level operational waste (<300 kBq/kg). Each landfill facility is licensed for a total activity of 100–200 GBq (the highest level according to the legislation is 10 TBq, of which a maximum of 10 GBq may consist of alpha-active substances).

Clearance

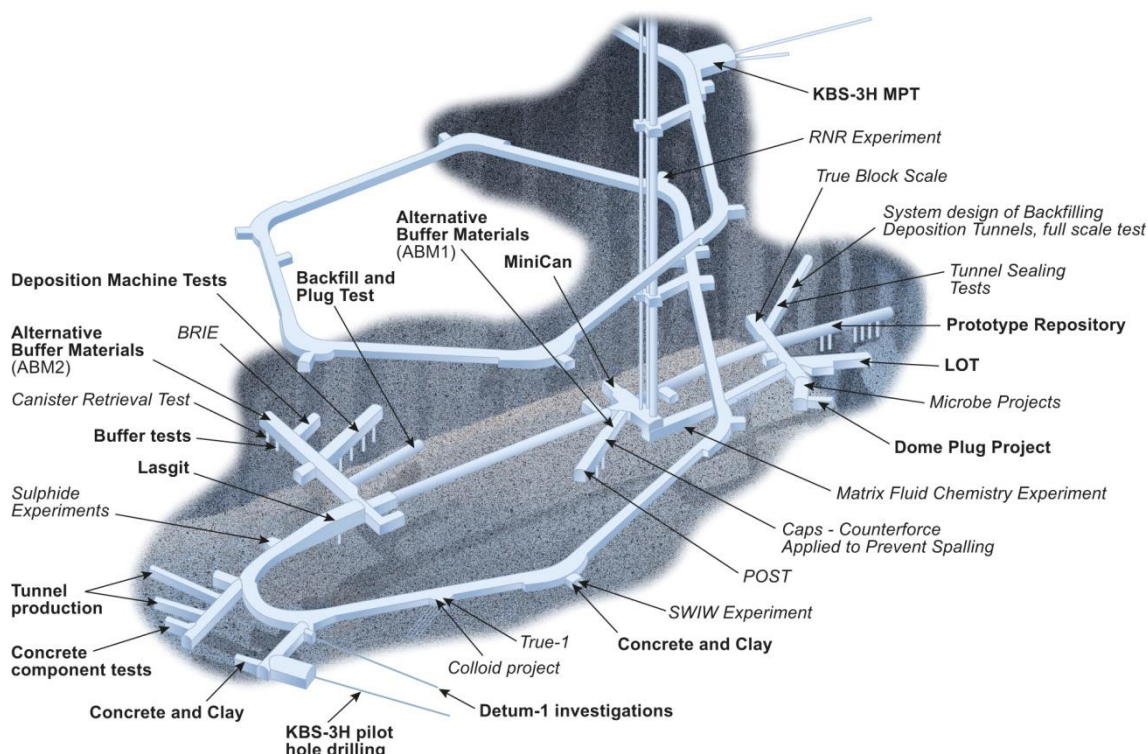
Material may be cleared for unrestricted use or for disposal as conventional non-radioactive waste (see also sections E.4.4 and F.6.1).

A.7.3.3 Research and demonstration facilities

The Äspö Hard Rock Laboratory

The Äspö Hard Rock Laboratory (HRL) is situated on the island of Äspö north of the Oskarshamn nuclear power plant. The main tunnel descends in two spiral turns to a depth of 460 metres. Various experiments are conducted in niches in the short tunnels that branch out from the main tunnel. An illustration of the HRL and concluded and ongoing (2017) experiments is shown in Figure A9.

Figure A9 The Äspö HRL with ongoing (**bold**) and concluded (*italics*) experiments

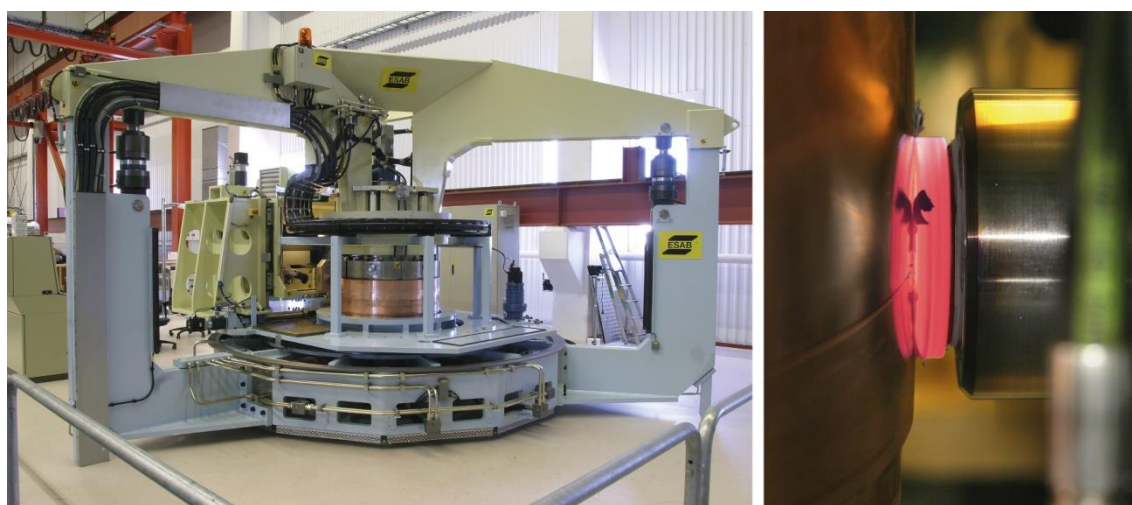


The Äspö HRL is used to investigate the behaviour of the barriers in the repository for spent nuclear fuel (canister, buffer, backfill and rock). Also, research on LILW is performed here. Development and demonstration of equipment to be used in future facilities are also performed in the HRL.

The Canister Laboratory

The Canister Laboratory, situated in the harbour area at Oskarshamn, has been in operation since 1998. The laboratory is used for developing sealing technology for the copper canisters, including welding and non-destructive testing techniques. Figure A10 illustrates equipment for friction stir welding of copper lids.

Figure A10 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

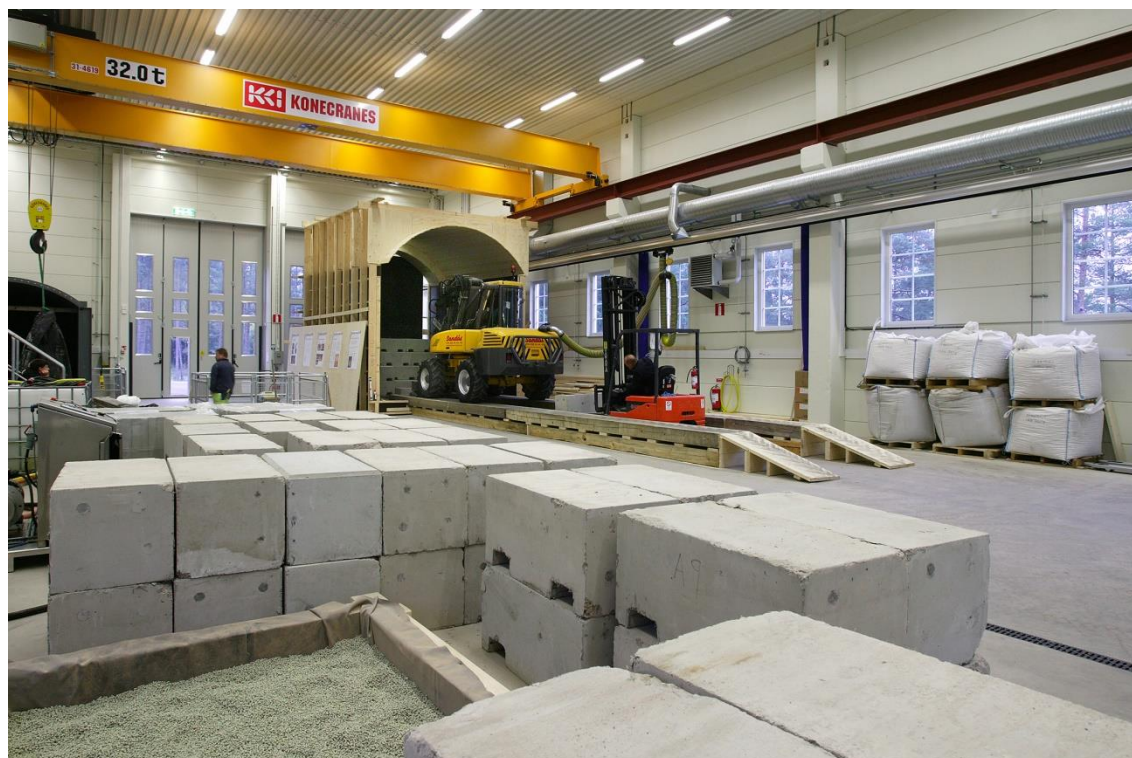


The Bentonite Laboratory

The Bentonite Laboratory was taken into operation in 2007. The facility is situated adjacent to the Äspö HRL and supplements the experiments being conducted there, see Figure A11.

In the Bentonite Laboratory, the properties of the bentonite are tested by (for example) simulating water conditions in a controlled manner. Here, SKB is also developing methods for backfilling of repository tunnels and building plugs to seal deposition tunnels.

Figure A11 The Bentonite Laboratory at Äspö

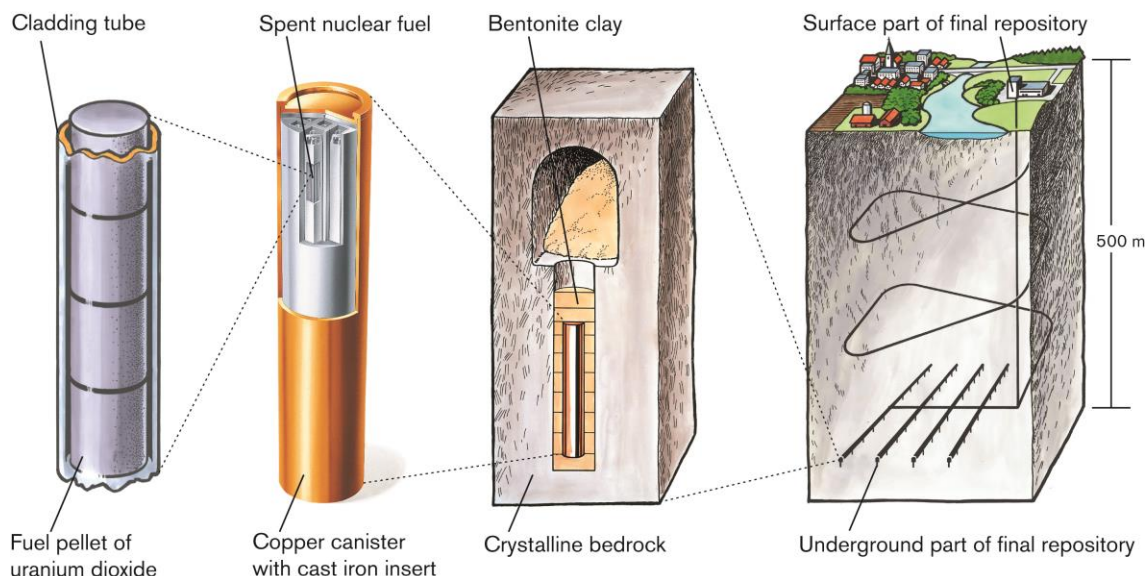


A.7.4 Planned facilities

The facilities that remain to be designed, constructed and licensed are as follows: an extension of the Clab facility with a plant for encapsulation of spent nuclear fuel, a repository for spent fuel, an extension of the existing repository, SFR, mainly for short-lived low and intermediate level waste from decommissioning and dismantling of nuclear power plants, and a repository for long-lived low and intermediate level waste (SFL).

A.7.4.1 Facilities for spent nuclear fuel

The main alternative for disposal of spent fuel, KBS-3, involves emplacement of fuel elements in copper canisters (corrosion resistance) with cast iron inserts (mechanical strength), see Figure A12. The canisters will be embedded in bentonite clay (protection against corrosion and rock movements, preventing water penetration and leakage of radioactive substances) in individual vertical deposition holes at a depth of about 400–700 m in the bedrock (maintains the technical barriers for a long time and isolates the spent fuel from human beings and the environment).

Figure A12 The reference method KBS-3 for disposal of spent nuclear fuel

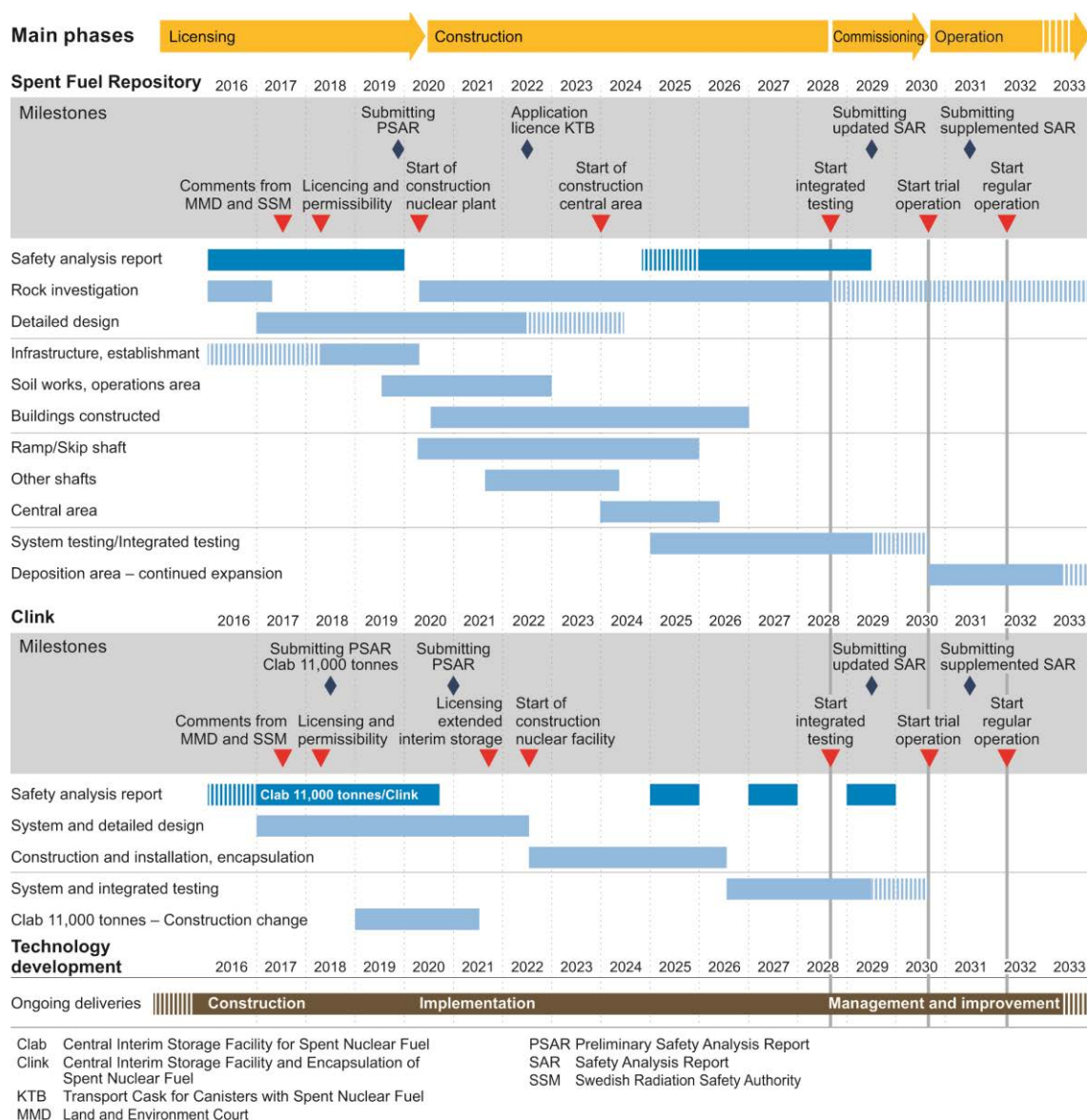
Encapsulation plant and repository for spent nuclear fuel

Figure A13 shows the estimated general timetable for establishment of the spent fuel repository and Clink. The licensing review process is currently (summer 2017) underway, and SKB has been responding to questions and requests for supplementary information from SSM and the Land and Environment Court since 2011 when the licence applications were submitted. The estimated start of construction for the spent fuel repository is 2020, and for Clink's encapsulation plant, 2022; the estimated start of operations for both facilities is 2030.

In parallel with the licensing review and up to starting construction of the encapsulation plant, SKB will design Clink and procure its construction. The system design phase started in 2016 and is planned to end in 2020.

When SSM has approved the PSAR for Clink, SKB will continue detailed design work and carry out the procurements required to commence construction of the encapsulation plant and implementation of the changes that need to be made in the interim storage area. SKB will also announce the changes that need to be made to the interim storage area in the form of 'change matters' in accordance with the requirements of SSMFS 2008:1. Once SKB has been granted a licence, the procurement phase enters its final stage and the construction phase begins.

Figure A13 Estimated general timetable for establishment of the spent fuel repository and Clink based on current situation in the licensing process for KBS-3



On 16 March 2011, SKB submitted an application under the Act on Nuclear Activities for final disposal of spent nuclear fuel and an application under the Environmental Code for the KBS-3 system.

The Land and Environment Court is preparing the case, and main hearings are planned to take place during September and October 2017. After the Court hearings, the Court will submit a statement to the Swedish Government on the licence application and recommend a decision. The Government will request statements from the municipalities of Östhammar and Oskarshamn. The municipalities will accept or reject the project and have a right of veto. The Government will then decide on the permissibility of the final disposal system. If the application is approved, the Land and Environment Court will hold a new hearing. Thereafter, the Court will grant permits and stipulate conditions pursuant to the Environmental Code.

In parallel with the Court's statement, the Swedish Radiation Safety Authority (SSM) will prepare a review statement in accordance with the Act on Nuclear Activities (1984:3) to the Government for a final licensing decision. Following the Government's permission, SSM may

stipulate further licence conditions. The authorities' licensing review process is described in more detail in section A.8.

Over the next few years, SKB will gradually prepare the organisation for the start of construction of the spent fuel repository.

The most important milestones to be considered are:

- The Land and Environment Court's and SSM's review statements to the Government, and
- The Government's decisions on licences and permissibility.

As soon as the above milestones are passed, SKB will increase the pace of the preparatory work. For example, extensive efforts relating to detailed design of facility parts and technical systems will be initiated following the Government's decisions on licences and permissibility.

Before construction of the facilities can be commenced, two documents must be submitted and approved by SSM:

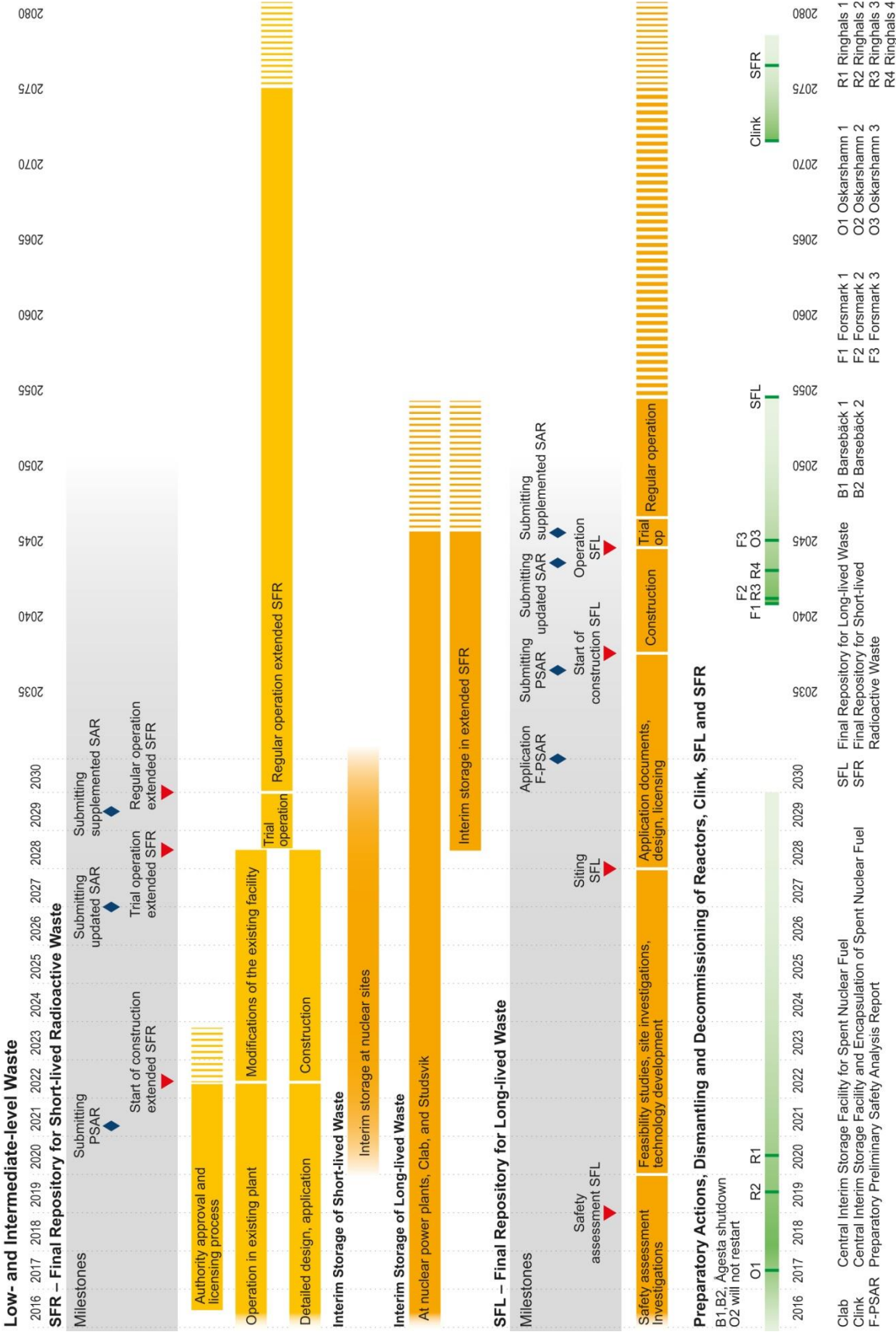
- The preliminary safety analysis report (PSAR), which also includes a description of the expansion of the repository's deposition areas and how this affects safety, and
- A report that describes how the construction of the facility affects safety during the operating phase and after closure.

The reports submitted to SSM must take into account the results of e.g. technological development and design activities since the applications were compiled. The construction projects must at this time be finished with detailed design and tendering specifications for the first facility parts to be built.

A.7.4.2 Low and Intermediate Level Waste (LILW)

The low and intermediate level waste programme comprises three main activities: the extension of the SFR facility to receive decommissioning waste; development of a repository for long-lived low and intermediate level waste (SFL); and interim storage of long-lived waste. The general timetable is illustrated in Figure A14 and described below.

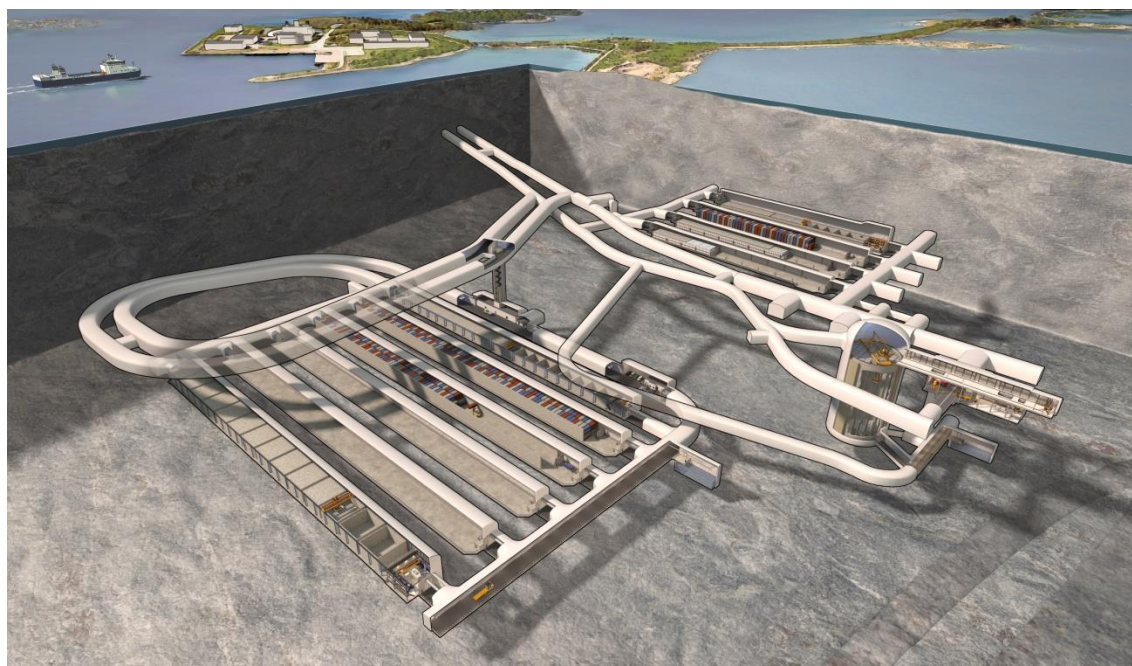
Figure A14 Timetable for low and intermediate level waste and decommissioning of the nuclear power plants. Dashed bars represent uncertainties and flexibility in the planning



Repository for short-lived low and intermediate level decommissioning waste (extended SFR)

SKB plans to dispose of waste from the future decommissioning of the nuclear power plants in an extension to SFR. The planned extension entails an increase of the facility's total storage capacity to about 170,000 m³, plus nine segmented reactor pressure vessels (RPVs) from BWRs; this is from today's capacity of 63,000 m³, see Figure A15. SKB submitted a licence application in 2014 and supplementary information was submitted in 2015 and 2016. Operations are planned to commence in 2028.

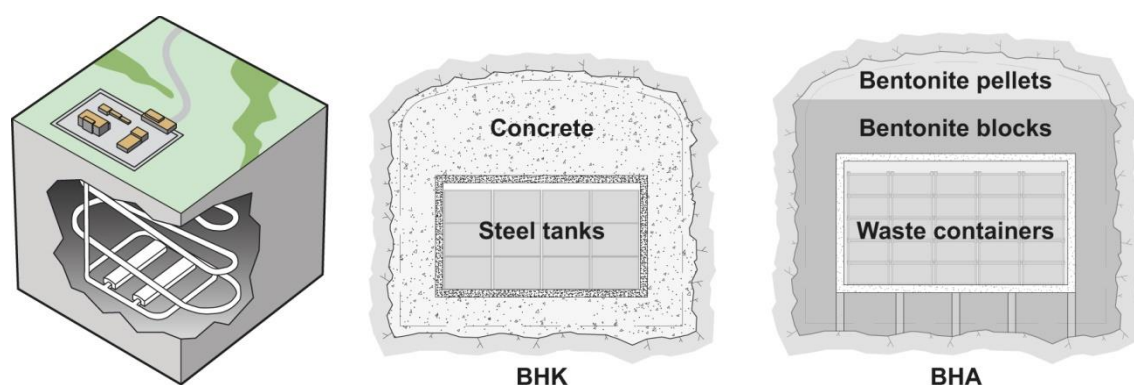
Figure A15 The existing facility in Forsmark for short-lived low and intermediate level operational radioactive waste, SFR (the silo and vaults in the upper right-hand part of the figure) and the planned extension of 6 vaults for decommissioning waste (lower left). The extended SFR will consist of four 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, a licence application to build a repository for long-lived low and intermediate level waste (SFL) will be submitted in 2030 and operations are planned to commence in 2045. The origin of this waste is primarily research, industry, medical applications, 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 Studsvik, the nuclear power plants and at Clab. The volume of SFL will be relatively small compared to SKB's other disposal facilities. The total storage volume is estimated at 16,000 m³. According to the current concept, SFL will be designed as a deep geological repository with two different repository sections: one repository section for metallic waste, which will be designed using a concrete barrier, and another repository section mainly for legacy waste; this section will be designed using a bentonite barrier. See Figure A16.

Figure A16 Preliminary layout and the proposed repository concept for SFL, comprising one rock vault for core components (BHK) and one rock vault for legacy waste (BHA)



During the period 2015–2018, the main focus of the work with SFL will be the evaluation of long-term safety that is to provide a basis for SKB to assess whether the proposed concept has the potential to meet the requirements for post-closure safety. Furthermore, the safety evaluation should provide a basis for assessing the conditions under which the repository concept (waste, barriers and the repository environs) has the potential to satisfy the safety requirements. The results of the safety evaluation are necessary for any modification of the concept, the evolution of the engineered barriers, waste acceptance criteria and for site selection.

Acceptance criteria for the long-lived low and intermediate level waste will be defined only when the design of SFL has been determined. However, today there is a need to clarify the planning prerequisites for handling of the waste arising during operation and decommissioning of the nuclear facilities. Following the ongoing safety evaluation, requirements for the waste from the proposed repository concept, ‘preliminary waste acceptance criteria’, will be formulated. The nuclear power plants should not commence final conditioning of waste until a verified repository concept exists.

A study will be initiated during the period to plan the site selection process for SFL. Based on the results of the evaluation of long-term safety that is planned for 2018, preliminary requirements for the repository site can be formulated and siting factors identified. In the light of the identified siting factors, contacts can later be made with municipalities where the prospects for siting are judged to be favourable. Feasibility studies will then be commenced on the part of interested municipalities.

Technological development of the chosen repository concept will commence once the safety evaluation is concluded.

Interim storage of long-lived waste

SFL is planned to be commissioned around 2045. Since several reactors according to the current plan will be decommissioned before the final repository is finished, capacity for interim storage of the long-lived waste from decommissioning is needed. In 2014 SKB sent in applications to extend SFR. As a part of the applications seeking to extend SFR, SKB submitted an application for interim storage of long-lived waste in the SFR extension. The application refers to long-lived waste from operation and decommissioning of the nuclear power plants, which consists of segmented reactor internals placed in steel tanks prior to interim storage. During the licensing process, in spring 2017, SKB decided to withdraw from its application the initially included parts regarding interim storage of long-lived low and intermediate level waste. The long lived waste will instead be interim stored at the nuclear power plants, until the interim storage of long-lived waste will be finalised.

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 will, due to its activity content, be designed according to the IAEA requirements type B(U). Delivery of the container is expected in 2020.

A.8 Licensing reviews

A.8.1 Final disposal of spent nuclear fuel

SKB's parallel licence applications under the Environmental Code and the Act on Nuclear Activities for an encapsulation plant in combination with the existing interim storage facility at Oskarshamn and a geological repository for final disposal at Forsmark have been undergoing review since March 2011. Following an initial assessment of the primary licensing documents, SSM has undertaken a thorough review of the quality and completeness of the two separate facility applications under the Act on Nuclear Activities together with related supporting material that was submitted by SKB. Over a period of three years up to 2015, the Authority requested and received from SKB substantial supplementary information at various levels of detail relating to both facilities, ranging from the scope of SKB's assessment of alternative methods and locations to detailed scientific and technical analyses relating to specific aspects of the disposal system design and its performance. Among other things, this has included a comprehensive revision of the preliminary safety analysis for the combined encapsulation plant and interim storage facility, submitted by SKB at the end of 2014. At the same time, a corresponding process of supplementation has been carried out by SKB in relation to material supporting its licence application under the Environmental Code.

The Land and Environment Court's role is, in the first instance, to prepare a recommendation for the Government relating to the permissibility of SKB's plans for final disposal in relation to the requirements imposed by the Environmental Code. Following the formal public notification of the licence applications in January 2016, the Land and Environment Court has received statements from a range of referral bodies in Sweden and neighbouring countries, including SSM and other supervisory authorities, relating to SKB's application. The Court has also considered the potential merits of merging its assessment of the spent fuel repository with that of the proposed extension to the nearby repository for short-lived low and intermediate level waste (see below), concluding that no such consolidation of review processes was necessary. At the time of preparing this report, it is expected that the main hearings of the Land and Environment Court in assessing SKB's licence application under the Environmental Code will be conducted in September and October 2017.

SSM's assessment of SKB's licence applications under the Act on Nuclear Activities entails a judgment of as to whether SKB has made a credible case for the feasibility of its plans and whether they offer the potential, when taken forward to detailed design and implementation, to comply with all relevant radiation safety requirements, including those applying to the repository after closure. SSM's statement in June 2016 as a statutory consultee to the Land and Environment Court was based on the outcome of its own review of SKB's rationale for method and siting as well as SKB's preliminary safety analyses for the two facilities, see also sections G.3.3, G.4.3 and G.5.3. It was preceded during 2015 and 2016 by the release of certain preliminary findings on specific topics associated with the Authority's review activities, with the intention of fostering a sense of openness in relation to what had become an extended review process. In addition, SSM has formally conducted its own national consultation process in support of its role to prepare SKB's licence applications for an eventual Government decision. An account of the consultation process and its influence on the Authority's recommendations will be incorporated into SSM's statement to the Swedish Government, which is expected to be submitted at approximately the same time as the Land and Environment Court's findings in early 2018.

A.8.2 Extension of the final repository for short-lived low and intermediate level waste at Forsmark (SFR)

In December 2014, SKB applied for an extension of the final repository for short-lived low and intermediate level waste at Forsmark (SFR) so that it can also accommodate decommissioning waste. Licence applications have been filed with regard to both the Environmental Code and the Act on Nuclear Activities. The two applications are reviewed in parallel by both the Land and Environment Court and by SSM. During the review, SSM issues a statement to the Court regarding its view on the completeness of the application and the permissibility of the extended facility. Statements to the Government regarding the outcome of the reviews are issued independently by the Court and by SSM.

The objective of SSM's review is to assess whether the activity that is applied for can be expected to be sited, designed and operated in a way so that the nuclear safety, security, and radiation safety requirements, as well as the general rules of consideration stipulated in the Environmental Code, are met. SSM has undertaken an initial review of the completeness of the application and has issued a number of requests to SKB for complementary information. The review is assisted by external experts procured in accordance with rules on public procurement. In response to SSM's requests, SKB has delivered additional information. Moreover, SKB has decided to withdraw from the application the initially included parts regarding interim storage of long-lived low and intermediate level waste. SKB has also announced that the reactor pressure vessels from the Swedish boiling water reactors will be segmented before deposition, instead of the initial plans to deposit intact vessels.

When the applications are deemed complete, they will be announced publicly by both the Court and SSM, whereupon the public can give their opinions. The Court will have hearings in preparation for the statement to the Government. The Court's and SSM's statements to the Government are expected to be issued in 2018. Before the Government can decide, the Municipality of Östhammar is requested to issue a statement regarding its veto right. If the Government does grant a licence under the Act on Nuclear Activities, a stepwise licensing process led by SSM will ensue.

A.9 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.9.1 The regulatory authority

The regulatory authority's missions and tasks are defined in the Ordinance (SFS 2008:452) with instructions for the Swedish Radiation Safety Authority (SSM), see section E.3. The Ordinance declares that SSM (among other tasks) shall carry out Swedish obligations according to conventions, EU ordinances/directives and other binding agreements (e.g. to provide points of contact, reporting, and act as the national competent authority), carry out inter-

national cooperation work with national and multinational organisations, and monitor and contribute to the progress of international standards and recommendations.

In addition, SSM is involved in international development cooperation within the areas of reactor safety, radiation protection, nuclear waste safety and non-proliferation, see section A.9.2.

SSM has substantial international cooperation with involvement in about 150 international groups, the majority of which are related to nuclear safety and radiation protection issues. This 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 Heads of European Radiation Control Authorities (HERCA), and the International Nuclear Regulators' Association (INRA).

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 and TRANSSC).

As a member of the European Union, Sweden is obliged 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 ENSREG (European Nuclear Safety Regulators' Group), 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. Through ENSREG and its working groups, 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. The development of common safety reference levels for decommissioning, storage of waste and spent fuel and geological disposal has been finalized and work is currently ongoing on the part of waste processing, with the aim of forming a set of requirements covering any activity in a full-scope waste management programme.

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 reduction of releases of radioactive substances from nuclear facilities.

In addition to multilateral collaboration, SSM has bilateral agreements with twelve countries on exchanging information and cooperation on agreed issues (e.g. nuclear safety, emergency preparedness, occupational exposure, environmental radiological protection, and radioactive waste management). These countries are Canada, Germany, Japan, Lithuania, Ukraine, Russia, France, Finland, the Republic of Korea, Australia, the United Kingdom and the United States. Additionally, Sweden has special agreements concluded with the Nordic countries (Denmark, Finland, Iceland and Norway) regarding emergency preparedness and information exchange on the technical design of nuclear facilities. A bilateral protocol on cooperation and information exchange regarding emergency preparedness has recently been signed with the Russian Federation. Also, a Memorandum of Understanding on cooperation and information exchange has been signed between the Nordic regulatory bodies (Norwegian Radiation Protection Authority, Finnish Radiation and Nuclear Safety Authority and Swedish Radiation Safety Authority) and the Ministry for Emergency Situations of the Republic of Belarus.

A multinational cooperation 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). SSM is hosting the 2nd DGRRF workshop in Stockholm in September 2017, the focus of which is Swedish and Finnish licensing review experiences.

SSM also participates in international research, primarily in the frameworks of the EU research programmes, but also as part of the IAEA and OECD/NEA. One particular example is SITEX, an FP7 Euratom project bringing together authorities performing technical and scientific assessments of geological disposal programmes.

SSM regularly provides experts to assist in international peer review missions, mainly in the framework of the IAEA's IRRS review services. In 2016 SSM also participated in a review, organised by the IAEA, of France's disposal programme, the Safety Options Dossier, in connection with the implementer, Andra's, planned licence application for a geological repository. In the same year, SSM also participated in an OECD/NEA review of Russian ROSATOM's model for calculating nuclear power plant decommissioning costs.

SSM's international involvement and work need to be continually reviewed with respect to available staff resources and as part of upholding competent regulatory supervision of licensees and activities in Sweden. In order 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.9.2 SSM's international support programmes

Since 1992, Swedish authorities have been engaged in providing assistance to states of the former Soviet Union in the areas of nuclear safety, nuclear security and radiation protection. As of 2008, this work has been carried out by the Swedish Radiation Safety Authority, SSM; prior to this, the tasks belonged to the two authorities that were merged to form SSM.

The aims of the bilateral assistance are to:

- improve reactor safety and minimise the risk of a nuclear accident involving uncontrolled radioactive releases at the facilities in question;
- improve conditions so that radioactive waste, including spent nuclear fuel, shall be handled and stored in a manner that is acceptable from the point of view of safety and radiation protection, regarding personnel, the public and the environment;
- impede the mismanagement of nuclear and radioactive materials and to strengthen the non-proliferation measures and institutions;
- improve national preparedness and awareness as far as concerns radiation protection of people and the environment;
- strengthen the legislation and exercising of authority in connection with nuclear facilities and handling of radioactive waste; and
- contribute to the development and strengthening of the countries' authorities and organisations within national emergency preparedness systems and to establish cooperation in the event of an emergency situation in the Baltic region.

Currently, Sweden's cooperation partners are Russia, Ukraine, Moldova, Georgia and Belarus. Previously, Sweden had similar cooperation programmes with Armenia, Kazakhstan, Belarus, Estonia, Latvia and Lithuania. In 2016, the funding allocated by the Swedish Government for these purposes amounted to 2.5 million euros.

A.9.3 Licence holders

A.9.3.1 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 (section A.9.3.2), AB SVAFO and Barsebäck Kraft AB participate actively in international working groups whose focus is on waste management and decommissioning.

A.9.3.2 SKB

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

The main aim of SKB's international activities is to monitor research and development work conducted in other countries and to participate in international projects within the field of nuclear waste management. Furthermore, this international work provides perspectives to the domestic programme and contributes to maintaining state-of-the-art competence in relevant scientific areas.

SKB participates actively in several IAEA, EU and OECD/NEA committees and working groups. SKB is also involved in a large number of research projects within these international organisations. From 2009 to 2012, SKB also ran the Secretariat of the 'Implementing Geological Disposal of Radioactive Waste Technology Platform' (IGD-TP) in which twelve waste management organisations cooperate. The IGD-TP identifies and prioritizes research and technological development initiatives that are necessary and time-critical for ensuring that the first geological repositories in Europe will be in operation by 2025. 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.

SKB's rationale for continuous participation in the platform is that it provides a shared arena for scientific cooperation and communication throughout Europe. SKB's cooperation with Posiva in Finland is the most extensive forum, comprising projects in the fields of repository technology and encapsulation techniques. An important example of SKB's international research cooperation is represented by the Äspö Hard Rock Laboratory, where organisations from Finland, Germany and Japan conduct joint studies. SKB International, a wholly owned subsidiary of SKB, also provides services related to the laboratory work.

A.9.4 International peer review missions

A brief account of recently conducted international peer review missions regarding the Swedish nuclear waste management programme is provided below. General information about policy and planning in this area is provided in section K.4.

A.9.4.1 IRRS missions

Between 25 April and 3 May 2016, an IRRS follow-up mission was performed in Sweden. The general conclusion from the 2016 IRRS follow-up team was that Sweden had made significant improvements to its regulatory framework for nuclear and radiation safety, and that most of the recommendations from the 2012 IRRS mission had been implemented. The main areas of progress identified included improvements in SSM's inspection activities and in the preparedness for radiological emergencies, whereas maintaining sufficient knowledge and skills relating to nuclear and radiation safety remained a challenge. Potential new challenges identified in the time ahead were the possible large-scale decommissioning of nuclear power reactors and ensuring that economic pressure on the utility industry due to lower electricity prices does not have a negative impact on nuclear safety.

Two out of 22 recommendations remain open. These refer to 1) provision to maintain competence for nuclear safety and radiation protection on a national level, and 2) the systematic evaluation of operational experience from non-nuclear facilities and radiation protection events and activities, including dissemination of all significant experience.

As a further outcome of the 2016 IRRS follow-up, SSM received four additional suggestions, stating that SSM should:

- Complete a comprehensive resource and competence assessment, based on a strategic review that incorporates the Swedish nuclear industry's perspective.
- Consider making key management system process documentation available to the applicants, licensees and other interested parties.
- Consider reviewing its roles, responsibilities, and expectations of its departments to ensure clarity and to consider methods to ensure clarity and to consider methods to ensure effective cross-organisational boundary communication that enable effective implantation of its management system components.
- The Swedish Government should consider expanding the scope of the national emergency response plan for management of nuclear accidents to take into consideration arrangements for responding to radiological emergencies, based on threat/hazard assessment.

SSM also received two new good practices referring to 1) the development of criteria for assessing risks in connection with the use of radiation sources, and 2) SSM's approach to establish consistent and comprehensive regulations, taking into account international standards and good practice.

A.9.4.2 World Association of Nuclear Operators (WANO)

In 2011 SKB became a member of WANO. SKB participates actively in WANO programmes and takes part in seminars and workshops. In the 2013 review, SKB received 18 areas for improvement (AFI). During the follow-up in 2015, the peer review team noted that work was in progress for all AFIs, some work was concluded and for some, the work has continued for a longer period of time. SKB has also developed its process on working systematically with the WANO SOER (Significant Operating Experience Report) and assists WANO with a Seconded.

A.10 The European spallation source research facility

On 31 August 2015, European Spallation Source ESS AB changed its structure to form a European Research Infrastructure Consortium, ‘European Spallation Source ERIC’ (ESS). The founding members of ESS are 12 European countries currently involved in constructing and operating a new neutron source. This source is based on a large accelerator that bombards a heavy target material (tungsten) with protons. The neutron source makes it possible to study materials in their smallest components. According to the current plan, the ESS facility should be operational in 2025 and it is envisaged that the facility will be in operation for about 40 years.

The ESS facility is not a nuclear facility, but it will house considerable quantities of radioactive material. Significant volumes of radioactive waste will be generated at the facility. The highest level of radioactivity will be generated in the tungsten target, but also to a lesser extent elsewhere, such as activation of the soil filling material surrounding the accelerator. The Swedish Radiation Safety Authority and Swedish Land and Environment Court are licensing the ESS facility. On 12 June 2014 the Land and Environment Court approved the first ESS application submitted in 2012. This approval was, however, conditional and ESS is not allowed to produce any radioactive waste or start the accelerator until the company has reported on further investigations concerning certain radiation protection issues and the management of radioactive waste. The results of the investigations, including a proposal for final licensing conditions, must be reported to the court by 1 July 2017. ESS has applied to the Land and Environment Court to submit these investigations on 31 December 2017.

The Swedish Radiation Safety Authority decided on 17 July 2014 to grant ESS authorisation to be situated at the sought site in Lund, and on 30 June 2017, to allow ESS to install equipment that can generate radiation. Further permission will be required from the Authority before this facility may be commissioned. The general licence ESS has today allows the company to import, acquire, install and own technical devices and other components for generation of ionising radiation. The licence is linked to a number of special conditions for the ESS facility in areas such as physical protection, emergency preparedness work and management of radioactive waste. One of several challenges faced by ESS in the continuing licensing process with the Authority 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 it can be performed in compliance with applicable regulatory requirements.

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 categorize radioactive waste.

B.1.1 Spent fuel and radioactive waste management policy

The Swedish policy for spent fuel and radioactive waste management nationally is based on the legal requirements contained in the Act on Nuclear Activities, Radiation Protection Act and Environmental Code. The national policy is also in accordance with the European Union's Council Directive 2011/70/Euratom establishing a Community framework for the responsible and safe management of spent nuclear fuel and radioactive waste (the Euratom waste directive), formally implemented in Swedish legislation since August 2013. The directive reinforces the principles of national responsibility, the licence holders' prime responsibility for the safety of spent fuel and radioactive waste management, and the independent competent regulatory authority.

The Swedish national policy can be summarized as the following four legal principles:

1. Funding liability
 - The expenses for management of spent nuclear fuel and radioactive waste from nuclear activities shall be covered by revenues from the production of energy that has generated these expenses.
 - The expenses for management of radioactive waste arising outside of the nuclear fuel cycle shall be paid directly by the producer of the waste.
2. The licence holder of a nuclear activity as well as the operator of activities involving ionising radiation are to safely dispose of spent nuclear fuel and radioactive waste arising from their activities.
3. The state has the ultimate liability for spent nuclear fuel and radioactive waste.
4. Each country is to be responsible for the spent nuclear fuel and radioactive waste generated by nuclear activities in that country. Disposal of spent nuclear fuel and radioactive waste from nuclear activities in 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 prerequisite as regards spent fuel management is that reprocessing will not take place, although this is not prohibited. Thus, in practice, spent nuclear fuel is both considered as and treated as waste, although it is not legally defined as waste until disposed of in a repository.

B.1.2 Spent fuel and radioactive waste management practices

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 the operations are safely managed and disposed of in a repository. This obligation signifies an extensive commitment on the part of a licensee until a final disposal facility for this waste has ultimately been closed. The nuclear power plant licensees are also subject to a particular shared obligation to establish and carry out a research and development (RD&D) programme for the safe handling and disposal of spent fuel and nuclear waste, and to prepare cost estimates for management and disposal of spent fuel and nuclear waste as a basis for payments to be made to the Swedish Nuclear Waste Fund.

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

Very low level short-lived waste (VLLW) is disposed of in shallow landfill facilities that are licensed under the Act on Nuclear Activities or subject to clearance according to 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) is treated and packaged according to a standardized system with predefined waste type descriptions (WTD) and disposed of in the repository for operational waste (SFR) in its rock caverns in crystalline bedrock at a depth of about 30–50 m. The repository consists of five different caverns. Wastes are directed to different parts of the repository depending on factors such as activity content and chemical characteristics.

Long-lived low and intermediate level waste (LILW) will be disposed of in a repository situated in rock caverns in crystalline bedrock. Until this repository has been constructed, the long-lived waste is stored at the reactor sites, at the Studsvik site, 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, following a storage period in Clab of about 30–40 years, fuel elements will be 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 technical barriers ensuring post-closure safety through containment over very long periods of time.

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 (1984:3) 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 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.

In the Radiation Protection Act (1988:220), the term ‘radioactive waste’ is used for radioactive waste that does not originate from the nuclear fuel cycle (medical use, use of sealed sources, research institutions, consumer products, etc.).

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 classification scheme that is used by the Swedish nuclear industry. The classification scheme is destination-driven and customized with regards to existing and planned repositories (end points) as shown in Table B1.

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 long-lived waste (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 commercial nuclear power plants at the Forsmark, Oskarshamn and Ringhals sites, but also from the Barsebäck site, which was permanently shut down on 31 May 2005. Small amounts of spent nuclear fuel originate from research reactors at Studsvik (which were permanently shut down on 15 June 2005). In addition, some spent nuclear fuel from the decommissioned research reactor, R1, and from the closed Ågesta reactor must be managed.

Spent nuclear fuel elements from the closed research reactors R2 and R2-0 at Studsvik have been exported to the United States in accordance with the contractual agreements.

All remaining spent fuel from the Ågesta district heating power reactor has been transferred to Clab. Spent fuel from the R1 research reactor consists of rods of metallic uranium enclosed in an aluminium alloy casing. This type of fuel is not suitable for disposal in accordance with the KBS-3 method. Since the closure of the R1 reactor, it has been in temporary storage at the

Studsvik site. In 2007, intact parts of the R1 fuel were separated from corroded parts, in the form of powder and lumps, and transported to the United Kingdom for reprocessing. The resulting fissile material, 1.2 kg of plutonium, was put in storage at Sellafield and the remaining waste from the reprocessing was sent back to Sweden in 2009. This waste is being stored temporarily at the Studsvik site prior to transport to a disposal facility. In 2014 the ownership of the plutonium was transferred to the UK Nuclear Decommissioning Authority.

The corroded parts of the R1 fuel are still being stored temporarily at the Studsvik site prior to transport to a disposal facility. The remnants of the R1 fuel consist of coarse pieces of corroded metallic uranium. The material has been placed in a special type of canister allowing controlled gaseous exchange. The material will probably be reconditioned before being sent for disposal in the planned 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

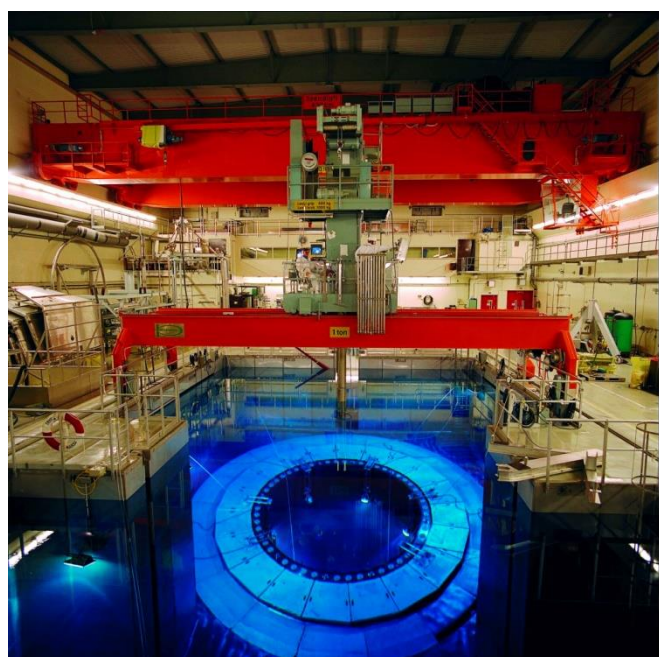
D.1.2.1 Interim storage at the nuclear power plants

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 at 31 December 2016 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 at 31 dec. 2016	
	No. of fuel assembly positions	No. of assemblies	Tonnes, uranium weight
Oskarshamn 1	969	140	23
Oskarshamn 2	1,052	236	41
Oskarshamn 3	1,040	320	55
Forsmark 1	1,392	397	65
Forsmark 2	1,268	406	67
Forsmark 3	1,040	338	57
Ringhals 1	1,426	242	42
Ringhals 2	432	36	17
Ringhals 3	381	155	71
Ringhals 4	364	117	54

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



D.1.2.2 Spent nuclear fuel facilities and inventories at Studsvik

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 Studsvik prior to transport to a disposal facility, see Table D2.

Table D2 Spent fuel from the research reactor R1 temporarily stored at Studsvik

Spent nuclear fuel in storage as at 31 Dec. 2016		
Origin	No. of assemblies	kg
R1	1	40

D.1.2.3 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 per cent before encapsulation and disposal take place. Other highly radioactive components, such as control rods from reactors, are also stored in Clab awaiting disposal. A schematic illustration of Clab is shown in Figure D2.

After being removed from the 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 underwater using hydraulic machines. 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.

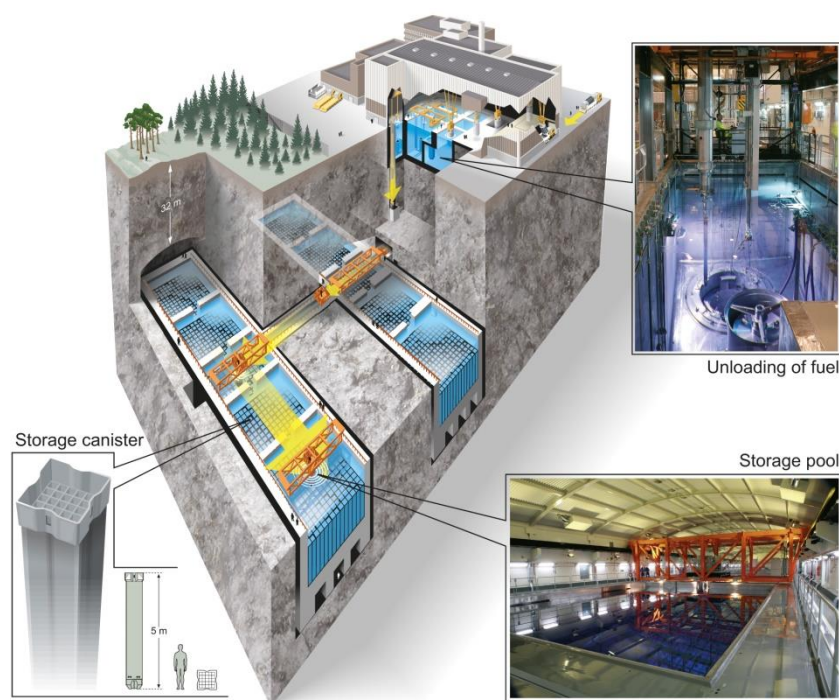
As a follow-up to the severe Fukushima Daiichi accident, the Clab facility was analysed (by means of stress tests) due to requirements specified by the European Nuclear Safety Regulators Group, ENSREG. The aim was to assess the robustness of the facility's beyond design basis. SKB's stress test analysis of Clab indicated that the facility is robust and able to withstand the events it is designed for, as well as having adequate margins in many of the situations analysed. The analysis also identified a number of areas for improvement regarding the facility's resilience and ability to withstand extreme events.

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 D3 below.

Table D3 Inventory of spent fuel stored in Clab as at 31 Dec. 2016

Specification	Spent nuclear fuel stored as at 31 Dec. 2016	
	No. of assemblies	Tonnes
BWR fuel	27,824	4,697
PWR fuel	3,533	1,524
Fuel from Ågesta district heating nuclear power reactor	222	20.2
Fuel from Studsvik	21	2.7
German MOX fuel (exchanged for Swedish fuel reprocessed in France)	217	22.5
Total	31,817	6,266
Storage capacity		8,000

Figure D2 The Clab facility



D.1.3 Management of radioactive waste at the nuclear power plants

Waste management at the NPP sites is fully integrated into the operations at each site. Fulfilment of the requirements of SSM's general regulations is accomplished and verified through regulatory review and inspection activities at the nuclear power plants, as reported in the

Swedish reports under the Convention on Nuclear Safety. In practice, temporary storage of radioactive waste at the nuclear power plants' sites is an integrated part of the site.

Waste with very low activity (VLLW) is disposed of in shallow landfill facilities on site, with the exception of Barsebäck, which disposes of 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. Four types of standardised packages (steel drums, steel moulds, concrete moulds and steel containers) are used, as well as standard ISO containers. Waste packages are placed temporarily in storage on the site before being transported to SFR, the repository for operational waste.

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

Table D4 Waste treatment methods at Swedish NPPs

(Note: operational waste is no longer generated at the Barsebäck site following the closure of this plant.)

Type of waste	Ringhals	Barsebäck	Oskarshamn	Forsmark
Ion exchange resins	Solidified in concrete moulds and steel drums	Solidified in concrete and packed in steel drums	Solidified in concrete and packed in concrete drums	Solidified in bitumen and packed in steel moulds
Metal scrap and residues	Cast in concrete and packed in concrete moulds Packed in standard ISO containers	Packed in standard ISO containers	Cast in concrete and packed in concrete moulds	Packed in steel moulds Packed in standard ISO containers
Sludges	Solidified in concrete, packed in concrete moulds			

D.1.4 Radioactive waste facilities and inventories

D.1.4.1 Radioactive waste treatment facilities and inventories at NPP sites

At the OKG site, the interim storage facility for low and intermediate level waste is located in a rock cavern. At the other nuclear power plants' sites, there are special buildings used for interim storage of conditioned operational waste on the respective site. Safety reports have been drawn up for all facilities where radioactive waste is handled and stored. The safety reports describe the facility and the waste handling activities, the content of radioactive substances, supervisory activities, and include a safety analysis. 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.

D.1.4.2 Radioactive waste management facilities at Cyclife AB

Cyclife's facilities at the Studsvik site are located around 30 km outside Nyköping. This is on the east coast of central Sweden. See the aerial view in Figure D3.

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 Studsvik. The work also comprises management, radiological measurement and final conditioning of the waste. Ash is stabilized in concrete for disposal, or if the waste comes from overseas, returned to the country of origin for further management. The current licence is 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. After having carried out melting and radiological measurement, the material may be exempted from regulatory control or returned to the source for further management. The current licence is for treatment of 5,000 tonnes of metal annually.

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 the two facilities FR0-A and R0-A. In R0-A, ionising smoke detectors are dismantled, 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 HM.

D.1.4.3 Materials research facilities at Studsvik Nuclear AB

The following facilities are operated by Studsvik Nuclear AB at the Studsvik 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 in other facilities. 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 been transferred to Clab, the facility may be used for other purposes, such as storing spent fuel from other reactors and storing other radioactive materials. Today the pools are used for storage, examination and demounting of pins of spent AGR (Advanced Gas-cooled Reactor) fuel prior to examinations performed in HCL. The AGR fuel is returned to the UK following examinations.

Monitoring at studsvik's facilities

Whenever there is a risk of airborne emissions, ventilation and/or exhaust systems are monitored for any radioactive substances. Likewise, to avoid contamination from waste water, drainage systems are monitored for any radioactive substances before the water is released to the recipient.

Figure D3 The facilities at Studsvik



D.1.4.4 Radioactive waste management facilities at AB SVAFO

The following are the most important facilities operated by AB SVAFO at the Studsvik site.

Treatment facility for intermediate waste, HM

This facility is used for the treatment of intermediate solid and liquid waste from facilities at Studsvik. Treatment of solid waste comprises sorting, volume reduction (compaction), packing and conditioning by means of stabilization using concrete. Treatment of liquid waste comprises sedimentation and solidification by means of stabilization 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 site. The storage facility is constructed in a cavern in bedrock with a rock cover of at least 20 metres. The rock mass 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 the year 2045. The storage area is divided into two parts: one part is used for waste requiring shielding, and the other is used for waste not requiring shielding. The shielded part of the AM storage facility has a capacity of about 4,000 m³, corresponding to 1,632 moulds and 1,020 four-drum unit trays; the unshielded part has a capacity of about 1,120 m³, corresponding to 660 moulds and 264 four-drum unit trays. A further 1,000 drums can be deposited in other parts of the storage facility. The waste is conditioned and packed in special containers before being positioned in the store. The ventilation and drainage systems are monitored for any radioactive substances.

The following types of waste originating from the Studsvik facilities are currently being stored at AM (see also Table D5):

- operational waste from the R2 research reactor and testing performed in the reactor,
- irradiated and contaminated material from the production of isotopes,
- 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.

These are the externally produced types of waste currently being stored at AM:

- residual products from incinerated waste from nuclear power plants, hospitals and industry,
- residual products from use of isotopes in industry and hospitals,
- decommissioning waste from old nuclear facilities, and
- waste from treatment of steam generators from Ringhals.

Table D5 Inventory of disposed radioactive waste in AM as at 31 Dec. 2016

Number of packages	Volume (m ³) incl. packaging	Activity (Bq)
2,749	2,301	10E15

Storage facility for radioactive waste, AU

The AU facility is an interim storage facility for long-lived low level waste that has been conditioned. It is a simple unheated building made of concrete and steel. The AU storage facility contains drums with historical 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.

Monitoring at Svafo's facilities HM and AM

The ventilation systems are monitored for the occurrence of any radioactive substances. The drainage water is also treated and monitored for any radioactive substances before the water is released to the recipient.

D.1.4.5 Repository for short-lived low and intermediate level waste (SFR)**General information**

The capacity of SFR is approximately 63,000 m³. By 31 December 2015, 37,931 m³ of waste had been disposed of. In the safety assessment, the total radioactivity of the waste in the filled repository is assumed to be 10¹⁶ Bq.

The repository is designed to isolate the waste from the biosphere in order to avoid harmful consequences for people and the environment both during operation and after closure. This is accomplished by emplacement in bedrock under the seabed and by the technical barriers surrounding the waste, see Figure A15.

SFR consists of a silo, a rock vault for intermediate level waste (BMA), two rock vaults for concrete tanks (1BTF, 2BTF) and a rock vault for low level waste (BLA). The storage vaults are located in the bedrock approximately 60 m below the seabed, 1 km from shore. The underground part of the repository is accessed through two tunnels.

The silo

The waste with the highest radioactivity, designated for SFR, 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 on a package is 500 mSv/h. All handling of waste packages is performed using remote control equipment. The dominant nuclides 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 high 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 stabilized with cement.

The rock vault for intermediate level waste (BMA)

The radioactivity in the waste that is disposed of in BMA is generally lower than in the waste contained in the silo. The waste in BMA 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 rubbish, is also disposed of in BMA.

The maximum dose rate permitted on packages is 100 mSv/h, and the radionuclide content is fairly low. BMA has been designed to handle 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 rock vault is approximately 160 m long, 19.5 m wide with a height of 16.5 m. Inside the cavern, a concrete construction has been raised so that the vault is divided into 15 compartments. The moulds and drums are placed in the compartments using remote-controlled equipment.

The waste is stacked on top of the concrete floor in such a way that the concrete moulds act as support for prefabricated concrete slabs, 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. Between the concrete structure and the rock wall there is a 2 m wide space, which will be filled with sand before closure. The space above the concrete structure may be left unfilled, but it could 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 rock 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 parts, whereas the waste in 2BTF consists of only the latter. Moreover, some large components of metal, e.g. steam separators and reactor vessel lids, may be disposed of in the caverns.

The maximum dose rate permitted on packages is 10 mSv/h. The radionuclide content is fairly low, and the dominant nuclides are Co-60 and Cs-137. The rock vaults are approximately 160 m long, 14.8 m wide with a height of 9.5 m. The concrete tanks, each 10 m³ in volume, are stacked in 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 stabilized with cement.

The rock vault for low level waste (BLA)

The waste disposed of in BLA, 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 standard steel containers.

The maximum dose rate permitted on the surface of the waste packages is 2 mSv/h. The radionuclide levels are low, and the dominant nuclide is Co-60. 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: it is basically only a concrete floor, on which containers are placed. During the operational phase, a ceiling is suspended above the waste in order to minimize

water dripping onto the waste. This suspended 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.

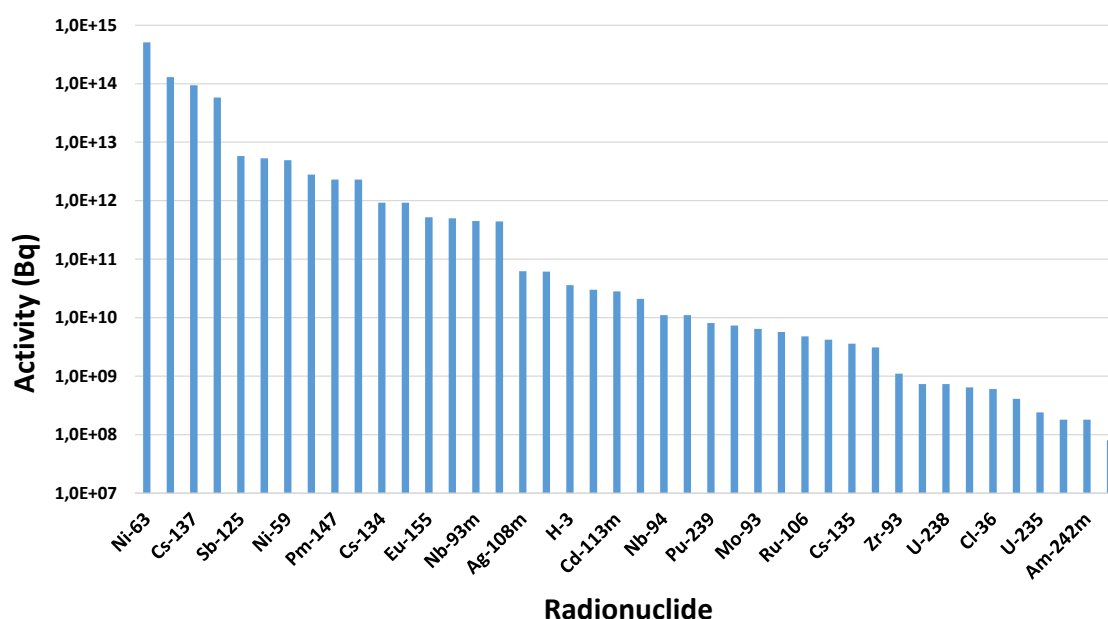
Inventories (Table D6) are listed below. The nuclide-specific activity content can be seen in Figure D4.

Table D6 Inventories of radioactive waste disposed of in SFR as at 31 Dec. 2015

Repository section	Volume (m ³)	Activity (Bq) per 31 Dec. 2015
Silo	7,106	5.8E14
BMA	9,371	2.4E14
1 BTF	2,454	2.3E12
2 BTF	7,680	1.2E13
BLA	11,320	5.4E11
SFR total	37,931	8.3E14

Figure D4 Radionuclide-specific activity content in SFR

The data reflects the situation as at 31 December 2015



D.1.4.6 Shallow landfill

The nuclear power plants at Ringhals, Forsmark and Oskarshamn as well as the Studsvik site have shallow landfill facilities for very low-level waste. The total activity content is, according to the licence, limited to 100–1100 GBq per facility.

In addition to the total activity content, waste acceptance criteria specify the nuclide-specific activity concentration and surface dose rate of the individual packages. The (remaining) activity concentration is specified for the future point in time when the shallow landfill facility is planned to be released from a radiation protection point of view, see Table D7.

The waste is disposed of at the three nuclear power plants as part of campaigns undertaken at three to five year intervals, with the facilities closed in between these periods. The waste

consists of low-level scrap and refuse from the operations of the NPPs. The waste consists of piping, tools, insulation material and protective clothing as well as rubbish such as plastics, paper and cables, etc. The dominant nuclides are generally Co-60, Cs-137 and Ni-63. The shallow landfill facility at Studsvik, also the location of waste disposed of from decommissioning of various old nuclear installations plus operational waste from other Studsvik facilities, has a somewhat different composition.

The design and layout of the shallow landfill facilities differ, but all facilities have a top sealing layer to reduce infiltration of water, see Figure D5. 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 and, on top of that, a protective layer of e.g. soil, approximately 1 metre thick. At the newer installations at Ringhals and Oskarshamn, a geological barrier has been installed down-gradient of the disposal facility. At the repositories at Forsmark and Studsvik, a natural or semi-natural geological barrier reduces leakages to the environment. 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) during which no further disposal of waste is allowed.

Figure D5 The shallow landfill facility at OKG



Table D7 Inventories of waste disposed of in shallow landfill facilities

The burial facilities at Studsvik (AB SVAFO) are closed permanently

Site	Licence conditions			Waste disposed of as at 31 dec. 2016		
	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	4,395	6,572	34.3
Oskarshamn	2075	10,000	200/0.2	5,415	10,949	37
Ringhals	2060	10,000	1100/0.1	5,360	9,180	265
Studsvik (Svafo)	2040	1,540	100/0.1	1,151	1,140	28

D.1.4.7 Waste from fuel fabrication

Westinghouse Electric Sweden AB operates a factory in Västerås for fabrication of nuclear fuel. This plant is located approximately 100 km west of Stockholm. The plant has been manufacturing fuel since the mid-1960s. Its annual production is approximately 500–600 tonnes of UO₂ fuel for PWRs and BWRs, mainly for customers abroad.

The manufacturing process generates some slightly uranium-contaminated wastes in the form of CaF₂, metal, construction waste, electronics, combustible wastes, sludge, filters, protective clothing, etc. Westinghouse disposes of wastes with very low uranium content, typically CaF₂, metal and construction wastes 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 AB has been developed, and currently processes combustible waste from Westinghouse. A minor proportion of the remaining waste can be considered for future storage in a disposal facility.

D.1.4.8 Nuclear facilities under decommissioning

Decommissioning of nuclear facilities is underway at three sites in Sweden: the uranium mining and milling facilities in Ranstad, the materials testing reactors at Studsvik, and the Barsebäck nuclear power plant. For more details, see Table D8.

Table D8 Nuclear facilities under decommissioning

Nuclear facility	Current projects	Start of project	Anticipated completion	Status	Details
Ranstad – uranium mining/milling	Decommissioning & clearance	2013	2017	Ongoing	Section F.6.2.5
Studsvik R2 facility, materials testing reactors	Dismantling & demolition	2015	2019	Ongoing	Section F.6.2.3
Barsebäck nuclear power plant – unit 2	Segmentation of internal components	2016	2017	Ongoing	Section F.6.2.1
Barsebäck nuclear power plant – unit 1	Segmentation of internal components	Expected in 2018	-	Application pending	Section F.6.2.1

Segmentation of reactor internal components at the Barsebäck NPP is being undertaken during the care and maintenance period. Segmentation activities in Unit 2 commenced in 2016, and an application for the same type of work in Unit 1 is pending. After these segmentation activities are completed, the next stage of major decommissioning work is planned to commence in 2021 (see section F.6.2.1).

Section E – Legislative and regulatory system

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

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.
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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.

E.2.1 General legal framework

The framework of Sweden's legislation in the fields of waste management, nuclear safety and radiation protection is to be found in the form of six Acts with associated Ordinances:

- Act on Nuclear Activities;
- Radiation Protection Act;
- Environmental Code;
- Act on Financing of Management of Residual Products from Nuclear Activities;
- Act on Financing of Certain Radioactive Waste, etc.; and
- Act on the Control of Dual-use Items and Technical Assistance (partly).

As reported below, SSM has a mandate to issue regulations concerning radiation safety according to the Act on Nuclear Activities and the Radiation Protection Act on the basis of 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. It contains basic provisions concerning safety in connection with nuclear activities, and applies to handling of nuclear material and nuclear waste as well as to the operation of nuclear power plants.

The Act does not contain provisions concerning radiation protection. This area is regulated in a separate act, the Radiation Protection Act, see section E.2.2.2. As far as nuclear activities are concerned, 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 and inspections.

The Ordinance also specifies that the regulatory authority assigned by the Government (SSM) is authorised to issue permits for transports of nuclear materials and nuclear waste. The Authority is also authorised to impose licence conditions and to issue general regulations concerning measures to maintain the safety of nuclear activities.

Safety Requirements

Nuclear activities shall be conducted so as 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 with nuclear material and spent nuclear fuel.

Safety in nuclear activities shall be maintained by taking all the measures required to prevent errors in equipment, or its defective function, to prevent incorrect handling or any other circumstances that could result in a radiological accident, and to prevent 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.

At least once every ten years, a new integrated analysis and assessment of the safety of a nuclear facility shall be performed by the licence holder. The analyses and assessments, as well as the measures proposed on the basis of these, must be documented and submitted to the regulatory authority for review.

Definitions

The handling or transport of nuclear waste or other dealings with this 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 measures necessary 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 no longer will be conducted.

In addition to the three bullet points above, 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 supplemented by more detailed regulations issued by SSM (see below) and, if needed, licence conditions that the Authority may issue in individual cases. The licensing conditions are imposed when a licence is issued. Licensing conditions can also be imposed during the period of validity of a licence.

Safe management and disposal of nuclear waste

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 cooperation 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 a large number of stakeholders for consultation and comment, such as other government 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 or not the programme can be approved. In connection with this decision, the Government may issue conditions concerning the content of the nuclear power operator's (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. The Act and the Ordinance entered into force in 1988. The purpose of the legislation is to protect people, animals and the environment against the harmful effects of radiation. Persons engaged in activities involving radiation are obliged to take the requisite precautionary measures. They are also responsible for proper handling and disposal of the radioactive waste produced, which includes covering the costs associated with both the handling and disposal of the waste.

The Radiation Protection Ordinance contains detailed provisions pursuant to authorisation under the Radiation Protection Act. 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 (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). As far as nuclear installations are concerned, this Act and the Act on Nuclear Activities are applied in close association with each other.

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

Radiation protection work in Sweden is based on the International Radiation Protection Commission's (ICRP) internationally recognised principles. These principles are:

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 in the respects specified in the Act.

General obligations of licensees and licence conditions

Any person who conducts activities involving radiation shall, according to the nature of the activities and the conditions under which they are conducted:

- take the measures and precautions necessary to prevent or counteract injury to people and animals and damage to the environment;
- supervise and maintain the radiation protection at the site, on the premises and in other areas where radiation occurs; and
- correctly maintain the technical devices and the measuring and radiation protection equipment used in the activities.

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 in the respects specified in the Act.

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

Safe management and disposal of radioactive waste

Anyone who conducts activities involving radiation is required to treat and, as necessary, dispose of the radioactive waste which may arise in 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. A number of ordinances supplement the Code. These are 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 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.:

- 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 in order 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 regards 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 in such a way as to make it possible 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 bullet points above apply to the extent that it cannot be considered onerous to comply with them. 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

The Act on Financing of Management of Residual Products from Nuclear Activities

The purpose of the Act on Financing of Management of Residual Products from Nuclear Activities (the ‘Financing Act’) is to ensure financing of the general obligations imposed by the Act on Nuclear Activities. This is ensured by an obligation for licensees to pay a nuclear waste fee.

The obligations for the purpose of ensuring financing apply to all licensees of a nuclear facility. The primary purpose of the Swedish financing system is to secure financing of the licensees’ costs for handling and disposing of residual products, decommissioning and dismantling of nuclear facilities, and carrying out needed research and development activities, but also minimising the State’s risk of being forced to bear costs considered to be a licensee liability.

‘Nuclear waste fee’ is defined as the fee for:

- the licensees’ costs for safe handling and disposal of residual products,
- the licensees’ costs for safe decommissioning and dismantling of nuclear facilities,
- the licensees’ costs for research and development needed for these activities,
- the State’s costs for research and development needed to review these measures,
- the State’s costs for administration of funded means and review of measures taken according to the Financing Act,
- the State’s costs for supervision of safe decommissioning and dismantling of nuclear facilities,
- the State’s costs for review of issues relating to disposal, and surveillance and control of a disposal facility,
- the respective costs of licensees, the State and municipalities for providing information to the public on management and disposal of spent nuclear fuel and nuclear waste, and
- the costs for providing financial support to non-profit organisations for efforts in connection with siting of facilities for management and disposal of spent nuclear fuel.

‘Residual product’ is defined as:

- nuclear materials that will not be reused
- nuclear waste which is not operational waste

Obligation to pay the nuclear waste fee and provide guarantees

The licensee of a nuclear facility that generates or has generated residual products must pay a nuclear waste fee. This fee is to cover the licensee’s share of the total costs.

The licensee of a nuclear power reactor must pay a nuclear waste fee. As far as concerns licensees of nuclear facilities other than nuclear power reactors, there is a possibility to allow an exemption to an obligation to pay a nuclear waste fee if the licensee provides a guarantee to cover the costs of its handling and disposal of residual products.

In addition to the obligation to pay a nuclear waste fee, the licensees must also provide guarantees whose purpose is to ensure adequate reserves for future financing if funded means should be proven to be inadequate.

The obligation to pay the nuclear waste fee and provide guarantees will end when the licensee has performed its obligations under the Act on Nuclear Activities or has been granted an exemption from such obligations.

Administration of fund assets

The fees are collected in a nuclear waste fund. The Nuclear Waste Fund is an independent government authority that controls and administers this fund.

The financial risk of the State

As mentioned previously, the State has the ultimate liability for long-term and safe management of spent fuel and radioactive waste. This responsibility includes a financial obligation in the event of damages claims.

Usage of funds and guarantees

The accumulated funds shall be used solely to provide reimbursement for the costs which the nuclear waste fee is intended to cover. If the Nuclear Waste Fund is proven inadequate, the guarantees shall be used to cover the costs.

If fund assets remain on the balance of the account of a fee-liable licensee after all costs relating to that specific licensee have been reimbursed, the surplus shall be refunded to the licensee or the payer.

Inspections and sanctions

A licensee is obligated to submit cost estimates and other information which may be required in order to fulfil the purpose of the Financing Act.

A licensee that intentionally or through gross negligence disregards its obligations by submitting incorrect information will be ordered to pay a fine, unless the action is punishable under the Penal Code.

The Ordinance on Financing of Management of Residual Products from Nuclear Activities

Cost estimates and nuclear waste fee

Swedish legislation requires licensees to submit estimates every third year on all future costs for management and disposal of spent nuclear fuel and nuclear waste, and for decommissioning. The licensee of a nuclear power reactor must base its cost estimates on 40 years³ of operation with a minimum remaining period of operation of six years. The licensee of a nuclear facility other than a nuclear power reactor is required to base its cost estimates on the expected remaining period of operation.

³ 50 years is proposed in a Government bill to Parliament, effective 1 December 2017.

The cost estimates are submitted to SSM for review. For each of the licensees, SSM must prepare a proposal for the nuclear waste fee that SSM considers that the reactor licensee should pay over the subsequent three calendar years.

SSM prepares the proposal:

- on the basis of the cost estimates,
- while taking into account the total added cost⁴, and
- so that all expected costs, after having taken into account previous payments, are expected to be covered by the fees that the reactor licensee will pay over the remaining operating period of the reactor.

The fees for reactor licensees are based on their projected electricity production.

In particular cases, SSM may order a licensee to submit a cost estimate earlier than within three years, or to submit an additional cost estimate. If a supplementary cost estimate has been submitted or if there are special reasons for doing so, SSM may propose nuclear waste fees for a period of less than three years. As regards licensees of a nuclear facility other than a reactor, SSM may set nuclear waste fees for a period of less than three years.

Guarantees

In addition to paying a fee on nuclear energy generation to the Nuclear Waste Fund, nuclear power reactor licensees must provide two types of guarantee. One guarantee is to cover the discrepancy between funded means and estimated costs. The other type of guarantee is to cover unforeseen events and be available until all reactors have been decommissioned and all nuclear waste has been disposed of in a disposal facility. This guarantee will be utilised if expenses for future costs are higher than expected, if these expenses must be met earlier than expected, or if the total assets in the fund are lower than estimated.

Licensees of nuclear facilities other than nuclear power reactors must only provide a guarantee to cover a possible discrepancy between funded means and estimated costs.

Requirements for management of assets

The assets of the Nuclear Waste Fund must be managed to ensure a good return and satisfactory liquidity. The Fund's assets are required to be deposited in an interest-bearing account at the National Debt Office, invested in treasury bills issued by the state or in covered bonds.⁵ Returns on Fund assets are added to the capital.

Disbursements to licensees

Licensees are entitled to disbursements on a continuous basis for expenses which they have already incurred for measures to perform the decommissioning, handling and disposal of spent nuclear fuel and nuclear waste, including the research needed for these activities. The remainder of the funds is accumulated for future needs. Funded means should only be utilised for the purpose for which they have been established and managed.

⁴ The added costs are those of the state, municipalities and non-profit organisations.

⁵ A broadening of the investment opportunities of the Nuclear Waste Fund is proposed in a Government bill to Parliament, effective 1 December 2017.

Disbursements to municipalities

Municipalities where there are site investigations relating to the disposal facility for spent nuclear fuel, or where an installation for such a disposal facility is planned or being built, are entitled to compensation from the Nuclear Waste Fund for their costs of providing information to the general public.

Disbursements may be set at a maximum of 10 million SEK (about 1.1 million EUR) per municipality and twelve-month period. The municipalities of Östhammar and Oskarshamn are currently receiving disbursements from the Nuclear Waste Fund.

Disbursements to non-profit organisations

Non-profit organisations that have at least 1,000 members, a democratically elected board and a charter for the respective association decided by the association's assembly may be eligible for financing for participation in consultation procedures under the Environmental Code or the Act on Nuclear Activities. The purpose is that such organisations should be given an opportunity to submit their opinion on a licensing application and an Environmental Impact Assessment (EIA) for a facility for the handling and final disposal of spent nuclear fuel, as well as receive compensation for costs to enable monitoring and assessment of issues related to disposal of spent nuclear fuel and its impact on human health or the environment.

The issue of disposal of spent fuel is one of the most complex issues in our time, where science and technology meet social science and humanistic issues. The complexity of the issue requires comprehensive evaluation as a basis for future decisions involving all stakeholders in society (Government bill 2003/04:116). For this reason, the Parliament approved new regulations in 2004 in the Financing Act which made it possible for non-profit organisations to apply for financing.

To be eligible for financing, the support may be provided at a total amount of 5 million SEK (about 0.55 million EUR) per calendar year, with a maximum of 2.5 million SEK per organisation and calendar year.

Non-profit organisations are eligible for financial support from the Nuclear Waste Fund up until 12 months after the Environmental Impact Assessment has been announced by the Land and Environment Court. In practice, this means that the possibility to receive financial support from the fund ended in January 2017.

Supervision of the financial system

SSM reviews the cost estimates in accordance with the Financing Act and subsequently suggests the level of the nuclear waste fees and guarantees to the Government. The Government sets the fees and guarantees for the licensees of nuclear power reactors. SSM sets fees and guarantees for the licensees of nuclear facilities other than nuclear power reactors. The Nuclear Waste Fund administrates and manages the collected fees.

The Swedish National Debt Office administrates and manages the guarantees. SSM decides on disbursement of funds to the nuclear licensees and municipalities. Furthermore, SSM has the responsibility of checking that the nuclear utilities have made their payments to the Fund and performing audits of disbursements made.

Disbursements from the Studsvik Fund to licensees

Since 1989, a special fee has been levied under the Act on Financing of Certain Radioactive Waste, etc. (commonly referred to as the ‘Studsvik Act’) on nuclear power utilities. This fee is intended to function as a contribution to help cover expenses for management of nuclear waste from old experimental facilities. These fees are collected in a unit in the Nuclear Waste Fund which is commonly called the ‘Studsvik Fund’.

The Studsvik Act will cease to be in effect by the end of 2017. Therefore no further payments are expected after 2017. The Financing Act regulates disbursements from the Studsvik Fund after 2017.

SSM decides on the disbursement of funds and checks how they were used. If there is any excess of funds when the last activity has been completed, the surplus assets go to the state.

Requirements for the Financing of Non-nuclear Waste

According to the Radiation Protection Act, any party that has produced radioactive waste is required to ensure the safe management and disposal of the waste, including securing of financial resources. This applies to all non-nuclear activities in which radioactive materials are used: in medicine, industry, agriculture, research and education.

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 in cases where such release seems imminent. The Act also stipulates that a rescue commander with a specified competence and having extensive authority is to be engaged for all rescue operations. In addition, the Act requires the owner of hazardous installations to take the measures necessary to minimise any harm to the public or environment if an accident were to occur in the installation.

The Civil Protection Ordinance contains general provisions concerning emergency planning. The county administrative board is obliged to draw up a radiological emergency response plan. The Swedish Civil Contingencies Agency (MSB) is responsible at national level for co-ordination and supervision of the preparedness for rescue services response to a radioactive release. The Swedish Radiation Safety Authority decides on 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 rules 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 transports of dangerous goods.

E.2.2 Legal requirements for specific issues

E.2.2.1 Licensing

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.

According to the Radiation Protection Act, a licence is required for the following:

- The manufacture, import, transport, sale, transfer, leasing, acquisition, possession, use, depositing or recycling of radioactive substances.
- The manufacture, import, sale, transfer, leasing, acquisition, possession, use, installation or maintenance of a technical device capable of and intended for emitting ionising radiation, or a part of such device that is of substantial importance from the viewpoint of radiation protection.
- The manufacture, import, sale, transfer, leasing, acquisition, possession, use, installation or maintenance of technical devices, other than those referred to in the previous sub-clause, and which are capable of generating ionising radiation, and for which the Government or the authority appointed by the Government has prescribed a licence requirement.
- The export of radioactive substances if a licence is not granted according to the Act on the Control of Dual-use Items and Technical Assistance (2000:1064).

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

According to the Environmental Code, a licence is required for environmentally hazardous activities. The Government has specified in the Ordinance on Environmental Licensing that facilities need a licence for the treatment, storage or disposal of spent fuel, nuclear waste or radioactive waste. A licence is also needed for decommissioning of nuclear reactors.

The Land and Environment Court is the first instance for hearings of cases concerning such activities. In addition, the Government must consider the permissibility of nuclear activities, e.g. the disposal of spent fuel and radioactive waste.

The Court's judgement when granting permission for an activity may include provisions concerning 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.2.2.2 Environmental impact assessments

General

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

In other cases with activities involving radiation, the Government or an authority appointed by the Government may, in licensing cases, prescribe that the applicant prepare an EIA before permission is given.

Legislation regarding EIA is in accordance with Council Directive 85/337/EEC of 27 June 1985, amended by Council Directive 97/11/EC of 3 March 1997 and by 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 permit for environmentally hazardous activities. An EIA must also be submitted at the prospect of the decommissioning of nuclear facilities.

The purpose of an EIA is to establish and describe the direct and indirect impacts of a planned activity or measure on people, animals, plants, land, water, air, climate, landscape and cultural environment, on management of the land, water and physical environments in general, and on the management of materials, raw materials and energy. Another purpose is to enable an overall assessment to be made of this impact on human health and the environment.

An environmental impact statement must have the following content:

- a description of the activity or measure including details of its location, design and scope;
- a description of the measures being 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 that is needed to establish and assess the main impact on human health, the environment and management of land, water and other resources that the activity or measure 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 and a description of the consequences if the activity or measure is not implemented; and
- a non-technical summary of the information.

Public consultation

In the EIA process, the implementer must consult with the county administrative board, regulatory authority and private individuals who are likely to be affected by the planned activity. This must be done in good time and to an appropriate extent before submitting an application for a permit and preparing the environmental impact statement. If the planned activity is likely to have a significant environmental impact, the applicant is also required to consult with other governmental authorities and the relevant municipalities, members of the public and NGOs that are likely to be affected.

Prior to consultation, the implementer must submit information to the county administrative board and to any private individuals affected about the location, extent and nature of the planned activity and its anticipated environmental impact.

If the county administrative board decides that the activity or measure is likely to have a significant environmental impact, an environmental impact assessment procedure shall be performed. In such a procedure, the person who intends to undertake the activity or measure

must consult with the other government agencies and municipalities, citizens and organisations that are likely to be affected. This consultation must relate to the location, scope, design and environmental impact of the activity or measure and the content and structure of the environmental impact statement.

Consultation with other countries

If an activity is likely to have a significant environmental impact in another country, the responsible authority as designated by the Swedish Government shall inform the responsible authority in the other country about the planned activity. This is to give the country concerned and the citizens who might be affected the opportunity to take part in a consultation procedure concerning the application and the environmental impact assessment. Such information shall also be supplied when another country that is likely to be exposed to a significant environmental impact so requests it. These provisions incorporate the requirements contained in the Aarhus Convention⁶ and the Espoo Convention.⁷

E.2.2.3 Prohibition and revocation

It is prohibited to carry out nuclear activities or activities involving radiation without a permit or 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 reasons from the point of view of safety to revoke the licence; or
- there are any other very specific reasons for revocation from the point of view of safety.

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

A licence under the Radiation Protection Act may be revoked if regulations or conditions imposed pursuant to the Act have been violated in a significant respect or if there are other very strong reasons for revocation. Furthermore, the Government, or the authority appointed by the Government, may issue prohibitions against e.g. the manufacture, sale, acquisition, possession or use of materials containing radioactive substances.

Under the Environmental Code, a supervisory authority may in individual cases impose the injunctions or prohibitions that are required on an operator for compliance with the obligations of the Code.

⁶ Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters.

⁷ Convention on Environmental Impact Assessment in a Transboundary Context.

E.2.2.4 Sanctions

The Act on Nuclear Activities also contains provisions on safeguards, sanctions, etc. Anyone who conducts nuclear activities without a licence, or disregards conditions or regulations, will be sentenced to pay a fine or imprisoned for a maximum of two years. If the crime is intentional and aggravated, the individual shall be sentenced to imprisonment for a minimum of six months and a maximum of four years. Liability shall not be adjudged if responsibility for the offence may be assigned under the Penal Code or the Act on Penalties for Smuggling (2000:1225), or if the offence is trivial.

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.

Under the Radiation Protection Act, the Government and the authority responsible decide upon matters regarding licences. A licence under this Act may be revoked if specific regulations or conditions have not been complied with in any significant respect, or if there are other very specific reasons.

Liability under the Act is not adjudged if responsibility for the offence may be assigned under the Penal Code or the Act on Penalties for Smuggling. Nor is liability adjudged in the instance of a minor offence deemed to be a trivial case. The police authority shall provide the necessary assistance for supervision.

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 and provisions, judgements and other decisions issued in pursuance thereof.

E.2.2.5 Institutional control, regulatory inspection, documentation and reporting

Institutional control

According to regulations on radiation protection,⁸ the licence holder must conduct environmental monitoring. All discharges from facilities for storage or disposal of radioactive waste must be monitored by a nuclide-specific measuring programme. The dose to any individual in the critical group is not allowed to exceed 0.1 mSv/y. The regulations are applicable to facilities in operation, but will be amended in due time to cover the period following closure of a disposal facility for spent nuclear fuel and radioactive waste.

The Swedish Radiation Safety Authority (SSM) has also issued conditions regarding institutional control of existing shallow land disposal facilities. The regulations stipulate that institutional control shall continue until the radioactivity no longer is 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. All nuclear facilities, including shallow land disposal facilities, are within areas where detailed development plans have been established.

⁸ Regulations on the Protection of Human Health and the Environment from Discharges of Radioactive Substances from Certain Nuclear Facilities (SSMFS 2008:23).

Inspections

In accordance with legal authorisation and the mandate defined by the Government,⁹ the Authority conducts regular inspections and assessments of Swedish nuclear facilities and other facilities handling radioactive waste to ascertain compliance with regulations and licence conditions.

Supervision of compliance with the Act on Nuclear Activities and Radiation Protection Act, as well as with conditions or regulations imposed under the Acts, is performed by SSM. SSM also conducts supervision of compliance with the Environmental Code and conditions or regulations imposed by the Code for matters concerning radiation safety. As far as concerns other environmental aspects covered by the Code, the county administrative board performs supervision.

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

The implementer must on request submit to the Authority the information and documentation required for its supervision. The Authority is also to be given access to the installation or site where the activities are conducted for investigations and sampling to the extent required for supervision.

SSM's supervisory practices include compliance inspections with respect to requirements found in regulations, licensing conditions and to some extent in regulatory decisions. The ambition is to systematically supervise and monitor developments based on a comprehensive inspection programme. The documented inspection findings provide a basis for SSM's annual integrated evaluation of radiation protection and safety on the part of each facility.

More about SSM's supervisory practices in detail

SSM has continued to develop its supervisory methods, which are also documented as part of SSM's overall management system. Inspection policies and procedures established in 2009 have been updated, and new procedures, among them harmonization between procedures in different supervisory areas, have been issued. In October 2016 the Director General decided to launch a project aiming for further development of supervisory and authorisation processes. A comprehensive project has been completed on updating of processes, procedures and routines.

SSM's supervisory practices for nuclear installations

Regulatory supervision carried out by the Authority is to be based on an analysis from the perspective of systematic, structured and integrated risk management work. The Authority started a project in 2014 with the purpose of establishing a more risk-informed method for evaluation of risks in the areas of nuclear safety and radiation protection. Results from the project are used when developing the inspection programmes.

In total, 17 areas are defined for which the corresponding requirements are found in regulations, licensing conditions and to some extent in regulatory decisions. The ambition is

⁹ Ordinance on Financing of Management of Residual Products from Nuclear Activities (2008:715).

to successively cover these areas as part of a basic inspection programme and to document the inspection findings.

Moreover, the same 17 areas are applied in the annual assessments of licensees (SSM's integrated safety assessments, see below) as well as in the periodic 10-year safety reviews. In this way, SSM is able to systematically supervise the safety situation and monitor developments. When new assessments are begun, previously performed and documented assessments of the areas can be consulted and any emerging picture consolidated. The idea is to apply the regulatory information and knowledge in a more efficient way. In order to further guide inspection and safety assessment work, each of the 17 areas also has a sub-structure.

The areas applied are:

1. Design and construction of facilities, including modifications
2. Organisation, management and control of the nuclear activity
3. Competence and staffing of the nuclear activity
4. Operations, including handling of deficiencies in barriers and the defence in depth
5. Core and fuel issues and criticality issues
6. Emergency preparedness
7. Maintenance, including materials and control issues with special consideration of degradation due to ageing
8. Primary and independent safety review, including the quality of notifications to SSM
9. Investigation of events, experience feedback and external reporting
10. Physical protection
11. Safety analyses and safety analysis report
12. Safety programme
13. Archiving and handling of plant documentation
14. Management of nuclear material and radioactive waste
15. Nuclear non-proliferation, export control and transport safety
16. On-site radiation protection
17. Radiation protection of the general public and environment

As a result of assessments within these areas, safety conclusions can be drawn in terms of the integrity of the physical barriers and the functioning of the five levels of the defence in depth.

In the regulations SSMFS 2008:1, the areas 1–15 are found in the general advice section (Chapter 4, Section 4) on periodic reviews of nuclear safety. The licensees are encouraged to analyse and report on their activities according to these areas. The added areas 16 and 17 cover issues regulated by the Radiation Protection Act.

SSM evaluates how regulatory time 'on site' is used and how to optimise the time allocated for compliance inspections and surveillance inspections as described below in order to be able to assess actual work practices at the plants, though without taking over inspection issues already under third party control.

Documentation and reporting

SSM's Regulatory Code, regulation SSMFS 2008:1, contains requirements for extensive reporting performed by licence holders. In this context, the following reports can be mentioned:

- Annual integrated report to SSM of activities at the facility with experience gained and conclusions reached with regard to safety.
- Annual report to SSM on the management of nuclear waste:
 - the quantities of nuclear waste occurring on the site or that have in any other way been transferred to this 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 information to SSM from all licensees of high activity sources (HASS) about the following:
 - 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, supplemented with information about the recipient of the source, and
 - when the practice has ceased and no sources are held.
- A deficiency in any barrier functions that is detected during the construction or operational surveillance of a repository, and that can lead to deterioration in safety after closure in addition to what is anticipated in the safety analysis report, must be reported to SSM without unnecessary delay. The same applies if such a deficiency is suspected to occur or if it is suspected that such a deficiency may possibly occur in the future.
- The licence holders shall, on the part of nuclear power reactors:
 - annually report to SSM on the measures that have been taken or are planned to be taken in order to limit the discharge of radioactive substances, with a view to reaching the goal values. If the reference values are exceeded, the measures planned with a view to reaching the reference values shall be reported;
 - semi-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; and
 - semi-annually report to SSM on the results of environment checks.
- At least once every ten years, licensees are required to perform a periodic safety review (PSR), i.e. an integrated analysis and assessment of the safety of a facility. The PSR should cover both nuclear safety and radiation protection with the purpose of clarifying how requirements stated in relevant 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 conducts a comprehensive review and assessment of the sub-mitted review and its references, 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 also apply to SSM according to the appropriation directions, Government decisions and acts and ordinances. In this context, the following reports may be mentioned:

- Annual Activity Report and Financial Statement, 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 for such annual reports issued 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 is required to submit to the Government a review report 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). In addition to the findings, conclusions and recommendations as to the purposefulness and quality of the programme, the review report also proposes conditions for the future conduct of the SKB RD&D programme that the Government may wish to prescribe in accordance with the Act on Nuclear Activities.
- Every three years, the regulatory authority appointed by the Government 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.
- The regulatory authority assigned by the Government shall on an annual basis report 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 a number of 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 in order 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 readily available to the media and general public.

E. 2.2.6 Enforcement of regulations and terms of licences

The authorities have extensive legal, regulatory and enforcement powers. As described in section E.2.2.3 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 terms of the licence, the supervisory authorities may issue any injunctions and prohibitions required in the specific case to ensure compliance. Injunctions or prohibitions under the Acts may carry contingent fines.

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

E.2.2.7 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 fuel and radioactive waste rests with the State. However, this ultimate responsibility has not been explicitly expressed in the legislation, but through Government statements in terms of it ‘is a matter of course’ and does not need to be implemented in the legislation.

E.2.2.8 Information and transparency provisions at existing nuclear facilities

It is considered crucial to give the general public insight into and information on nuclear activities. In municipalities where major nuclear facilities are located (power reactors, research reactors and facilities for manufacturing, handling, storage or disposal of nuclear material or nuclear waste), it is particularly important to provide the residents with correct and reliable information. For this purpose, ‘local safety boards’ have been established in the municipalities hosting nuclear power plants.¹⁰

The licence holder of a major nuclear power plant is required to give the local safety board insight into the safety and radiation protection work at such plant. The licence holder must, at the request of the board, provide the board with information on the facts available and not only give the board opportunities to study relevant documents, but also access to plants and sites.

The function of these boards is to obtain insight into safety and radiation protection matters and to inform the public about these areas. Consequently, it is important to point out that the board does not have the powers to impose requirements on 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.3.4, G.3.1.2, K.3.1.6 and K5.

E.2.3 Regulatory framework

With reference to its legal mandate, the Swedish Radiation Safety Authority (SSM), in its Regulatory Code (SSMFS), issues legally binding safety and radiation protection regulations for nuclear activities and other activities involving radiation.

In addition, SSM issues general advice on interpretation of most of the safety regulations. The general advice is not legally binding per se. Measures should be taken according to the general advice or, alternatively, methods justified to be equivalent from the point of view of safety should be implemented. The regulations and general advice listed below all entered into force on 1 February 2009.

SSM’s regulations also implement binding EU legislation and international obligations. As part of preparing SSM’s regulations, consideration is given to IAEA safety standards, international recommendations, industrial standards and norms, and the rulemaking of other

¹⁰ The municipalities of Kävlinge (Barsebäck NPP), Oskarshamn (Oskarshamn NPP), Nyköping (Studsvik research facility), Varberg (Ringhals NPP) and Östhammar (Forsmark NPP).

Swedish authorities. SSM's regulations are issued in accordance with an established management procedure that stipulates technical and legal reviews of draft versions. In accordance with governmental rules, a review is performed of the final draft by authorities, licensees, various stakeholders and industrial and environmental organisations.

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

E.2.4 Licensing – implementation in practice of legal and regulatory framework

The following text 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.2.4.1 Facilities for the management and disposal of spent fuel and radioactive waste

General

The Environmental Code and Act on Nuclear Activities govern the licensing of facilities for management and disposal of spent fuel and radioactive waste from the nuclear fuel cycle. In addition, the Radiation Protection Act applies to establishing radiation protection conditions for the 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 private individuals likely to be affected, as well as with the government agencies, affected municipalities and organisations, is emphasised in Swedish EIA legislation. The consultations must relate to the location, scope, design and environmental impact of the 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 the country concerned and the citizens affected the opportunity to take part in a consultation procedure concerning the application and the EIA.

Permissibility

According to the Environmental Code, the Government is to 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 the permissibility assessment. The Land and Environment Court reviews an application from the point of view of permissibility, which is thereafter forwarded to the Government for final consideration.

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 the 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 shall nevertheless not apply in cases where another site is considered to be more appropriate for the activity, or if an appropriate site has been designated for the activity in another municipality that is likely to approve the activity.

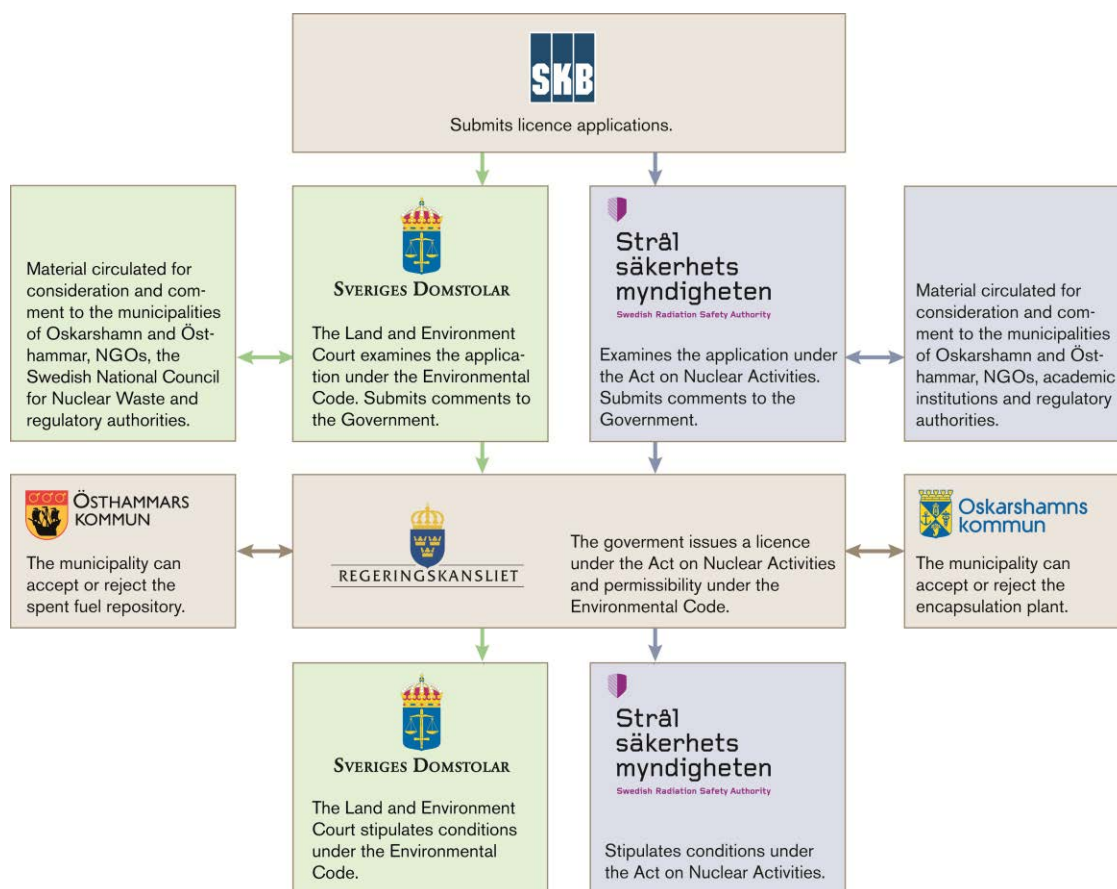
Licensing Approval According to the Environmental Code and Act on Nuclear Activities

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

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

It may be noted that the review of an application according to the Environmental Code takes place in open court hearings 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 hearings, 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 according to the Act on Nuclear Activities. SSM is expected to participate in the hearings as an expert authority concerning nuclear safety and radiation protection issues.

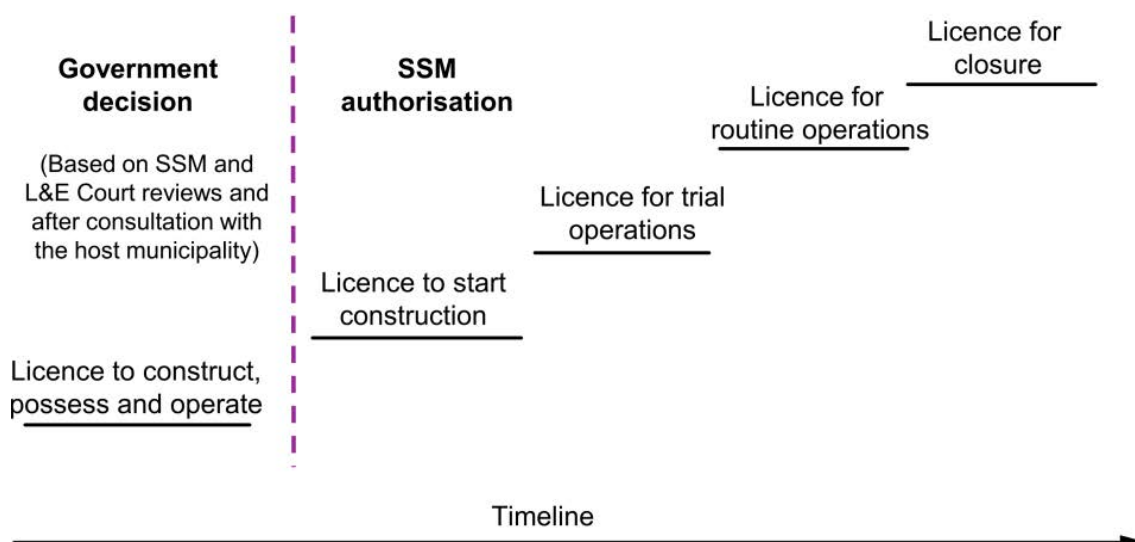
Figure E1 Process for licensing of nuclear facilities that is applicable to the spent nuclear fuel repository and encapsulation plant



The Stepwise Process of Regulatory Authorisation

Following Government approval, the regulatory authority (SSM) authorises the start of construction, the start of trial operations, the start of routine operations, and the decommissioning of the facility (see Figure E2). A Government decision is again needed for de-licensing and the exemption from responsibilities. 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 on licensing of a nuclear facility



Safety Analysis Report

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

In addition, and as appropriate, SSM examines the organisational, human and administrative capacity to carry out work to the extent and quality required as well as preliminary plans for decommissioning of the facility.

E.2.4.2 Shallow landfill facilities

Shallow landfill is used in Sweden for very low-level radioactive waste from nuclear activities. Like other nuclear installations, shallow landfill facilities are licensed under both the Act on Nuclear Activities and the Environmental Code. In the Ordinance on Nuclear Activities, SSM is given the mandate to license nuclear installations such as shallow land fill facilities up to a specified inventory limit of 10 TBq, of which a maximum of 10 GBq may consist of alpha-active substances. Furthermore, shallow landfill 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, according to the Environmental Code.

Similar to other repositories for nuclear waste, applications are to be filed according to the Act on Nuclear Activities and according to 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 should involve the private individuals, government agencies, municipalities and organisations concerned in a consultation procedure. 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 the Swedish Radiation Safety Authority and Land and Environment Court can issue the conditions necessary from specific aspects concerning nuclear safety, radiation protection and environmental protection, respectively. Conditions may be issued in connection with licensing or during the period of validity of the licences. As of 2011, SSM is the supervisory authority of radiation safety conditions issued according to the Environmental Code. The relevant county administrative board previously supervised all parts of the licence and licence conditions according to the Environmental Code.

E.2.4.3 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.2.4.4 Clearance

Clearance of nuclear materials or nuclear waste must be in accordance with the Act on Nuclear Activities as well as with the Radiation Protection Act, and approved by the regulatory authority. Material may be cleared for unrestricted use, or for disposal as conventional non-radioactive waste. A licence according to the Environmental Code, as is applicable to non-radioactive waste, may be needed if material that has been ‘cleared’ is to be disposed of as non-radioactive waste, see also sections A.7.3.2 and F.6.1.

E.2.5 Conclusion

Sweden complies with the obligations of Article 19.

E.3 Article 20: Regulatory body

1. 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.
2. 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 Regulatory bodies and their mandates

E.3.1.1 General information

The legal basis for regulatory activities in Sweden is the Swedish constitution. By law, Parliament may hand over regulatory mandates to the Government or to the authority designated by the Government.

Through annual government appropriation directions and specific governmental decisions, including specific licensing decisions, the Government can also give specific assignments to a regulatory body.

The Swedish Radiation Safety Authority (SSM) is a central administrative authority under the auspices of the Ministry of the Environment and Energy. SSM is the regulatory body in Sweden authorised to supervise spent fuel management and radioactive waste management according to the Act on Nuclear Activities and Radiation Protection Act. According to the Swedish constitution, the administrative authorities are quite independent within the legislation and statutes given by the Government. An individual minister cannot interfere in a specific case handled by an administrative authority.

Swedish Government ministries' main responsibilities are:

1. preparing the Government's bills to Parliament on budget appropriations and acts;
2. issuing acts, regulations and general rules for the administrative authorities;
3. international relations;
4. appointment of higher officials in the administration; and
5. certain appeals from individuals that are addressed to the Government.

The cabinet of ministers is collectively responsible for all Government decisions. Although a large number of routine matters are in practice decided upon by individual ministers, and only formally confirmed by the Government, the principle of collective responsibility is reflected in all forms of governmental work.

The Director General of the Swedish Radiation Safety Authority is appointed by the Government, normally for a period of six years. As all other Swedish authorities, SSM issues an annual report and financial statement, submitted to the Government, which summarize major results, effects, revenues and costs. The Government carries out follow-up work and evaluates the Authority's operations based on this report.

The level of requirements imposed on SSM and other Swedish authorities for openness and provision of information services to the public, politicians and media is very high. Swedish official documents are public unless a decision has been made to classify them as confidential under the Public Access to Information and Secrecy Act (2009:400). Reasons for

secrecy might be due to the interests of national security, international relations, commercial relations, or of individuals' right to privacy. No one needs to justify a request to view a public document or to reveal their identity in order to gain access to a particular document.

E.3.1.2 The Swedish Radiation Safety Authority (SSM)

SSM is the national regulatory body with mandates in the areas of nuclear safety, radiation protection and nuclear non-proliferation.

SSM's missions and tasks are defined in the Ordinance with instructions for the Swedish Radiation Safety Authority (2008:452) and in the annual appropriation directions. The Ordinance states that SSM is the administrative authority for protection of people and the environment against harmful effects of ionising and non-ionising radiation, for issues of nuclear safety including physical protection in nuclear technology activities as well as in other activities involving radiation, and for issues regarding non-proliferation.

SSM shall work actively and preventively to promote high levels of nuclear safety and radiation protection in society, and through its activities, act to:

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

SSM shall ensure that regulations and work routines are cost effective and straightforward for citizens and enterprises to apply and/or understand.

SSM shall deal with financial issues connected with the management of radioactive wastes from nuclear activities. The Authority informs the Nuclear Waste Fund about the size of payments and disbursements from the fund, planned or projected by each reactor operator or other relevant licensee, and about SSM's own activities regarding financing issues, so that the Nuclear Waste Fund can fulfil its tasks.¹¹

SSM is in charge of the Swedish metrology institute for ionising radiation. SSM operates a national dose register and, as appropriate, issues national individual dose passports.

SSM also has mandates to:

- carry out Swedish obligations according to 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 used as declared and in compliance with international commitments;
- carry out international cooperation work with national and multinational organisations;
- monitor and contribute to the progress of international standards and recommendations;

¹¹ The Nuclear Waste Fund is a government authority that manages the fees paid by the power companies and owners of other nuclear facilities in Sweden.

- coordinate the 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;
- contribute to national competence development within the Authority's fields of activities;
- provide data for radiation protection assessments and maintain the competence to predict and manage evolving issues; and
- ensure public insight into all of the Authority's activities.

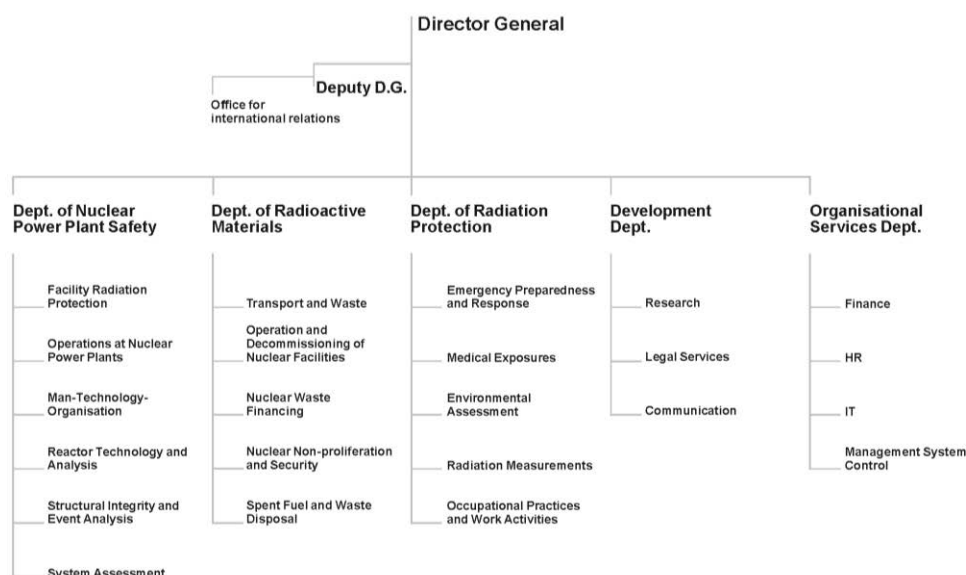
SSM publishes reports to inform interested parties and stakeholders. The SSM website is used to provide information on current events and official decisions. R&D reports and central regulatory assessments are published as part of the SSM report series.

All reports issued by SSM are publicly available (unless classified for e.g. security reasons); most of them are available for downloading from the SSM website.

SSM maintains a function on duty around the clock for response to incidents and other urgent matters. In the case of severe events, the emergency organisation will be mobilised. SSM also has one employee available for press contacts and IT support outside office hours.

The annual appropriation directions focus on short-term issues and funding of the Authority's activities. In its appropriation directions for the fiscal year 2017, SSM was for example assigned to report to the Government Offices on how the annual need for resources for carrying out the Authority's mission will be affected up until 2022. This report should refer to the impact on SSM's activities that is likely to occur when nuclear power plants are shut down and decommissioned during the period.

Figure E3 The present organisation of SSM



As reflected in SSM's organisational structure, shown in Figure E3, supervision of spent nuclear fuel and radioactive waste management, the tasks that are the subject of this report, are to a large extent carried out by the Department of Radioactive Materials. The Department is responsible for all regulatory issues concerning spent fuel and radioactive waste management, as well as the supervision and licensing of fuel cycle facilities, transports, decommissioning and financing included. The department is also responsible for security and nuclear non-proliferation.

The Department of Nuclear Power Plant Safety focuses on supervision of nuclear safety and radiation protection work on the part of nuclear power reactors in operation. The Department of Radiation Protection coordinates national nuclear and radiological emergency preparedness activities, regulates the use of radiation sources in industrial and medical applications, performs laboratory measurements and calibrations, and is responsible for non-ionising radiation issues and environmental monitoring.

International development cooperation work is managed by the Office for International Relations, which reports to the Deputy Director General. All work is coordinated between the departments with respect to providing the right skills and resources to regulatory 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 has an advisory council consisting of a maximum of ten members appointed by the Government. They are usually members of Parliament, high-level agency officials or representatives of interest groups. The functions of the council are to advise the Director General and to ensure public transparency (insight) in relation to the Authority's activities, but it has no decision-making powers.

The delegation for financing of management of residual products from nuclear activities is an advisory body for calculation of nuclear waste fee guarantees. The delegation is led by the Director General and its members are appointed by the Government.

SSM's advisory committee on the safe management of spent fuel and radioactive waste is led by the head of the Department of Radioactive Materials. Its members are appointed by the Director General and represent other 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 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.

E.3.1.3 Other relevant authorities

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, off-site emergency planning and oversees the planning of regional county administrative boards. MSB also evaluates on-site and off-site emergency exercises and initiates educational efforts.

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.

The Swedish Work Environment Authority

The Swedish Work Environment Authority's (AV) paramount 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 points of view of physical, psychological and organisational

aspects. AV is tasked with (for example) ensuring compliance with occupational health and safety legislation.

The Swedish National Council for Nuclear Waste

The Swedish National Council for Nuclear Waste is an independent body belonging to the Ministry of the Environment and Energy. The Council's mandate is to study issues relating to nuclear waste and decommissioning of nuclear facilities, and to advise the Government and certain authorities on these issues. Council activities are financed through the Nuclear Waste Fund, as approved by the Government. The members of the Council are independent experts within different areas of importance for the disposal of radioactive waste, not only in technology and science, but also in areas such as ethics and social sciences.

According to its latest Government instructions from 8 April 2009 (Dir. 2009:31), the Council shall:

- assess the research and development programme of the Swedish Nuclear Fuel and Waste Management Company (SKB), licence applications and reports of relevance to the disposal of nuclear waste;
- at the latest nine months after which SKB, according to Section 12 of the Act on Nuclear Activities (1984:3) has reported on its RD&D programme, present an independent assessment of the research and development activities and other measures presented in the RD&D programme. The Council shall also monitor the activities carried out in the area of decommissioning and dismantling of nuclear facilities;
- during the month of February, report on its activities during the preceding year and give its independent assessment of the situation within the area of nuclear waste management;
- investigate and illuminate important issues within the area of nuclear waste management, inter alia through seminars and public hearings, and create the prerequisites for establishing as good a foundation as possible for its advice to the Government; and
- monitor the development of other countries' disposal programmes for spent nuclear fuel and radioactive nuclear waste. The Council should also monitor and, when necessary, participate in the work of international organisations as regards disposal of radioactive nuclear waste and spent nuclear fuel.

County Administrative Boards

The county administrative boards exercise supervision under the Civil Protection Act (SFS 2003:778) and Ordinance (SFS 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 in cases where such release seems imminent.

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 owners of other nuclear facilities in Sweden. The Nuclear Waste Fund makes payments in accordance with SSM'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 National Debt Office, 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.3.2 Human and financial resources at SSM

E.3.2.1 Human resources

General Information

In 2016, 309 employees worked at the Authority: 175 men and 134 women. Their average age was 49. The same year 42 new employees were recruited (27 women and 15 men). The staff turnover rate, including retirements, was 6 percent, which is normal for a mid-sized expert authority such as SSM.

Table E1 Educational background of SSM staff at the beginning of 2017

Education	Percentage
Postgraduate degree	17
Bachelor's/Master's	73
Upper secondary school	8
Other	2
Total	100

Compared with many other authorities, the staff of SSM have a relatively high level of educational background, see Table E1. This is a result of the many specialist areas covered by the Authority, and to some extent the fact that there are no dedicated Technical Support Organizations in Sweden to support the regulatory body with specialist knowledge.

In an international comparison, the number of regulatory staff in Sweden is small for the size of the nuclear programme. Many staff members are typically involved in several tasks, such as inspections, regulatory reviews and approval tasks, revision of regulations, handling research contracts and participation in public information activities, with each activity requiring personal expertise. When comparing workforces between different countries, it is nonetheless important to not only count the number of staff members per reactor, but also to consider the types of legal obligations imposed on licensees and the different supervisory practices.

Internal Staff Training

From 2016, SSM applies a new competence supply model. The objective of the model is to provide an overview of the methods and other measures that SSM uses in order to acquire and maintain the competence needed by the Authority. Table E2 schematically illustrates the competence supply model.

Table E2 SSM's competence supply model

Measures	Aims	Examples of Methods
Attract	To attract staff with the right education, experience and competence	Elaborated guidelines on how to systematically attract staff Internal programmes for competent staff – A general introductory programme for new staff – Development programme for staff working with supervision
Recruit	To recruit the right person with the right competence	Documented recruitment procedure – Recruitment procedure based on the operational need for the right competence at the right time and place Competency mapping – A planning tool for analysing what competencies are needed in the short and long term
Develop	To develop the right competence for each task	Competent leadership – Basic education and training of managers – Evaluation of each manager's leadership Development discussions – A forum and strategic tool for staff and managers to openly discuss ways on how to fulfil the Authority's overall goals
Keep	To keep right competencies	Competence transfer concept – Structured competence transfer aiming to, when staff retire, preserve competence that only one or a few staff members have Exit interview – For staff whose employment is terminated, a final discussion is conducted for receiving feedback

Competency Mapping – Gap Analysis

One component of competency mapping (mentioned in Table E2) is a GAP analysis. SSM has developed a systematic process for implementing GAP analyses.

1. The starting point is to specify the competencies needed for the various tasks that the Authority is responsible for. The specified competencies are defined in a matrix for each individual unit of personnel at SSM.
2. The next step is to find out what competencies are available at the Authority. For this purpose, each employee carries out a self-assessment and rates his or her own competence in relation to the skills specified in the matrix. The manager validates the rating. At the annual professional development reviews held between managers and employees, it is discussed whether the employee's competence has evolved over the past year. Based on the revised review, the rating in the matrix will be adjusted.

3. The outcome of 1–2 reveals the competencies and levels of skills within the Authority. It also reveals competencies that are not present in-house. Thus, this mapping provides the basis for strategic decisions regarding future recruitment and/or development of the skills of in-house personnel.

E.3.2.2 SSM's process-based and integrated management system

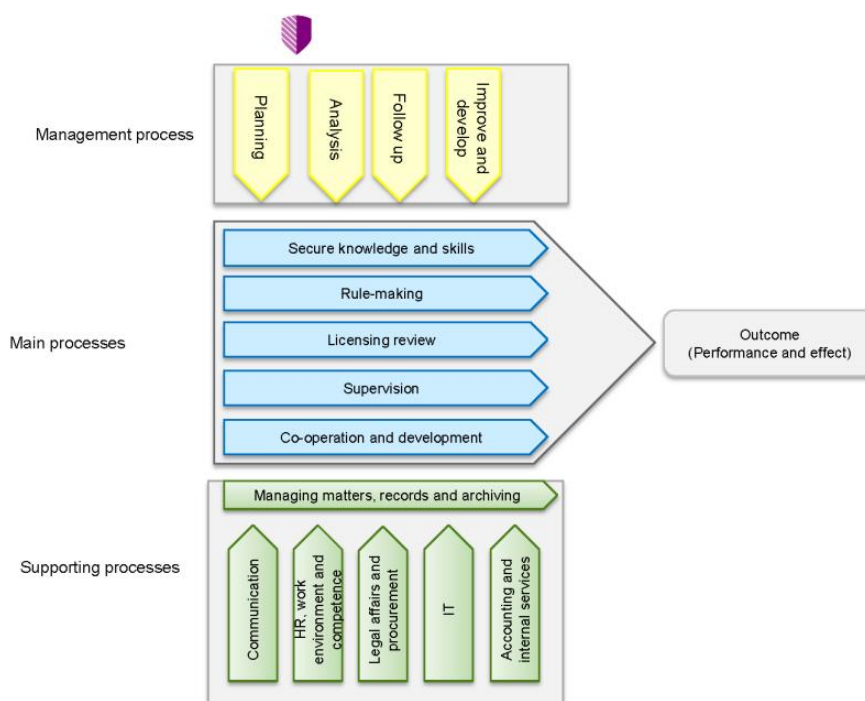
SSM has an integrated and process-based management system which is certified in the areas of environment, quality management and occupational health and safety in accordance with the international standards SS-EN ISO 14001:2004, SS-EN ISO 9001:2008 and OHSAS 18001. Work is nearly completed on supplementing the system with requirements for information security in accordance with SS-ISO/IEC 27001:2006. The management system encompasses all activities of SSM.

New Process Map

The management system has been further developed. In 2015, adjustments were made which relate to the division into main and sub-processes. The purpose of the adjustments was to more comprehensively reflect the Authority's tasks in the management system, better reflect the main output and outcomes of processes, and lessen administration in certain support processes.

Figure E4 shows SSM's present process scheme. The process model highlights the sequence and interaction of all key processes, validated and published on the intranet. Component sub-process information and associated guidance materials can be readily accessed by way of the process model, dedicated intranet pages and a robust document management system. Assigned process ownership applies to the key processes.

Figure E4 SSM's management system process scheme



Increased Focus on Continual Improvements of Processes

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

In early 2015, as a first step of tangible implementation, SSM launched the ‘UTP’ project for development of the supervisory process. An additional project was launched in tandem with this, with a special focus on developing a systematic and structured approach to continual improvements to our processes, called ‘Prosit’. Also, in August 2015, a preliminary study called ‘UTT’ was launched with the purpose of process development for supervision and licensing reviews. The objective was to study existing supervisory and licensing processes, management of official matters, systems support and information management.

The recommendations from the UTT study, reported on in December 2015, laid the foundation for the ‘ETTAN’ project, whose aim is significant development work focusing on the Authority’s processes and procedures, including internal bureaucracy. In October 2016, the decision was made by the Director General to launch the project ETTAN, focusing on developing processes for supervision, authorisation and managing matters and records. The work is comprehensive and the objective is to further elaborate the processes including policies, procedures and routines in order to achieve clarity and give the support that is needed for all employees. The process mapping will also be the basis for the type of IT support that is needed.

Implementation of Audits

As for all government authorities, external audits of SSM’s annual report, finances and the effectiveness of its work are carried out every year by the Swedish National Audit Office.

SSM also ensures that annual internal and external audits of the Authority’s activities are carried out with respect to SSM’s management system requirements; this includes ISO standards, statutes and legal provisions, e.g. occupational health and safety and information security.

SSM has recently revised the audit programme for the period 2016–2018. The objective of internal audits is to follow up the activities of the Authority on all levels, 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 if the management system is effective and adapted to its purposes. The internal auditors are appointed by the Director General on the basis of experience, competence and audit objectives.

The requirements of ISO 9001, ISO 14001 and OHSAS 18001 and other relevant management system requirements are audited by contracted external auditors. They are accredited by the Swedish Board for Accreditation and Conformity Assessment. The latest external review was carried out in April 2017.

E.3.2.3 Communication

SSM’s communication policy, updated in June 2017, emphasizes the key values of integrity, reliability and openness while defining their implementation (availability, proactive information, good quality, no unnecessary delay). Other strategy documents, also permeated with the key values, include a communication strategy, media strategy and an Internet strategy. The crisis communication strategy, established in June 2012, was formed through the experience gained during the accident at the Fukushima Daiichi NPP. The aim of the SSM website is to be transparent and comprehensible, thus giving stakeholders the opportunity to monitor the Authority’s work.

E.3.2.4 Financial resources

The regulatory activities of SSM are largely financed through yearly state budget appropriations and reimbursements 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 recovered to the state budget. The amounts of the fees are proposed annually by SSM but decided by the Government. The budgets for 2015, 2016 and 2017, including the funding of the separately financed international cooperation and development work, are shown in Table E3.

In addition, some additional resources are from fees for reviewing special applications or licensing work that are paid directly to the Authority. The financial resources of the regulatory body have increased in real terms as compared to what was reported in the fifth Swedish national report. The 2017 budget for SSM has been increased further and totals approximately 510 million SEK.

Table E3 Budget of SSM in million SEK (1 SEK is about 0.1 euro)

Budget item	2015	2016	2017	Source of funding
Nuclear safety, emergency preparedness and radiation protection (including administration)	294.1	295.9	308.5	Mainly fees
Supervision of nuclear facilities (proportion of above)	137.1	139.8	145.0	Fees
Licensing of new nuclear facilities, including new nuclear reactors	24.5	20.9	10.0	Fees
Scientific research and development work	72.9	76.0	76.0	Mainly fees
Final disposal of radioactive waste, including licensing, financial control and decommissioning	54.7	55.7	63.0	Nuclear Waste Fund
Historical wastes, etc.	2.0	6.0	8.0	Tax revenues
Crisis management	6.5	6.6	5.5	Tax revenues
International cooperation and development	29.5	27.5	39.5	Tax revenues
Total (million SEK)	484.2	488.6	510.5	

E.3.2.5 Regulatory research and assistance by external experts

General

According to the Ordinance (2008:452) with instructions for the Swedish Radiation Safety Authority, the main purposes of SSM's research are 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 review and supervisory activities.

SSM supports basic and applied research, including development of models, software and, to a limited extent, experimental studies. SSM has a total yearly research budget of approximately 8 million euros. In addition, some of the research relating to waste management (mainly spent fuel disposal) is financed through the Nuclear Waste Fund.

SSM provides funding for a number of research projects and positions at Swedish universities in order to develop and sustain national competence and teaching capacity. Key areas include reactor physics, severe accidents and non-proliferation. Since 2015, SSM also provides funding for four research positions within the area of radiation protection. Research is also funded through open calls in the areas of radiation protection, waste management and Man-Technology-Organisation (MTO).

Regulatory Research in the Area of Waste Management

The former regulatory authorities, SKI and SSI, decided already in the late 1980s to develop a high level of in-house competence in geological disposal and post-closure safety assessments. This was in order to prepare for the regulatory review of SKB's anticipated licence application for a spent nuclear fuel repository. Subsequently, the authorities developed an extensive research programme covering different technical aspects of spent fuel disposal and safety assessment methodology. Because Sweden has no TSO (Technical Support Organization), the Swedish regulators have developed a network of national and international experts by involving universities, institutes and consulting firms, both nationally and internationally, in their research programme. In the 1990s, SKI also carried out two comprehensive safety assessment projects of the KBS-3 disposal method for spent nuclear fuel (Project-90 and SKI SITE-94). In parallel with these research activities, SKI and SSI initiated a number of international research initiatives in the areas of hydrogeology (e.g. Intracoin and Hydrocoin), model validation (e.g. Intraval), radionuclide transport, rock mechanics modelling (e.g. Decovalex), biosphere modelling (e.g. BIOMOVs) and protection of the environment (the European Commission FASSET and Erica projects).

In addition to the more technical research programme, Swedish regulators have also carried out a research programme on stakeholder dialogue together with environmental organisations, other non-governmental organisations and the municipalities involved in SKB's programme for siting of a spent nuclear fuel repository (e.g. the RISCOS I and the European Commission Riscos II projects). These projects have contributed to developing methods and fora for stakeholder dialogue and a better understanding of the roles and needs of different players.

In the 2000s, the budget for research funding in the area of waste management varied between 1.5 and 2 million euros per year. However, as of SKB's licence application in 2011 for a spent fuel repository, there has been a shift in funding from research over to external review support. Between 2011 and 2016, a total of approximately 3 million euros has been used for research and around 3.5 million euros for external review support in the area of spent fuel disposal.

E.3.3 Independence of regulatory function

The de jure and de facto independence from political pressure and promotional interests is well provided for in Sweden. The laws governing SSM concentrate solely on nuclear safety and radiation protection (also security, physical protection and non-proliferation, but outside of the scope addressed in this convention). SSM reports to the Ministry of the Environment and Energy. The responsibility for nuclear regulation and energy policy is effectively divided within the Ministry, whereas the Minister of the Environment and the Minister of Energy act independently from each other. The Ministry of Finance represents the Government's ownership in Vattenfall AB (the owner of seven nuclear power reactors in Sweden). All Government matters are decided on collectively by the Ministers, in Cabinet.

SSM performs its regulatory work autonomously and independently. The Government directs its authorities through budget appropriations and ordinance decisions on tasks and the general orientation of operations, but it has no powers to intervene in the Swedish Radiation Safety Authority's decision-making in applying the law or discharging its authority in individual cases.

E.3.4 Action to ensure transparency in regulatory activities and communication with the public

According to the Ordinance with instructions for the Swedish Radiation Safety Authority (2008:452), SSM shall by means of communication and transparency contribute towards public insight into all operations encompassed by the Authority's mandate. The aim of this work shall for example be to provide advice and information about radiation, its properties and areas of application, and about radiation protection.

SSM publishes all its significant decisions on the SSM website. Through an e-register on the website, the general public can view the documents sent from the Authority or submitted to it. The Constitution gives everyone the right to access the 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 not subject to confidentiality upon request from the general public and journalists.

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 the administrative burden for the operators. For this reason, SSM always communicates drafts through a referral process to obtain opinions on these and other aspects of the proposed regulations.

As part of the preparation of an Environmental Impact Assessment (EIA), an applicant must, before the application documents are submitted, consult with the county administrative board, relevant authorities, the potential host municipality, other stakeholders, the public and NGOs. 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, a number of consultation meetings with different stakeholders may be required. The Authority also 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 a large number of 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 on. In the event the planned nuclear activity is large and complex, an international peer review of the application documents will be arranged.

According to the Environmental Code, the municipality concerned generally has the right to veto siting of facilities for final disposal of spent nuclear fuel and nuclear waste. A municipality may also arrange for a referendum before it takes a final decision on whether to approve the project or exercise its right of veto.

E.3.5 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

According to the Act on Nuclear Activities and Environmental Code, a party that holds a licence for nuclear activities shall be responsible for ensuring that all the necessary measures are taken for:

- maintaining safety, taking into account the nature of the operation and the circumstances in which it is conducted,
- safe management and disposal of nuclear waste generated by the operation or nuclear material derived from the operation that is not reused, and
- safe decommissioning and dismantling of facilities in which the operation shall be discontinued until such date that all operations at the facilities have ceased and all nuclear material and nuclear waste have been placed in a disposal facility that has been sealed permanently.

According to the Radiation Protection Act and Environmental Code, a party conducting an activity involving radiation shall, while taking into account the nature of the activity and the conditions under which it is conducted:

- take the measures and precautions necessary to prevent or counteract injury to people and animals and damage to the environment,
- supervise and maintain the radiation protection at the site, on the premises and in other areas where radiation occurs, and
- properly maintain technical devices and monitoring and radiation protection equipment used in the activity.

According to the legislative history of the Acts, it is also underlined that the licensee shall not only take measures to maintain safety and radiation protection, but also measures to improve these protective measures where this is justified.

SSM's Regulations on Safety in Nuclear Facilities (SSMFS 2008:1) specify the responsibility of the licensee through a number of functional requirements for safety management, design and construction, safety analysis and review, operations, nuclear materials/waste management and documentation/archiving. In addition, it is clearly pointed out in these regulations that safety shall be monitored and followed up by the licensee on a routine basis, and deviations identified and corrected so that safety is maintained and further developed according to valid objectives and strategies.

The continuous preventive safety work required 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 of this proactive and continuous safety work 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 liability is managed.

According to SSM's Regulations Concerning Basic Provisions for the Protection of Workers and the General Public in Practices Involving Ionising Radiation (SSMFS 2008:51), anyone who conducts activities involving ionising radiation must ensure that the practice is justified. By this it is meant that the use of radiation should give a benefit exceeding the estimated health detriment caused by the radiation. The radiation protection measures shall be optimized, meaning that human exposures are as low as reasonably achievable, while taking into account societal and economic factors, and no dose limit in these regulations is to be exceeded. These basic radiation protection principles also apply to waste management and disposal as regulated in SSM's 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 optimisation and use of the best available technique (BAT) also apply to discharges to the environment during normal operation of nuclear facilities. This is regulated in Regulations on Protection of Human Health and the Environment in connection with Discharges of Radioactive Substances from certain Nuclear Facilities (SSMFS 2008:23).

SSM shall ensure that regulations and procedures used are cost effective and useful for individuals as well as companies. They must be written and designed so that the regulatory body does not take over the prime responsibility for safety and radiation protection.

The supervision that SSM carries out shall ensure that licensees operate the activity in a safe way and while maintaining radiation protection.

F.1.1.2 The ultimate responsibility

The State has an overall responsibility for activities regulated by the Act on Nuclear Activities. However, this ultimate liability is not explicitly expressed in the legislation, although by means of Government statements.

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

Section 10 of the Act on Nuclear Activities defines the general obligations for a party holding a licence for nuclear activities, i.e. the licensee shall be responsible for ensuring that all the necessary measures are taken for maintaining safety throughout the lifecycle of the nuclear facility, including during decommissioning and dismantling of nuclear facilities.

Basic provisions concerning the organisation and financial, administrative and human resources for the nuclear activity are contained in Section 13 of the Act on Nuclear Activities (1984:3).

These basic provisions are expressed in further detail in the general safety regulations concerning safety in nuclear facilities (SSMFS 2008:1), where specific requirements are defined about the staffing of organisations operating under a nuclear licence. Long-term planning is required in order to ensure that enough staff with sufficient competence are available for all safety-related activities. A systematic approach should be used to define the different competencies needed as well as the planning and evaluation of all safety-related training. The regulations require that personnel, in addition to contractors and other hired personnel, have the competence and suitability otherwise needed for the tasks that are of importance for safety in the nuclear activity, and are to ensure that this is 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 management system should clearly specify 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 the staff must be fit for their duties. This implies medical requirements and 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 in order to manage the general obligations, including safety obligations, as specified in Chapter 10 of the Act. Each prospective licensee must be assessed in this respect during the licensing procedure.

As regards nuclear power reactors and nuclear fuel cycle facilities, funding of decommissioning is provided by means of investments in government-controlled funds. Licensees of

nuclear facilities must pay a fee to the Nuclear Waste Fund according to the Act on Financing of Management of Residual Products from Nuclear Activities (2006:647), as described in section E.2.1.4. This is to ensure financing of decommissioning work and handling and disposal 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.2.2.5, the holder of a licence for nuclear activities shall be responsible for ensuring that all measures are taken that are needed for the safe handling and disposal of spent fuel and nuclear waste resulting from the activity. The legal framework does not require post-closure institutional control and monitoring. This is because regulatory requirements on a disposal facility for spent fuel or nuclear waste mean that the facility is to be designed such that no institutional control or monitoring is required. It ensues that a licensee may 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 in the Act on Nuclear Activities (1984:3). It follows that the State assumes liability for the arrangements and costs of any institutional control or monitoring conducted once a licensee has been exempted from its responsibilities.

F.2.2 Measures taken by the licence holders

F.2.2.1 Qualified staff during the operating lifetime

SKB has in its management system implemented a process for systematically developing the organisation and ensuring qualified staff and competence. Linked to internal and external requirements, this process also clarifies roles and responsibilities within the process.

The process starts with competence analyses to ensure that adequate personnel are available with relevant competence and ability for the job in question. A competence management system, Competence Tool (CT), is used to make the competence assurance and to ensure that important information is well documented. The analyses are also fundamental for systematic development and design of training programmes. Competence planning uses a systematic approach to ensure staffing over the long term.

As a consequence of regulatory requirements stipulating that staff must be fit for their duties, the management system for the operation of SKB's nuclear facilities includes provisions for medical checks and drug testing.

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 year and ultimately the yearly budget, initiate the planning. The plan, together with the RD&D Programme (section A.6.4), 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 the Nuclear Waste Fund (section E.2.1.4) and directly from the 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 is not required by the legal framework (see section F.2.1.3 above).

F.2.3 Regulatory control

F.2.3.1 Qualified staff during operation

Compliance with the requirements for competence assurance has been inspected a few times since SKB took over the operation of Clab and SFR. The regulatory authority concluded at the time that the required systematic approaches are in place to ensure long term staffing and competence of operations staff.

During 2013 and 2014, SSM initiated a more systematic inspection programme directed at SKB's nuclear facilities, i.e. Clab and SFR. The outcome indicated that there was room for improvement in several areas. SSM therefore issued an injunction requiring SKB to e.g. more clearly define the distribution of responsibilities, safety management routines, control of requirements, handling of deviations, and the methods for continuous improvements in general. SSM is currently monitoring the actions taken by SKB within the programme for safety improvement, which is called Säkerhetslyftet ('Safety boost').

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 during decommissioning as an integral part of the yearly inspection programme. In addition, SSM 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

Post-closure institutional control and monitoring is not required by the legal framework (see section F.2.1.3 above).

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

The general safety regulations SSMFS 2008:1 (Chapter 2, Section 8) require that nuclear activities, design, construction, operation and decommissioning shall be managed, controlled, assessed and developed through a management system so designed that requirements for safety are met. The management system, including the needed routines and procedures, must be kept up to date and be documented. This view on quality and safety, to be integrated with other business concerns into an integrated management system, is in line with the recently issued IAEA Safety Standards Series No. GS-R-3 (The Management System for Facilities and Activities).

It is further required in regulations that application of the management system and its efficiency and effectiveness must be systematically and periodically audited by a function having an independent position in relation to the activities being audited. An established audit programme must be in place at the nuclear facility.

In the general advice to the regulations, it is made clear that the management system should cover all nuclear activities at the facility. Furthermore, the management system should clearly define how contractors and vendors should be audited, and how to keep the results from these audits up to date.

The internal audit function should have a sufficiently strong and independent position in the organisation and report to the highest manager of the facility. The audits should have continuity and auditors should have good knowledge about activities being audited.

Audit intervals should take into account the importance for safety of the different activities and special needs that can arise. Normally all audit areas should be covered every four years as a minimum.

The auditing activity itself and the management function of the plant should also be audited periodically.

F.3.2 Measures taken by the licence holders

F.3.2.1 Quality programmes

In Sweden, the general description of the quality and management system is normally regarded as the nuclear licensees' most important document, as it gives an overview of the requirements and the way in which the organisation is supposed to work in order to meet these demands. The documents are to be kept available for everyone in the organisation, and for others who are affected by the information in the documents, for instance contractors, consultants and regulatory authorities. All documents in the quality and management system are under controlled revision, regularly or when needed, in order to reflect the actual situation at the facility at all times.

Development of quality assurance programmes began at Swedish NPPs in the late 1970s. These programmes have since then been developed continuously over the years and used as a model for other nuclear licensees as well. Today, the quality assurance programmes are integrated in the licensees' management systems.

The main principle for the quality and management systems is a structure with documents on three levels. The top-level documents typically include a vision to strive for, a business concept that outlines the mission of the facility, objectives for different areas, and strategies for accomplishing the objectives. Objectives are typically defined for:

- nuclear safety,
- occupational safety,
- economic results,
- confidence from society,
- environmental impact, and
- personnel responsibility.

A comprehensive description of the organisation with responsibilities for functions and processes, division of responsibility and management principles is also included in the top-level documents. Furthermore, policies, conditions and directives apply to the main activity processes at the facility. In the conditions, all the legal requirements are included, as well as the owners' requirements and additional instructions. Lastly, the top-level documents include directives to all departments and staff units at the facility.

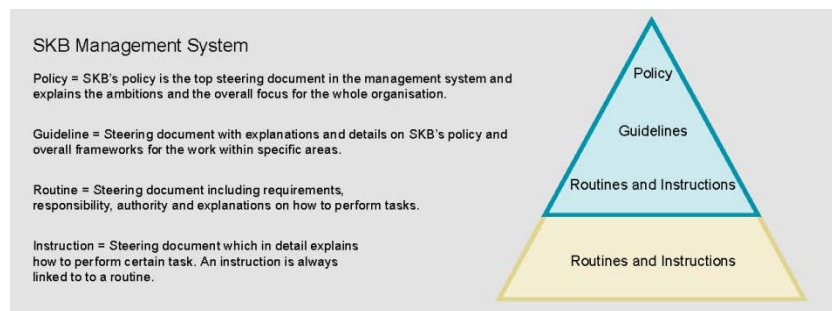
The second-level documents of the management system contain commitments defined by the managers responsible on how to work with the tasks delegated in the top-level documents. These commitments are formulated as objectives, directives, process descriptions and instructions for the different areas of responsibility.

The third-level documents include instructions for specific activities and tasks included in the different areas of responsibility as defined by the second-level documents. In addition to the three levels of documents, various types of administrative handbooks may also be used.

The purpose of the quality and management system is to achieve a unified and consistent control system for all activities, based on clear policies and measurable objectives. There should be complete traceability from policy to work instruction. The standard ISO 9001:2000 for quality management systems leads to more emphasis on processes and attempts to implement process orientation in the organisation and daily work.

F.3.2.2 Management system – SKB

The management system of SKB consists of a number of steering documents; see Figure F1, divided on overall company level (blue part) and an operational level (beige part). An explanation of the hierarchy and definitions of policy, guideline, routine and instruction are provided below. The management system is to ensure that SKB fulfils external and internal requirements. During 2017, SKB launched a project to modify the management system. The new system will adapt a process-oriented approach.

Figure F1 SKB's Management System

F.3.2.3 Management system implementation and internal audit programme

The nuclear licensees' internal audit programmes are used to ensure that the management system is implemented and applied to the organisation at different levels. The internal audit programme shall contribute to continuous development of the management system so that it fulfils requirements and assists the organisation to ensure safe and efficient operation.

F.3.2.4 Quality audits of suppliers

According to the requirements for quality assurance contained in the general regulations SSMFS 2008:1, all purchases of goods and services which might have an effect, directly or indirectly, on the protection and safety of the environment or personnel, shall be made from suppliers that through quality audits, or in other ways, have shown that they can comply with quality requirements.

The ambition of the licensees is not limited to these demands, but also includes suppliers of goods and services, where malfunctioning might cause considerable consequences for the operation. A review of a supplier not only includes a quality audit, but also a technical and commercial evaluation of the equipment or services offered. The purpose of a quality audit of a potential supplier is not only to evaluate whether the supplier has implemented and uses a documented quality system, but also to evaluate the supplier's capability of providing the correct and expected quality. Quality audits are typically performed by teams of up to four auditors. The audit team is to be led by a person with documented knowledge and experience in the QA area and of the quality norms. The team leader shall have experience from participation in several quality audits. The team must comprise one or more persons with knowledge of or experience from the product or service to be reviewed. Thus, there is no formal licensing of audit team leaders and audit team members for Swedish nuclear facilities.

A quality audit results in a report, which must be accepted by the company reviewed, before being presented to the purchasing organisation. If deficiencies are identified during the audit, the organisation under review is requested to describe what measures will be taken to correct the deficiencies in order to be accepted as a supplier of products or services to the organisation. In certain cases, a follow-up visit to the audited company is required to verify that the company has taken the actions.

F.3.3 Regulatory control

The Swedish Radiation Safety Authority's (SSM) own quality system includes guidance for SSM staff when they review licensees' quality systems. Usually the quality system itself is not the only target of SSM's review and inspections. Appropriate aspects of applying quality as-

surance are included in all of SSM's regulatory inspections. Thus, during inspections, routines and instructions are studied, as well as how they are enforced in practice in order to direct safety-related activities. The licensees' plans for quality audits and the reports from performed audits have also been subjected to review by SSM.

In general, SSM has been satisfied with the implementation of quality assurance. In general, SSM has found that the management system has been implemented and applied on all levels of the organisation. The plans for and implementation of quality audits have also been found to be acceptable. However, regulatory experience shows the necessity of having an active quality audit programme at the facilities and using the audits to develop quality and safety, ensuring that all areas and activities are covered, while also enabling sufficient traceability. This means that the audits should not only investigate compliance with documented routines, but also the suitability and efficiency of the routines in line with the concept of a learning organisation.

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

In order to regulate and create a basis for effective supervision of radiation protection at nuclear facilities, including those for management of spent nuclear fuel and radioactive waste, basic radiation protection requirements are laid down in the Radiation Protection Act (SFS 1988:220) and in regulations issued by SSM.

An extensive revision of Swedish legislation, including a considerable revision of SSM's Code of Statutes, is ongoing in connection with the transposition of the new Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation. This Directive repealed various earlier directives regarding ionising radiation: 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom.

In this context, it has been suggested to issue an amended Radiation Protection Act and Ordinance, and to include the more fundamental requirements, such as basic requirements for optimisation and justification, dose limits and constraints/reference levels as appropriate, in the new act and ordinance. The needed legislation, which also includes changes made to other acts, and the new or updated SSM regulations, must be ready by 6 February 2018 in order to transpose the Directive within the stipulated timeframe. In the text below, however, we refer to the situation as of April 2017.

F.4.1.1 Regulatory requirements for occupational radiation protection

Swedish occupational radiation protection requirements follow the requirements of Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation. The principal provisions as regards occupational radiation protection are stipulated in the SSM regulations SSMFS 2008:24, SSMFS 2008:26, SSMFS 2008:51 and SSMFS 2008:52, see also section L.1.

General requirements

Anyone who conducts an activity involving ionising radiation shall ensure that it is justified, i.e. the benefit to society or individuals outweighs the radiation harm, the radiation protection is optimised and that exposure of workers and the public is kept below the dose limits. Accordingly, the licensee must have the necessary staff (knowledge, abilities and skills), economic resources and an effective organisation in order to take on these responsibilities and to ensure proper radiation protection.

Optimisation

Anyone who conducts a practice using or resulting in ionising radiation shall ensure that the radiation protection is optimised and that dose limits are not exceeded. In this context, dose constraints should be used as appropriate. The licensee must ensure that goals and measures for optimisation work are established and that the necessary resources are made available in order to perform the actions and work towards the established goals.

Dose limits for workers

The limit for a worker in terms of effective dose is 50 mSv in a calendar year. The integrated effective dose over five consecutive years must not exceed 100 mSv. 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 dose (average for those who incur a radiation dose above 0.1 mSv during at least one month of the year) at Swedish nuclear power plants is 1.5 mSv; several dozen have doses above 10 mSv in a year and no one has received radiation doses above 20 mSv since 2009.¹²

Medical examinations

Each year, all workers must arrange to obtain a new doctor's certificate as proof of their being fit for service. This must be based on a full medical examination performed at least every third year.

¹² See Sweden's seventh national report under the Convention on Nuclear Safety, Ministry Publication Series, Ds 2016:30.

Supervised and controlled areas

Workplace zoning and a division into supervised and controlled areas are requirements. Areas must be marked and information provided about dose rates, sources, contamination levels, entrance restrictions, etc.

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

Information and education

All workers, both permanent staff and contractors, must be informed about radiation risks and receive proper education and training prior to working within a controlled area. The training shall be adjusted to the scope and type of work to be performed and to the existing radiological working environment.

Site-specific instructions, radiation protection expert

The licence holder shall establish site-specific instructions for radiation protection and appoint a radiation protection expert (RPE). SSM approves the RPE after checking radiation protection competence, his/her ability to promote radiation protection work, and the RPE's capacity to act as a controller of the licensee's implementation of the radiation protection legislation.

Instruments and equipment

All instruments used for radiation protection and the control of radiation doses shall be calibrated and undergo regular functional checks.

Policy in the event of fuel failures

It is mandatory to have a documented policy and strategy for avoiding fuel failures as well as managing any such occurring failures. The aim is to minimize the negative radiological impact of radiation doses to workers and the public.

Reporting

Annual reports are required describing the radiation protection work, the progress and evaluation of optimisation work, and experiences from outages. In the case of an accident or events that led or could have led to the spread of contamination or high doses, rapid communication to the regulatory body is required. 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 Swedish Radiation Safety Authority's regulations (SSMFS 2008:23) concerning the protection of human health and the environment from discharges of radioactive substances from certain nuclear facilities apply to nuclear facilities under normal operation. Below is a description of key provisions.

Public dose limits, dose constraints and critical group

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

The 0.1 mSv 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 50-year integration period is used for the committed effective dose. If the calculated sum dose exceeds 0.01 mSv per year, realistic calculations of the individual radiation doses, using measured dispersion data, food habits, etc., shall be performed.

Discharges, optimisation and best available technology

Sweden has no legally binding nuclide-specific discharge limits. Instead, site-specific dose constraints for discharges are used in the planning and work on limiting releases and restricting radiation dose to the critical group. Limitation of releases is guided by the principles of optimisation of the radiation protection measures and application of the Best Available Technology (BAT).

Release monitoring

Releases of radioactive substances shall be measured. All non-monitored releases must be investigated and an upper boundary shall be 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, as well as measurements of carbon-14 and tritium.

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, strontium-90 and tritium.

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 according to programmes determined by SSM. These programmes specify type and sampling frequency, sample treatment, radionuclides to consider, reporting, etc. The licensees and many authorities are involved in the sampling. Samples are analysed by laboratories that have adequate quality assurance systems. To verify compliance, SSM performs inspections and takes random subsamples for control measurements at SSM or at other independent laboratories.

Reporting

Releases of radioactive substances to air and water as well as results from environmental monitoring must be reported twice 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. If established reference values are exceeded, actions to meet the reference values shall be reported. Events that lead to an increase in releases of radioactive substances from a nuclear facility shall as soon as possible be reported to SSM 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 Swedish Radiation Protection Act (1988:220) states that ‘The aim of this Act is to protect people, animals and the environment against harmful effects of radiation.’

The recent international development is visible in the International Basic Safety Standards, GSR Part 3, which 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’ (point 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).’

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, and require an assessment to be performed describing biological effects in habitats and ecosystems, and thereby demonstrating that the environment is protected. Similar requirements are included in the draft revision of SSMFS 2008:23, the Swedish Radiation Safety Authority’s Regulations on Protection of Human Health and the Environment in connection with Discharges of Ra-

radioactive Substances from certain Nuclear Facilities, which, for final promulgation, awaits a broader revision of several SSM regulations. The request for such assessments was also communicated to the European Spallation Source ERIC as part of the licence application to build the ESS facility in Lund, Sweden, and is likely to be a condition if a final construction licence is granted.

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. The general methodology used for these assessments followed the ERICA integrated approach and screening values, developed during a series of EU research projects (FASSET, ERICA, PROTECT). In brief, activity concentrations in environmental media (air, soil, water and organisms) are calculated from a release rate and transfer parameters. The ERICA Tool can then be used to estimate internal and external dose rates to organisms, assuming homogenous distribution of radionuclides in organisms of simple ellipsoid shapes. These are compared to a screening dose rate so that situations exhibiting dose rates lower than the screening value could confidently be judged as being of no regulatory concern.

SSM's regulatory control of environmental protection against harmful effects of ionising radiation is currently performed through the review of licence applications. First, a formal check is made that an assessment has been performed in order to describe biological effect and demonstrate that biodiversity and the sustainable use of biological resources are protected. Subsequently, the assessment is reviewed to assess the relevance, completeness and quality of the assessment in order to ensure that it indeed demonstrates that the environment is given adequate protection if the licence is granted. Future inspections of licence holders, when the above-mentioned revised regulations have been promulgated, will enforce updating of today's risk assessments to also match the pace of international evolution within the area of environmental protection against ionising radiation.

F.4.2 Radiation impact of spent nuclear fuel or 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 annual collective effective dose for staff working with radioactive waste at the nuclear power plants is, per site, in the order of a few tens of mSv. This section presents examples of radiation doses received at other facilities, including spent fuel and radioactive waste management facilities.

Clab

At the central interim storage facility for spent nuclear fuel (Clab), radiation doses are incurred during normal operation, including receiving, unloading and cleaning of transport containers. 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 15–35 mmanSv in recent years depending on the activities performed. Radiation dose data for the operation of Clab during the period 2009–2016 are shown in Table F1.

Table F1 Radiation dose data for staff at Clab during the period 2009–2016

Year	No. of exposed staff members	Collective dose (mmanSv)	Maximum effective dose (mSv)	Average effective dose (mSv)
2009	28	20.3	3.5	0.7
2010	26	16.3	3.0	0.6
2011	29	16.0	3.0	0.6
2012	35	24.2	3.1	0.7
2013	34	19.9	2.0	0.6
2014	34	22.7	2.8	0.7
2015	45	23.1	2.7	0.5
2016	54	32.6	3.0	0.6

SFR

Open radiation sources are only in exceptional cases managed at SFR, the Swedish disposal facility for low and intermediate level waste. The wastes received are 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 6.0 mmanSv. This is much lower than the 25 mmanSv per year that the repository was designed for. In fact, due to ALARA measures and improved work procedures, actual incurred radiation doses over the past few years have been very low, below 0.3 mmanSv.

The Studsvik site

Nuclear activities at the Studsvik site are undertaken by three different licensees, Studsvik Nuclear AB, AB SVAFO and Cyclife Sweden AB. The majority of these activities are related to decommissioning and waste management, but research is also carried out, especially regarding nuclear fuel and materials relevant for the nuclear sector. The former operator Studsvik Nuclear AB shut down the last two research reactors, R2 and R2-0, in 2005. In 2010, the licences for these were transferred to AB SVAFO. Decommissioning is ongoing and after the completion of the first step, which included the removal of the reactors and auxiliary systems, the second step, dismantling of the biological shield and concrete pools, is presently being performed.

The annual collective effective dose for the activities at the Studsvik site varied between 0.51–0.15 manSv (subsiding trend) during the period 2010–2015. The average yearly individual effective dose varied at 0.9–2.8 mSv and the highest annual individual effective doses varied at 12.3–14.0 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

For staff working with waste management at the fuel fabrication plant Westinghouse Electric Sweden (WSE) AB, annual individual effective doses are reported to be below 1–2 mSv. To put this into perspective, in 2015 (2014) the average effective dose due to external and internal exposure (committed effective dose) for all staff at WSE was 3.9 (4.1) mSv and 7.5 (10.0) mSv, respectively. The annual collective dose for WSE is around 0.3 manSv.

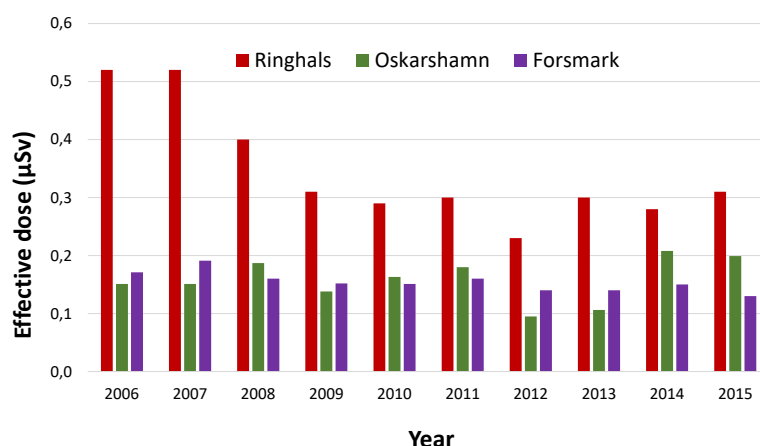
Ågesta

From the closed and partially dismantled Ågesta reactor (PHWR), small amounts of tritium are released through drainage of the rock chamber where the shut down reactor is situated. The corresponding radiation doses are negligible.

F.4.2.2 Radiation doses from releases of radioactive substances

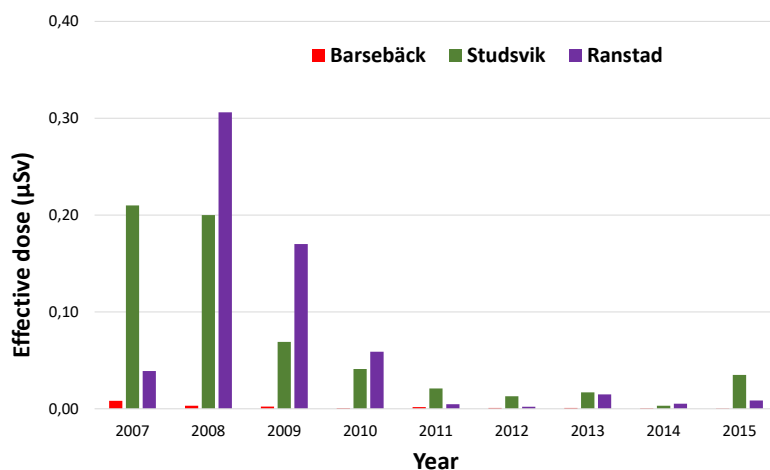
Figure F2 displays the estimated effective dose to the representative person ('critical group') from the releases of radioactive substances from the operating power plant sites for the years 2007–2015. The resulting estimated effective doses are less than 1% of the stipulated dose constraint of 100 microsievert (μSv) at all the sites.

Figure F2 Estimated effective dose (μSv) to the representative person in the critical group from releases of radioactive substances from sites with operating NPPs



The releases of radioactive substances from the Barsebäck NPP (no operating reactors) and the facilities at Studsvik and Ranstad are shown in Figure F3 below. Extraction of uranium from waste at Ranstad Mineral stopped in 2009. The resulting calculated radiation doses from the releases from Clab, SFR, Ågesta and the Westinghouse fuel fabrication plant would be too small to be visible and are for this reason omitted.

Figure F3 Estimated effective dose (μSv) to the representative person in the critical group due to releases of radioactive substances at the Barsebäck NPP, Studsvik site and Ranstad



F.4.3 Regulatory control

See section E.2.2.5 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

The emergency plans for the three operating nuclear power plants and the industry facilities at Studsvik Nuclear AB, AB SVAFO and Cyclife AB include 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 will lead to a new investigation of SFR and possible revisions of the formal requirements for an emergency plan. Westinghouse Electric Sweden AB operates the fuel fabrication facility in Västerås. This facility also has an emergency plan in accordance with 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 2008:1) concerning safety in nuclear facilities; and
- SSM's regulations (SSMFS 2014:2) concerning emergency preparedness at 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 incident, accident, emergency, crisis and disaster. 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 release seems imminent.

The Civil Protection Ordinance (2003:779) contains general provisions concerning emergency planning and is more specific about reporting obligations, information to the public, and the responsibility of the county administrative boards 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 is obliged to draw up a radiological emergency response plan. The Swedish Civil Contingencies Agency is responsible at national level for 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 (1984:3) 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 the facility.

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

SSM's former regulations concerning on-site emergency preparedness (SSMFS 2008:15) have been replaced by new regulations. The new regulations concerning on-site emergency preparedness (SSMFS 2014:2) were issued in 2014 and entered into force on 1 January 2015. Like the previous enactment, SSMFS 2014:2 uses the concept of threat categories (I, II and III) based on the IAEA's emergency preparedness categories, which introduces, in the regulation, the application of a graded approach depending on the radiological hazard at the nuclear facility.

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

- emergency planning including alarm criteria and alarming
- 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
- communication equipment

Depending on the radiological hazard potential at the facility, the requirements differ regarding radiation monitoring, emergency ventilation and collection of meteorological data.

F.5.2 National structure

Appointed central or regional (county) authorities are responsible for managing nearly all accidents and emergency situations involving nuclear technology with potential off-site consequences. However, if a national emergency with the potential of affecting many citizens, with (linked) major, negative cross-sectoral or cross-regional economic, environmental or other detrimental societal effects should occur, this will require decisions and actions by the Government.

The county administrative board in each affected county (region) is responsible for planning and leading regional emergency preparedness work. The 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/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 was compiled in 2014 and reported to the Government on 31 January 2015. This national plan describes basic preconditions such as the relevant legislation and the authorities involved in the handling of an incident and the responsibilities of these authorities. The plan also describes 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 national level. The Government's mandate is primarily strategic national issues. Responsibility for management and coordination of operational work rests with the relevant authorities. The Government has the overall responsibility to ensure that an effective crisis management system is in place and that crisis communication is credible. The Government is also responsible for certain contacts with international organisations. The Government Offices assist the Government in the crisis management work.

A senior official for crisis management has a post at the Ministry of Justice. During emergencies, the senior official has the task of ensuring that the crisis management work begins promptly; this official is also responsible for the coordination and assistance of crisis management work at the Government Offices. The senior official is assisted by the Secretariat for Crisis Management. The Secretariat monitors threat and risk developments around the clock, both domestically and internationally, and is the central focal point in the Government Offices. The Government's strategic direction for the Government Offices is prepared by a group for strategic coordination (GSS) that consists of the state secretaries of all the ministries involved in management of a serious incident. GSS is convened by the Ministry of Justice's state secretary or by an appointed state secretary.

The Swedish Civil Contingencies Agency (MSB) has the responsibility in preparedness work to support coordination of preparedness measures taken by local, regional and national authorities. MSB also provides communication networks for competent authorities during extraordinary events. The Agency 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.

The Swedish Radiation Safety Authority (SSM) has the responsibility of coordinating necessary emergency preparedness and response measures for preventing, identifying and detecting nuclear and radiological events that can damage human health or the environment. In the event of an emergency involving nuclear technology in Sweden, or outside Sweden with consequences for Sweden, SSM is the appointed National Competent Authority (NCA) and is responsible for:

- providing advice and recommendations concerning protective measures in the area of radiation protection,
- radiation measurements,
- cleanup and decontamination following a release of radioactive substances,
- 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 and measures taken as well as planned, and, following a request by the Crisis Management Coordination Secretariat at the Prime Minister's Office, or by MSB, providing the information needed in order to paint an overall picture of the situation.

A number of authorities, organisations and laboratories will cooperate or operate as supporting functions to the national organisations mentioned above in the event of a nuclear or radiological emergency. Participating authorities that have cooperating roles for crisis management include, for example, the National Food Administration, which is responsible for taking decisions on action levels for the content of radioactivity in foodstuffs, and the Board of Agriculture, which is responsible for taking decisions on action levels regarding agricultural practices and products. Other authorities that have responsibilities during crises and that cooperate with SSM, or receive advice and recommendations from SSM, include the county administrative boards, MSB, the Swedish Board of Health and Welfare, Swedish Customs, the Swedish Meteorological and Hydrological Institute, Swedish National Police Board, Swedish Coast Guard and the local rescue leader, police officers and medical personnel.

The Swedish Meteorological and Hydrological Institute (SMHI) assists SSM by providing weather forecasts, weather data and some dispersion calculations in the event of a radiological or nuclear emergency.

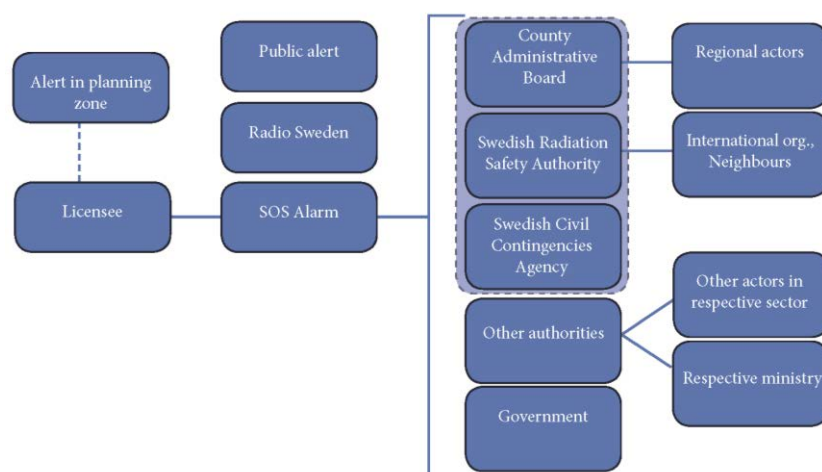
In an international context, and in regards to the Community arrangement on early exchange of information, it is SSM's responsibility as both an EU and IAEA designated Competent Authority, to promptly inform the European Commission, neighbouring countries that might be affected and the IAEA in accordance with the IAEA's Conventions on assistance and early warning and the European Commission's Convention on early warning. Fur-

thermore, 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 nuclear power plant, 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 F4. In the event of an emergency at a nuclear facility categorized in threat category II, the alarm chain is relatively 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 the Swedish Meteorological and Hydrological Institute (SMHI), which is the national contact point (National Warning Point, NWP). 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 acute phase of a nuclear accident or incident.

Figure F4 Current alarm sequence for an emergency event at a Swedish nuclear facility

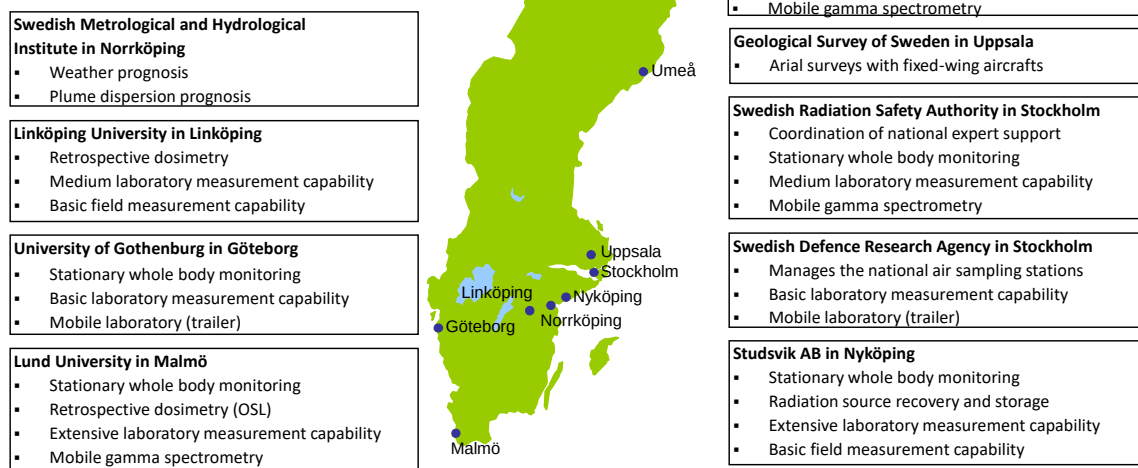


F.5.3 National monitoring

The national expert response organisation that conducts radiation monitoring and sampling following a radiological emergency is comprised of a number of different authorities, universities and organisations, shown in Figure F5, along with a summary of contracted capability. In addition to the tasks shown in Figure F5, the laboratories are also contracted for providing expert advice.

Figure F5 National expert response organisation for nuclear and radiological emergencies

National expert response organisation



In addition, a number of voluntary organisations, such as the Women's Voluntary Defence Service, the Women's Motor Transport Corps and the Women's Auxiliary Veterinary Corps, are prepared to provide assistance in the event of a radiological emergency. One area of assistance, for which these voluntary organisations are extensively trained and organised, is the rapid collection of agricultural field samples. These are transported to the laboratories belonging to the national expert response organisation for measurement. This allows for early decision-making on agricultural countermeasures.

Sweden has a new and modern gamma monitoring network that presently has 28 permanent stations distributed around the country. They are designed to provide warnings and rapid information on radiation levels. Each gamma station continually records the radiation level. If the integrated 24-hour radiation dose differs from the previous 24-hour period value by more than 10 per cent, the radiation protection officer on duty at SSM will be alerted. The alarm level can be changed in accordance with prevailing conditions. In addition, a fixed alarm level is currently set at 300 nanosieverts per hour (nSv/h).

In addition to the national gamma monitoring network, new stations are currently being installed around the Swedish NPPs. The new monitoring stations will provide information on the dose rate at 90 locations around these plants. While the national gamma monitoring network is primarily used as an early warning system, the new stations will, when the online data transfer is taken into operation in late 2017, provide fast, reliable and automatic information on dose rates to be used in decision-making on early public protective actions in the event of an accident at a Swedish NPP. Figure F6 shows monitoring stations set up around the Forsmark NPP.

Figure F6 New monitoring stations around the Forsmark nuclear power plant



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Sweden also has six sensitive and permanent air filter stations that sample the air continuously and that can detect increased levels of radioactivity in the atmosphere. The system is sufficiently sensitive to measure activity levels in the order of tens of microBq/m^3 (corresponding to approx. 100 atoms per cubic metre) and is therefore also used for environmental monitoring.

The gamma monitoring system is supplemented by radiation level data collected every seven months by the environmental and healthcare offices of local authorities. This takes place at permanent measurement points in the municipalities, thus providing a background measurement base. The results of the measurements after deposition can be compared with these reference measurements, which have been registered at two to four measurement points in each municipality. This data is collected from the municipalities by the county administrative board, which compiles and transmits the readings to a national database.

The Geological Survey of Sweden is contracted for the use of fixed-wing aircraft for airborne measurements of radiation. Detailed nuclide-specific measurements can be made to serve as a basis for decisions concerning, for example, declaring pastureland free of contamination for grazing.

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, or in hospitals or at medical health centres.

At major national hospitals, mainly university hospitals in Sweden, more advanced treatment and care can be arranged. Cooperation and sharing of resources also takes place between European hospitals in the event of major accidents. The Nuclear Medical Expert Group (RN-MEG) 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 RN-MEG.

In order to facilitate medical emergency preparedness in Sweden, the National Board of Health and Welfare has established the Centre for Radiation Medicine, located at Karolinska Institutet in Stockholm. The tasks of the Centre include contributing to Swedish emergency preparedness through healthcare information, education and advice, and conducting research activities in areas related to medical effects of ionising radiation. Close collaboration is in place with SSM and various other national and international bodies.

F.5.5 Exercises

A number of 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-site and off-site organisations. The full-scale exercises are designed to enable evaluation of command at the regional level, national inter-agency cooperation and public communication. The full-scale exercises are often also used for testing of 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 and Government.

In addition, a number of more limited on-site functional exercises are conducted at all the Swedish nuclear power plants every year. Specific plans exist for these exercises. Exercised functions include accident management, communication within the emergency preparedness organisation, environmental monitoring and sampling, assessment of core damage and source terms, and assessment of total environmental consequences of a scenario. The rescue forces are exercised regularly, as well as first aid and emergency maintenance. SSM frequently participates in such exercises both as an observer and in its supervisory role, or for the purpose of exercising the authorities' own emergency staff.

Other exercise scenarios have included physical protection events such as sabotage, armed intrusion and the taking of hostages in order to exercise coordination between the special police forces and other actors. An IAEA pilot exercise was conducted in Sweden in 2015. The scenario was a terrorist attack on transport of spent nuclear fuel and radioactive waste. The purpose was to test and evaluate the emergency management system in a terrorism-related emergency.

Sweden has a long tradition of participating in international emergency preparedness exercises. This allows for testing of 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 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 a nuclear power plant in Sweden or abroad. An agreement at regulatory body level has also been signed with Lithuania. Sweden uses the ECURIE information system for information exchange within the European Union and the UISE system for notification and information exchange between the IAEA member states.

The five Nordic countries of Denmark, Finland, Iceland, Norway and Sweden have compiled a Nordic manual describing communication and information routines between the countries applying to an extensive list of scenarios, as agreed between the Nordics. Communication exercises are performed five times per year between these countries.

F.5.7 Nuclear accidents abroad

As demonstrated by the effects on Sweden due to the Chernobyl accident of 1986, Sweden can be affected by radiological consequences as a result of a nuclear accident abroad. Although the foreseeable consequences are such that the use of iodine tablets, or sheltering or relocation of people due to fallout is unlikely, the impact can be substantial on agriculture, animal breeding, forestry, hunting, recreation and private household activities (fishing, picking mushrooms, game hunting, vegetable gardening, etc.) as well as on the environment due to the uptake and concentration of radioactive substances in plants, animals and human food chains.

The responsibility that SSM and other authorities have to distribute information is strengthened in this situation. Local county administrative boards that are affected still have the responsibility to provide information and take any protective action needed in their respective regions under the above-mentioned legislation. During the Fukushima Daiichi NPP accident, which had no direct impact on Sweden, SSM and other central authorities, such as the National Board of Health and Welfare and MSB, were responsible for communicating the consequences of the event. SSM's emergency response organisation was activated and worked around the clock for three weeks analysing and evaluating the situation in order to give advice to the Swedish embassy and Swedish citizens located in Japan. The nuclear accident at the Fukushima Daiichi NPP underlined the importance of international cooperation and the capability of a country to coordinate assistance from international authorities and organisations during emergencies.

F.5.8 New developments in emergency preparedness

A development project together with Swedish NPPs regarding electronic transmission of nuclear power plant parameters was launched in 2012. A first memorandum of understanding was signed by the Director General of SSM and the managing directors of the NPPs in the autumn of 2012, which included four phases of development and a specification of requirements regarding the first three phases. In 2015, phases one and two were completed, including a transmission solution and a shared standard for visualizing the parameters. By the end

of 2016, the online visualization tool, together with transmission of process parameters, was commissioned and in use. July 2018 is the planned point in time for feeding the online visualization tool with simulated process parameter data for educational and training purposes.

MSB has developed recommendations on shared foundations for collaboration and management of emergencies, which will contribute to an improved capability to deal with emergencies in Sweden. The aim is to provide guidance to authorities on joint methods and approaches for creating shared direction and coordination. Moreover, the goal is to make it easier for authorities to work together in a structured and consistent way, and to efficiently manage available resources. Approximately 70 parties in the field of civil contingencies—experts, researchers and operational staff—have been working over the past two years on development of the recommendations. This coordinated emergency response system is now being implemented by several authorities in Sweden, including county administrative boards and SSM. The recommendations are based on experiences from emergency response exercises and actual emergency cases. When it comes to implementation of the shared foundations at SSM, specific experiences from SSM's area of expertise have also been taken into account, which has led to a major review of SSM's emergency response organisation. The purpose of the review is to enable SSM's role in the emergency response system to efficiently provide advice and recommendations to other authorities.

Regarding implementation of Council Directive 2013/59/Euratom, the analysis for identification of necessary amendments to the Swedish regulatory framework has led to several suggestions having been made relating to emergency preparedness and response. SSM proposes that reference levels be set in the amended Radiation Protection Act, which would have an impact on prerequisites for emergency planning and necessitate a review of several Acts and Ordinances. SSM collaborates closely with MSB in this process.

The Government has tasked SSM with analysing and reviewing emergency planning zones surrounding nuclear facilities and other activities involving ionising radiation. The analysis will include suggestions regarding emergency planning zones and planning distances, applicable facilities and activities, criteria for geographic boundaries and protective actions to be prepared within the zones. The analysis will be reported to the Government by 1 November 2017.

A national strategy for radiation measurements in the event of a nuclear or radiological accident is being developed by SSM, MSB and county administrative boards together with NPPs. Initially, the project will focus on an accident at a Swedish NPP. In 2018, the project will broaden its scope to cover other nuclear and radiological emergencies.

New GIS software is being developed by SSM for reporting, storing, extracting and visualizing radiation monitoring data and environmental samples collected during an emergency. The new software, RadGIS 2.0, will replace RadGIS 1, which was developed in the 1990s. RadGIS 2.0 will be used by all Swedish organisations that perform radiological monitoring and sampling during a radiological or nuclear emergency. The project will be completed by the end of 2017 and implemented by the relevant organisations belonging to the national structure for emergency preparedness and response.

Based on the Nordic Flag Book and in collaboration with the National Food Agency, Board of Agriculture, county administrative boards, MSB, National Board of Health and Welfare, and Police Authority, SSM is in the process of developing national guidelines on urgent and early protective measures in the early and intermediate phases of a nuclear or radiological accident. The guidelines will 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 project will be completed in 2018.

In collaboration with the Swedish Civil Contingencies Agency (MSB), National Food Agency and others, SSM is developing revised guidelines on cleanup and food production following fallout of radioactive substances in Sweden. As these two sets of guidelines mainly

address the same government authorities, shared work on revisions is closely linked. New guidelines will be finished by 2017, and information initiatives and possibly education and training in accordance with the new guidelines will commence after this.

F.5.9 Regulatory control

Over the past few years, regulatory control of on-site emergency preparedness and response has focused on implementation of the new requirements contained in the regulations SSMFS 2014:2. During the autumn of 2014, surveillance inspections were carried out at all nuclear facilities of threat category I–III to ensure unanimous interpretations of SSMFS 2014:2 (see Table F2).

Table F2: Swedish nuclear facilities by threat category.

Table F2 Swedish nuclear facilities by threat category

Facility	Threat category
Forsmarks Kraftgrupp AB (NPP)	I
Oskarshamnsverkens Kraftgrupp AB (NPP)	I
Ringhals AB (NPP)	I
SKB Clab (central interim storage facility for spent fuel)	II
Westinghouse Electric Sweden AB (fuel fabrication facility)	II
Studsvik Nuclear AB (facilities for fuel and materials testing)	III
Cyclife Sweden AB	III
AB SVAFO (waste management and storage)	III
Barsebäck Kraft AB (permanently shut down NPP)	III

Following the surveillance inspections, specific transition rules were developed regarding implementation of SSMFS 2014:2 at each specific facility. During 2015, compliance inspections were carried out regarding new requirements at the nuclear facilities in threat category I and at Clab (threat category II). In late autumn of 2015, surveillance inspections were carried out at all facilities of threat category I regarding termination of transitional rules and further implementation of SSMFS 2014:2. Inspections in 2016 focused on implementation of SSMFS 2014:2 at facilities in threat category II. Regulatory control has shown that on-site emergency preparedness at the Swedish nuclear facilities has been strengthened in recent years and that the main elements of SSMFS 2014:2 have been effectively implemented.

F.5.10 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.

Since the last review meeting, the principal changes of importance to decommissioning are the decisions taken during 2015 on earlier than planned, permanent shutdown of four reactors: Oskarshamn 1, Oskarshamn 2, Ringhals 1 and Ringhals 2, as further described in section 6.2.1 below. In addition, a project involving segmentation and interim storage of reactor pressure vessel internal components commenced in 2016 at Unit 2 of the Barsebäck nuclear power plant.

Table D8 lists of nuclear facilities in the process of decommissioning and the status of decommissioning activities at these facilities.

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 in order to ensure safe decommissioning of facilities in which the operation has been discontinued until such date that all operations at the facilities have ceased and all radioactive waste has been disposed of. It follows that a licence holder is not exempted from responsibilities under the Act until decommissioning has been completed and all radioactive waste has been disposed of. This still applies when a licence is transferred to a new holder. 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.

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

The general regulations 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 handle the nuclear material and nuclear waste located at the facility site. These steps include the processes of decontamination, clearance of buildings and materials, and site release. The general regulations SSMFS 2008:1 set out a number of specific requirements relating to decommissioning. These include requirements relating to documentation of the facility, prerequisites for planning, and the decommissioning activity itself. The information to be contained in the decommissioning plan is specified further in SSMFS 2008:1. SSM is currently preparing additional licence conditions for decommissioning of reactors. These complement the provisions of SSMFS 2008:1, especially concerning allowed preparatory activities, the safety report for dismantling and demolition, the final decommissioning plan, and the decommissioning strategy for the entire site.

Licensees are required to prepare the following documents prior to, and in some cases, continuously, during the execution of decommissioning:

- Decommissioning plan and decommissioning strategy
- Waste management plan
- Safety analysis report (SAR)
- Submission of information according to the Euratom treaty, Article 37
- Sub-project notification
- Final decommissioning report
- Measurement programmes for clearance of materials and for site release

The general obligations contained in the regulations SSMFS 2008:1 and several other regulations are applicable to decommissioning and dismantling activities regarding:

- 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).

The present Swedish regulations on clearance of materials, rooms, buildings and land (SSMFS 2011:2) have been in force since 1 January 2012. This set of regulations is currently undergoing revision to enable implementation of the new European Basic Safety Standards. Here, the main issues concern adaptation of clearance levels for materials and development of requirements for site release.

The regulations contained in SSMFS 2008:38 require archiving of documentation at nuclear facilities. The licence holder must archive documentation related to radiation protection aspects of a practice. If the practice ceases, the archives 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 2008:1. The register must (for instance) contain information on the origin of the waste and the amount and nuclide-specific content of the waste. Moreover, a decommissioning report on the actual execution of the decommissioning work is required to be compiled and 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. The decommissioning report should also include a description of the management of all the wastes arising from dismantling and demolition, including conventional wastes.

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 detail depends on the amount of available information. These decommissioning plans also form the basis of decisions on financing for decommissioning activities, see sections A.6.5, E.2.1.4, F.2.2.2.

Management of decommissioning waste is coordinated through SKB. Future transport and disposal of decommissioning waste are also tasks of SKB.

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 twin BWR units Barsebäck 1 and 2 were shut down permanently in 1999 and 2005, respectively. In 2015, the operators decided on an additional phase-out of the four oldest reactors at Oskarshamn (BWR units 1 and 2) and Ringhals (BWR unit 1 and PWR unit 2) by 2020. The decisions were based on the overall business and energy market situation with falling electricity prices.

Oskarshamn 1 was permanently shut down in June 2017. Oskarshamn 2 has not been in operation since a substantial modernization programme started in 2013, and is permanently shut down since December 2016. The operator, OKG, has applied for a licence to decommission the reactors pursuant to the Environmental Act. The Land and Environment Court authorised OKG in June 2017 to proceed with its post-shutdown planning activities and authorised the Swedish Radiation Safety Authority (SSM) to issue additional requirements as necessary.

As regards Ringhals 1 and Ringhals 2, it has been decided to permanently shut down these units by mid-year 2020 and 2019, respectively. Work is ongoing to assess the prerequisites for decommissioning and to evaluate how the specific decommissioning steps should best be resolved. In conjunction with the shutdown decision for the two Ringhals units, the project STURE (Safe and Secure Phase-out of Reactors 1 and 2) was launched with the purpose of preparing for decommissioning of the two reactors.

As far as the remaining six operating reactors are concerned, the planned operating time 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, all of which were commissioned between 1980 and 1985.

At Barsebäck 1 and 2, all spent nuclear fuel was removed by 2006, and since this time the units are in care and maintenance operation awaiting the licensing and construction of a disposal facility for short-lived radioactive waste from decommissioning. Reconditioning and removal of nuclear waste from the operational phase are ongoing. Preparations for and detailed planning of dismantling and demolition have intensified since 2016. During the care and maintenance period, a project involving segmentation and interim storage of the reactor pressure vessel internal components commenced during the autumn of 2016. Segmentation of the Unit 2 reactor internal components is underway and an application is pending for the segmentation of the reactor internal components in Unit 1. Following completion of the segmentation activities, the next stage of dismantling is planned to commence in 2021. Site release is planned for the late 2020s. The final goal of decommissioning is to have the Barsebäck NPP cleared in accordance with regulatory requirements.

SKB has been contracted by the nuclear power companies to participate in planning and execution of the 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 final 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 so that it can be transported and disposed of in the appropriate final repository.

Plant-specific and scenario-specific decommissioning studies have been performed for all the Swedish nuclear power plants in order 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 regarding decommissioning that may be of value for activities in Sweden.

The challenges posed by the accelerated timetable for the decommissioning of four reactors at Ringhals and Oskarshamn, as well as the start of segmentation and interim storage of reactor pressure vessel internal components at the Barsebäck nuclear power plant, have led to an increased focus on decommissioning planning by the licence holders and SKB. Updates of preliminary decommissioning plans for all nuclear power plants were submitted by the licence holders during 2016. As a consequence of the dismantling and demolition of Barsebäck 1, Barsebäck 2, Oskarshamn 1, Oskarshamn 2, Ringhals 1 and Ringhals 2 commencing before the extended SFR is ready to receive decommissioning waste, the licensees need to provide interim storage of this waste at their sites or externally.

The decisions to permanently shut down 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 licensees' staffing and competence planning were strengthened during the review period. 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 pressurized heavy water reactor in Ågesta was permanently shut down in 1974. Two steam generators were dismantled and waste treated at Studsvik in the early 1990s as part of an NEA research project. A licence for continued care and maintenance until 2020 was issued under the Environmental Code by the local Land and Environment Court in November 2008.

Currently, preparations are being made for radiological characterisation and planning of future dismantling, intended to begin no later than 2020. Since the Ågesta reactor is an older facility that has been shut down for a long time, a number of measures have been taken to update the documentation. These include collecting all the relevant documentation and digitalising selected parts of this in order to provide a good basis for defining the extent and limitations of the project, and a 3D model has been made of selected parts of the facility. Additional documentation will be produced using modern photo technology in order to have a complete basis for planning of dismantling and demolition. In addition, a radiological survey will be initiated, which will include calculation of induced activity in and around the reactor pressure vessel and measurement of contamination in other parts of the facility.

The different waste streams that will be generated in conjunction with dismantling and demolition of the Ågesta reactor have been identified. For each waste stream, different steps are being evaluated up to final clearance or disposal through one of the available deposition alternatives.

F.6.2.3 Old research and other facilities at Studsvik

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. Dismantling of the reactors and associated facilities is ongoing. Decontamination of two test loops was performed in 2008. Dismantling of the reactors commenced in 2015. According to the current time schedule, dismantling activities will continue until 2019 to achieve an end state with the facility prepared for free release.

Other installations

There are a number of other old facilities at the Studsvik site that are to be decommissioned and/or dismantled. Preliminary plans for the decommissioning and dismantling of these facilities have been prepared by the licence holders and submitted to the Swedish Radiation Safety Authority (SSM) for evaluation, according to requirements contained in the general regulations. Decommissioning of these nuclear installations at Studsvik is performed by the licensee, AB SVAFO. Two old underground silos for liquid intermediate level waste have now been decontaminated and partially dismantled. The underground silos were approved for clearance in 2015 by the Swedish Radiation Safety Authority.

F.6.2.4 Studsvik Nuclear and Cyclife facilities at Studsvik

Studsvik Nuclear and Cyclife are licensees of a number of nuclear facilities at Studsvik. Preliminary decommissioning plans for these nuclear facilities have been prepared and submitted to SSM according to 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 extraction of uranium from waste originating from nuclear fuel fabrication.

Currently, decommissioning of the facility is proceeding. The former mineral processing plant was dismantled and demolished in 2013 following approval by SSM. The leaching plant has been emptied of loose objects and processing equipment has been dismantled. Waste contaminated by uranium has been transported to a facility for treatment and disposal of hazardous waste, following clearance by SSM. In early 2017, the Authority took the decision to allow the leaching plant to be dismantled and demolished. The leaching plant is now being demolished, with the project scheduled to terminate in 2017.

F.6.2.6 SKB facilities

In preparation for its application under the Act on Nuclear Activities seeking the extension of SFR, SKB developed during the period 2012–2013 a new decommissioning plan for the facility. Decommissioning of SFR will begin when the main activity ceases, not to be resumed, and will continue until the above-ground facility has been cleared and there are no radiological reasons to prevent the establishment of another industrial activity on the site. The extent of demolition beyond this mainly depends on how the site will be used in the future. Current plans call for 60 years of operation for the nuclear power plants and a few more years for Clink. Decommissioning of SFR could thereby commence in the mid-2070s.

SKB has conducted a decommissioning study of the combined Clab and encapsulation facility (Clink), based on the current planning while also focusing on waste volumes, the content of radionuclides and costs. A preliminary decommissioning plan for Clab was updated and submitted to SSM in January 2017.

A preliminary decommissioning plan has been prepared for the spent fuel repository. It was included in the application under the Act on Nuclear Activities (1984:3) for disposal of spent fuel and under the Environmental Code for the KBS-3 system.

No decommissioning plan has yet been prepared for SFL, since the design of the facility is 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 the Swedish Radiation Safety Authority according to requirements in the general regulations.

F.6.3 Regulatory control

See sections E.2.2.5 and F.3.3 for details on the Swedish Radiation Safety Authority's (SSM) system of controls and inspections.

SSM is currently performing regulatory supervision of ongoing decommissioning activities at the Ranstad uranium mining and milling facilities, as well as the decommissioning of the materials testing reactors at Studsvik. In addition, SSM is performing regulatory supervision of the planning for dismantling and demolition at the Barsebäck nuclear power plant, as well as the segmentation and interim storage of the reactor pressure vessel internal components from the reactors.

The regulations on clearance (SSMFS 2011:2) have been enforced since 2012. Examples of clearance of rooms and buildings include both nuclear and non-nuclear facilities (e.g. hospital rooms and accelerator facilities). In addition, the former ship used for transport of spent fuel and radioactive waste has been taken out of service, cleared according to the regulations and its structure scrapped for metal recycling. Since 2013, SSM has performed inspections at nuclear facilities focusing on procedures for clearance of materials. In this context, SSM has made own measurements of materials for clearance for comparison with the measurements performed by the licensees. The main observations arising from these inspections have concerned quality assurance and considerations of nuclide distributions and measurement uncertainties.

From ongoing and earlier decommissioning projects, SSM has experience from applying the general regulatory requirements to decommissioning. The regulations have proven to be sufficiently well suited for the purposes of nuclear safety and radiation protection, and continue to be applicable during decommissioning. Nevertheless, SSM has identified some issues that it considers would benefit from further development and clarification, mainly concerning the requirement for different documents. In 2015, SSM issued comprehensive guidelines on the safety requirements it considered applicable following the removal of all nuclear fuel from a unit.

The challenges posed by the accelerated timetable for the decommissioning of four reactors at Ringhals and Oskarshamn, as well as the start of segmentation and interim storage of reactor pressure vessel internal components at the Barsebäck nuclear power plant, have also led to an increased focus on decommissioning on the part of SSM. During 2016, dialogue was initiated with licensees concerning additional licence conditions for the soon to be dismantled nuclear reactors. These conditions, decided on by SSM in June 2017, will complement and clarify the existing requirements in regulations SSMFS 2008:1. They address, among other things, the requirements for the SAR and operational limits and conditions for reactors during dismantling and demolition. Furthermore, the requirements for the decommissioning strategy and the final decommissioning plan, as well as the notifications of dismantling and demolition work packages, are clarified and complemented, as is a definition of preparatory work that may be conducted in advance of actual decommissioning and dismantling.

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 are 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 the matters (primarily regulatory requirements) that are common to both section G and section H is presented in full in section G only. Where appropriate, 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 repositories 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;
- (vi) aim to avoid imposing undue burdens on future generations.

G.1.1 Regulatory requirements

G.1.1.1 The general obligations of licence holders

Licence holders of nuclear power plants are expressly responsible for the safe management and ultimate disposal of the spent nuclear fuel and radioactive waste that they generate. As accounted for in section E.2.1.1, the Act on Nuclear Activities requires that the holder of a licence for the operation of a nuclear power reactor shall – in cooperation 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. The scope of the system for final disposal encompasses wastes from nuclear facilities other than nuclear power reactors, legacy wastes from historic nuclear activities and wastes from non-nuclear activities where radioactive material is used. Every third year, the programme must be submitted to the Government, or to an authority assigned by the Government (i.e. the Swedish Radiation Safety Authority), for evaluation.

In addition, as accounted for in section E.2.1.4, the Financing Act requires the licensees to submit every third year estimates of all future costs for management and disposal of spent nuclear fuel and nuclear waste, and decommissioning. The licensee of a nuclear power reactor shall base cost estimates on 40 years (50 years is suggested in a Government bill, but not decided yet) of operation with a minimum remaining operating time of six years. Licensees of nuclear facilities other than nuclear power reactors must also pay fees and provide guarantees to the Nuclear Waste Fund; these are based on cost estimates that take into account the expected remaining period of operation. Costs for management and disposal of wastes from non-nuclear activities are covered by fees paid by the producers to Cyclife Sweden AB (section A.6.5.5).

G.1.1.2 Basic provisions and licence obligations

Basic safety provisions are stipulated in the Act on Nuclear Activities (1984:3). The requirements are further clarified in the general safety regulations SSMFS 2008:1. In the regulations it is stated that, in order to ensure adequate protection at all stages of spent fuel management and radioactive waste management, the licensee shall:

- establish documented guidelines for how safety shall be maintained at the facility as well as ensure that the personnel performing duties important for safety are well acquainted with the guidelines;
- ensure that the activities carried out at the facility are controlled and developed with the support of a quality system which covers those activities of importance for safety;
- ensure that decisions on safety-related issues are preceded by adequate investigation and consultation so that the issues are comprehensively examined;
- ensure that adequate personnel are available with the necessary competence and suitability in all respects needed for those tasks which are of importance for safety as well as ensure that this is documented;
- ensure that responsibilities and authority are defined and documented with respect to personnel carrying out work which is important for safety;
- ensure that the personnel are provided with the necessary conditions to work in a safe manner;
- ensure that experience from the facility's own activities and from similar activities is continuously utilised and communicated to the personnel concerned; and

- ensure that safety, through these and other measures, is maintained and continuously developed.

In the Radiation Protection Act (1988:220) it is stipulated that radioactive waste shall be handled and disposed of in a manner that is satisfactory from a radiation protection point of view.

There are specific regulations on the protection of human health and the environment in connection with the final management, including disposal, of spent nuclear fuel and nuclear waste (SSMFS 2008:37), with a focus on application of radiation protection principles for the long term. There are also requirements contained in the regulations SSMFS 2008:21 concerning the long-term safety of a disposal facility. These latter two regulations impose requirements for the design and long-term safety assessments of disposal facilities.

G.1.1.3 Criticality and removal of residual heat

The general safety regulations (SSMFS 2008:1) state that radiological accidents are to be prevented by the design, construction, operation, monitoring and maintenance of a facility. Requirements for prevention of unintended criticality are included in a section on defence in depth, and heat generation and removal of residual heat must be considered when establishing the operating limits and conditions of any nuclear facility.

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 that they generate provides an incentive to consider all steps from generation to disposal. Detailed requirements are stipulated in SSM's general regulations SSMFS 2008:1 and SSMFS 2008:3:

- Measures for the safe on-site handling and storage of spent fuel shall be analysed and verified, and included in the safety report of the facility. The safety report shall also include measures that need to be taken on-site to prepare for the safe subsequent transport, storage or disposal of spent fuel. (SSMFS 2008:1)
- An inventory of all spent fuel on-site must be kept updated at all times. (SSMFS 2008:3)
- Plans shall be drawn up providing a general description of management, including disposal, of spent nuclear fuel likely to be generated while operating the facility. The plans shall be reported to the authorities for approval before commissioning (SSMFS 2008:1) of nuclear reactor facilities.
- As regards spent nuclear fuel deviating from that specified in the plans as stipulated above, all necessary measures for management of the non-conforming material shall be explained and documented in a separate plan. The separate plan shall be reported to the authorities before handling of the spent fuel (SSMFS 2008:1).
- Acceptance criteria shall be derived stating the properties of the spent nuclear fuel that can be received for storage, disposal or any other management. Acceptance criteria shall, to the extent that is feasible and possible, be formulated while taking into account safety and radiation protection throughout all steps of spent fuel management. Procedures must be in place for management of material that does not meet the acceptance criteria, e.g. by returning it to the consignor or by taking measures to rectify identified deviations (SSMFS 2008:1).

G.1.1.5 Protection of individuals, society and the environment

General radiation protection provisions are described in section F.4.1. Radiation protection of the public and the environment in connection with spent fuel management is specifically addressed in SSM's regulations SSMFS 2008:37, SSMFS 2008:21 and SSMFS 2008:1; see also section L.1. In summary, the following are required:

- Human health and the environment shall be protected from the detrimental effects of ionising radiation during the various stages of the final management of spent nuclear fuel or nuclear waste, as well as in the future.
- 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 sustainable use of biological resources are protected.

G.1.1.6 Account of biological, chemical and other hazards

Biological, chemical and other hazards are addressed in the licensing process of an activity. Any such risks that might be associated with the activity in question should be reported in the corresponding Environmental Impact Assessment (EIA). The EIA should also include a description of the measures envisaged to prevent, reduce or remedy adverse effects (E.2.2.2). During operation the operator is required to continuously take protection measures and precautions to prevent or hinder the activity from causing detriment to human health or the environment from chemical, biological and other hazards, as well as from a radiological point of view.

Supervision of activities that deal with chemical and biological hazards is primarily exercised by county administrative boards.

The topic was addressed by SKB's RD&D programme as well as during the national consultations carried out according to the Environmental Code regarding SKB's plans for disposal of spent nuclear fuel. Non-radiological environmental risks arising during construction and operation of planned facilities were assessed¹³ and the outcomes presented by SKB in the EIA submitted to the regulators as part of the licence application for the disposal of spent nuclear fuel (see section A). A post-closure chemotoxic assessment for the disposal of spent nuclear fuel was also performed by SKB.¹⁴

G.1.1.7 Striving to avoid impacts and undue burdens on future generations

As described in section A.5.3, the practices for management of spent fuel and radioactive waste are governed by fundamental principles adopted by the Swedish Parliament. The first governing principle is that costs for the treatment and disposal of spent fuel and radioactive waste from nuclear activities shall be covered by fees that licensees are required to pay. The second principle is that the licensees are to safely dispose of spent nuclear fuel and radioactive waste from nuclear activities. Although the state formally has the ultimate liability for spent nuclear fuel and radioactive waste from nuclear activities, these principles imply that a burden on future generations should be avoided, especially with regard to the fundamental aspects of safety and costs. The principles also imply that action should be taken without undue delay, i.e.

¹³ SKB Report 2009, P-09-78, can be downloaded at www.skb.se

¹⁴ SKB Report 2010, P-10-13, can be downloaded at www.skb.se

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.

SSM's regulations SSMFS 2008:23 state 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, the regulations SSMFS 2008:37 contain general requirements stipulating that human health and the environment shall be protected from detrimental effects of ionising radiation during all stages of the final management of spent nuclear fuel or nuclear waste, 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 2016

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 was promulgated. Since 1986, SKB has produced eleven RD&D programmes having the KBS-3 system as the industry's preferred alternative for the disposal of spent fuel. The current status of SKB's licence applications in relation to establishing KBS-3 is outlined in section A.8.1.

In September 2016, SKB submitted the eleventh RD&D programme to the regulator, SSM, for review and a public consultation.¹⁵ In RD&D Programme 2016, SKB presents its plans for research, development and demonstration during the period 2017–2022. The programme consists of four parts:

- Part I SKB's activities and plan of action
- Part II Waste and final disposal
- Part III Decommissioning of nuclear facilities
- Part IV Other issues

Using the 2011 licence applications as a basis, SKB has planned and structured the remaining RD&D work up until the start of trial operation of the facilities in the KBS-3 system. For the spent fuel repository, the system design of the final repository's facility parts and technical systems has been completed. The preparatory work prior to detailed design is now underway, which, among other things, includes supplementary geotechnical investigations, preliminary design and studies, as well as the formulation of requirements prior to detailed design. Compensatory environmental measures have been adopted on the site, and the day-to-day work of monitoring the site and managing buildings, land and drilling sites is underway. Work on system design of the integrated interim storage and encapsulation facility, Clink, has been initiated.

Technological development projects for the spent fuel repository are structured in accordance with the 'production lines' linked to the repository's barriers and parts (canister, buffer, backfill, closure and rock). The projects are governed by a strategic technological development plan that links the deliveries from technological development to construction projects and future safety analysis reports (SARs).

¹⁵ SKB Report 2016, TR-16-15 (in English), can be downloaded from www.skb.se

Cost calculations

Since the early 1980s, cost calculations have been submitted on a regular basis as part of the cooperation between licence holders of nuclear power reactors. From the outset, they were submitted on an annual basis, but they are currently submitted every third year. In January 2017, SKB submitted the most recent cost calculations in compliance with the Act on Financing of Management of Residual Products from Nuclear Activities (2006:647).

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 that have been taken by licence holders with respect to the continued safe management of spent fuel include the following.

Spent fuel storage at reactor sites

As a follow-up to the severe Fukushima Daiichi nuclear power plant accident in 2011, all Swedish nuclear power plants as well as the central interim storage facility for spent nuclear fuel (Clab) were subjected to stress-test analyses in accordance with requirements specified by the European Nuclear Safety Regulators Group, ENSREG. The aim was to assess the robustness of the facility beyond design basis.

As a result of the stress test assessments, some areas of improvement for the spent fuel pools in Swedish NPPs were identified by the licensees and the regulator. The most important actions identified in the Swedish action plan for the spent fuel pools are the following:

- Seismic analyses: a return frequency of 10^{-5} /year shall be used as a basis for reviews/back-fitting of the fuel pools' structural integrity.
- Consideration taken to loss of electrical power, different situations and the impact on the NPPs' spent fuel pools due to loss of electrical power.
- Prolonged extreme situations should be the basis for technical and administrative measures to ensure the capabilities for spent fuel pool cooling during these extreme situations, including alternative means of cooling and residual heat removal of the spent fuel pool.
- Instrumentation: ensure instrumentation for measurement of necessary parameters (water level, temperature) in the spent fuel storage during extreme situations.

The above actions should be implemented by the licensees by the end of 2017.

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. From the start of operation in 1985 until 2006, the operations were contracted to OKG. In January 2007, SKB took over Clab's operations in order to manage the facility as part of SKB's own organisation.

The approved storage capacity at Clab was increased from 5,000 to 8,000 tonnes of fuel through the opening of new storage pools that were taken into operation on 1 January 2008. A modernisation of the SAR for Clab was submitted to the regulator (SSM) in 2016, with a focus on the outcome of post-Fukushima stress tests as well as the updated event inventory

that was developed in the context of the licence application for Clink, the proposed facility for combined storage and encapsulation.

In 2015, SKB applied for permission (as a supplement to the licence application for the KBS 3 combined storage and encapsulation facility, Clink) to increase the Clab facility's interim storage capacity further from 8,000 to 11,000 tonnes of spent nuclear fuel, without the construction of new storage pools. The intention is that this increased capacity should accommodate all potential requirements for interim storage prior to taking the KBS-3 disposal system into operation. In the work with design premises for Clab's accommodation of 11,000 tonnes, a set of requirements has been established and the needed changes in the safety concept have been specified. An update has been made of the analyses that are dependent on the inventory. It is currently planned that the preliminary SAR for Clab with regard to increased storage capacity to 11,000 tonnes will be completed in the summer of 2018.

All areas of improvement identified in the post-Fukushima stress test analysis of Clab have now 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 after loss of electric power supply or other extreme disturbances of the cooling system will not occur within a period of 30 days.

Transportation of spent fuel

Work is underway to replace SKB's current fuel transport casks with new casks that comply with modern requirements. A contract for fuel transport casks was signed in October 2013 encompassing construction, licensing and manufacture of five transport casks with auxiliary equipment. There is an option for manufacturing of an additional container. The casks are to be delivered during the period 2019–2021. In 2019, a decision on ordering a sixth transport cask needs to be taken.

As of August 2015, requirements are set for a new design of bottom shock absorbers for SKB's existing fuel transport casks. Previously, SKB judged it as possible to carry out a limited number of shipments without purchasing new bottom shock absorbers. The strategy was, by taking compensatory measures and minimising the number of shipments, to obtain licences from SSM by special agreement for the remaining shipments before commissioning new transport casks that meet the requirements. Among other things, the decisions regarding premature shutdown of nuclear power plants (section A.7.1) have changed these assumptions. SKB has for this reason decided to acquire new bottom shock absorbers. Pending delivery of these, a licence to carry out shipments using existing transport casks without bottom shock absorbers has been obtained from SSM by special agreement. Existing transport casks with new bottom shock absorbers will be validated by SSM before they are used.

G.1.3 Regulatory control

G.1.3.1 The general obligations of licence holders

Evaluation of the RD&D programme

In September 2016, SKB submitted the nuclear reactor owners' eleventh programme since 1986 for research, development and demonstration, RD&D Programme 2016, to SSM for review and broad consultation with national stakeholders. In March 2017, SSM submitted the results of its evaluation and a statement to the Government with a recommendation to approve SKB's RD&D programme.

The regulatory evaluation of the programme was constrained so as not to forestall the eventual outcome of SKB's licence applications for an encapsulation plant and a spent fuel

disposal facility. However, the overall conclusion as regards spent fuel management was that the programme (including further research into corrosion mechanisms for the disposal canister) provided an adequate summary of the basis for continued work to establish a final repository for spent nuclear fuel, thus providing a fair account of how continued development can take place alongside an incremental process for implementation. SSM's recommendation was that SKB still needs to consider key aspects of requirement definition, and that appropriate reporting should be undertaken during the construction phase.

SKB's plans for the management of non-standard fuels were judged to be appropriate by SSM. However, it was considered that SKB needs to give attention in the upcoming RD&D period to issues relating to the management of damaged fuel, and furthermore, that the programme should continue to strive for a systematic and mutually consistent understanding of the fuel dissolution mechanisms in order to minimize uncertainty in the safety analysis.

Nuclear waste fees and guarantees

In December 2014, the Government decided to raise the nuclear waste fee to be paid by the nuclear power plant owners to the Nuclear Waste Fund from an average of SEK 0.022 per kWh of produced nuclear electricity (approx. EUR 2.0 per MWh) to an average of SEK 0.04 (approx. EUR 4.0 per MWh) for the period 2015–2017.

In January 2017, SKB submitted new cost estimates to SSM on the nuclear reactor owners' liabilities for the management and disposal of spent nuclear fuel and nuclear waste. By 7 October 2017, SSM is to submit its review results to the Government together with a new proposal for fees and guarantees to be decided upon for the period 2018–2020.

G.1.3.2 Basic provisions and licence obligations

Inspections and surveillance

As noted elsewhere in this report (e.g. sections A.6.3.4 and E.2.2.5), the Swedish Radiation Safety Authority 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. In May 2015, based on the results of inspection findings, SSM published its integrated evaluation of radiation protection and safety on the part of SKB's facilities, including Clab and SFR. The integrated evaluation identified shortcomings in SKB's management systems with respect to certain aspects of responsibility, authority and supervision of contractors, which were subsequently followed up by demands for action in relation to organisation, management and control.

SKB has developed and submitted to SSM a plan of action for addressing the identified shortcomings and no special supervision measures have been required, see also section K.2.6. Nevertheless, based on routine surveillance across SKB's operations as a whole during 2016, SSM identified some continuing concerns at employee level regarding safety culture, the role of SKB's safety department, and how safety challenges are translated into the organisation's strategy. A follow-up of these issues is planned by SSM in order to ensure consistency with the overall requirement on licence holders (see above) to ensure that decisions on safety-related issues are preceded by adequate investigation and consultation.

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 the Joint Convention entered into force on the part of Sweden, the situation was satisfactory as regards safety of spent fuel management facilities. The elements of the Joint Convention have long been implemented in the form of requirements imposed in the Swedish legal and regulatory framework, as well as implemented in management of spent fuel. Dedicated inspection and review activities carried out in the early 2000s confirmed that the licensees' activities were in conformance with the legal and regulatory requirements. This conclusion has been reaffirmed during subsequent inspection and review activities.

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

Under the Environmental Code and Act on Nuclear Activities, a licence is required in order to construct, possess and operate any nuclear facility (the licensing procedure is described in section E.2.4). An application must demonstrate that the requirements are fulfilled under these enactments as well as under the Radiation Protection Act. It must also be made clear that the more detailed requirements contained in SSM's regulations can be met. In relation to safety issues regarding the siting of proposed facilities for management of spent fuel, key regulations in this context 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)
- 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)

Key inputs for the licence application are the Environmental Impact Assessment (EIA) and preliminary safety report.

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 or development to be achieved with a minimum of 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, see section E.2.2.2. The EIA must contain the following elements:

- a description of the activity or measure with details of its location, design and scope;
- a description of the measures being 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 activity or measure 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 and 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 are stated in the regulations concerning safety in nuclear facilities, and include (for example):

- A description of how the site and its surroundings, from the standpoint of safety, can affect the facility.
- A description of the design basis, including the requirements that have determined the design and construction of the facility. Descriptions of facilities for the handling of spent fuel or nuclear waste shall contain requirements that are determined by the description of safety in the particular disposal facility after closure.
- A description of measures taken to ensure adequate protection of workers, the public and the environment from radiation, as required by the Radiation Protection Act and regulations promulgated according to that Act.

It is further explained in regulations relating to development of geological disposal facilities (SSMFS 2008:37) that site selection should be seen as contributing to identification and implementation of the best available technique for the repository system.

G.3.1.2 Public information and involvement

The legal framework for licensing of nuclear activities stipulates provisions on transparency, openness and public participation. There are several procedures that serve the purpose of involving the public as part of siting of new spent nuclear fuel and nuclear waste facilities. As mentioned above, an EIA must be performed for any new nuclear facility. Swedish legislation emphasizes the role of the public and other stakeholders in the EIA. The EIA must for instance contain a plan for the formal process of consultation with stakeholders. 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 county administrative boards,
- national environmental organisations,
- local interest groups, and
- affected individuals, e.g. land owners or those living close to a proposed location.

County administrative boards have an important function besides participating in the consultations. They are requested to assist the developer in identifying stakeholders and to facilitate consultations and the exchange of information.

Furthermore, the regulatory authority (SSM) is tasked with performing a formal consultation in association with its evaluation every three years of the nuclear power plant licence holders'

joint RD&D programme (see section G.1.1). These consultations provide a broad range of interested parties with information regarding the programme for development of new facilities, as well as a possibility to state opinions in the pre-licensing process.

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 facility, including a disposal facility, are to be reimbursed for information activities aimed at their residents. Municipalities have since the mid-1990s been reimbursed for their information activities associated with SKB's siting process in connection with geological disposal of spent fuel. Currently, the municipalities of Östhammar and Oskarshamn are receiving reimbursement. In 2004 the Parliament approved a new regulation in the Financing Act, which made it possible for certain non-profit, non-governmental organisations as well to apply for financing. These organisations are entitled to financial support from the Nuclear Waste Fund at the discretion of SSM until 12 months after the EIA has been announced by the Land and Environment Court (for further details, see section E.2.1.4). As of January 2017, following the expiry of this period in relation to SKB's licence applications for the KBS-3 system, the Government has made it possible for non-governmental organisations to instead apply for continued financial reimbursement as part of the budget appropriation allocated to the Swedish Environmental Protection Agency.

Prior to the Government's licensing decision in relation to development of an encapsulation plant and a spent nuclear fuel repository, the host municipality concerned has a right to veto and must formally declare its support or rejection of the decision. In practice, the formal consultations, financial support to host municipalities and certain environmental organisations, and the municipal right to veto have to date been very beneficial to the overall quality and 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 building trust in the high-level waste management system together with the integrity of the regulator was credited as a good practice in the 2011 IAEA IRRS review.

G.3.1.3 Consulting contracting parties

Sweden (as well as the EU, Canada and USA) 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 to impose the requirement for 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 the requirements imposed for Environmental Impact Assessments (EIA). The Environmental Code specifies that if another country is likely to be affected, the responsible authority as designated by the Government shall inform the competent authority in that country about the planned activity. The country concerned and the citizens who may be affected should be given the opportunity to take part in the consultation procedure. The Government has designated the Swedish Environmental Protection Agency to be responsible for this task.

As part of this procedure, and in accordance with Article 5 of the Espoo Convention, 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. 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. A record of the process, including statements from neighbouring countries and

SKB's response to issues raised, was submitted to the Land and Environment Court that is responsible for examining the licence application.

As an EU Member State, 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 of radioactive waste in whatever form as will make it possible to determine whether the implementation of such a plan is liable to result in the radioactive contamination of the water, soil or airspace of another Member State. Information regarding the planned encapsulation facility and repository for spent nuclear fuel, which is currently the subject of the licensing review process (see section A.8.1), 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 spent fuel and radioactive waste facilities that are planned, 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 in September 2016.
- Consultations and an EIA for the planned encapsulation facility (Clink) and the repository for spent nuclear fuel began formally in 2002, but in practice started 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 license 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

SSM and its predecessors (the Swedish Nuclear Power Inspectorate, SKI, and the Swedish Radiation Protection Authority, SSI) reviewed and analysed SKB's siting programme for a deep geological disposal facility for spent fuel over a period of more than three decades prior to the submission of the licence application. The main instruments for regulatory control of SKB's siting programme have been:

- review of SKB's recurrent programme for research, development and demonstration (RD&D programmes),
- consultation meetings with SKB on their site investigations at two candidate sites,
- participation in EIA consultation meetings led by SKB in accordance with the requirements in the Environmental Code, and
- independent review and analyses of SKB's site investigation data and site descriptive models.

Based on the outcome of these review activities, the Government concluded in a decision in 2001 that SKB could start detailed investigations at the candidate sites using the KBS-3 method as a planning premise for the site investigation. The Government added that this did not remove the need for formal justification of method selection at the time of repository licensing.

The Government also concluded that SKB should conduct consultation meetings with SKI and SSI during the full duration of the site investigation programme. Both authorities contributed to these consultation meetings, which were held between 2001 and 2010, by asking questions and providing comments related to SKB's site investigation methods as well as their interpretation of site-specific information. A series of reports¹⁶ is publicly available covering all external regulatory reviews and analyses of SKB's site investigation programme.

As part of the licensing review (section A.8.1), SSM has formally reviewed SKB's selection of Forsmark as the proposed site for the proposed repository for spent nuclear fuel. SSM's conclusion is that of the locations considered within the framework of the voluntary engagement process, Forsmark is the most suitable site from the perspective of radiation safety.¹⁷ According to the Authority's assessment, none of the alternative locations considered during the site selection process demonstrated properties that, taken together, were more advantageous from the perspective of preventing, limiting and delaying releases from the engineering and geological barriers, compared with SKB's proposed location at Forsmark. The factors judged to weigh most heavily in favour of Forsmark in relation to the other locations are its relatively homogeneous rock mass with few water-bearing fractures at repository depth.

Moreover, SSM assessed that SKB's preferred location for the encapsulation facility adjacent to the central interim storage facility is one that, from the perspectives of nuclear safety, radiation protection and safety, best meets the siting requirements of the Environmental Code. It is nevertheless recognised that constructing the encapsulation facility at Clab implies certain risks that SKB will need to take measures to minimise. At the time of preparing this national report, the Land and Environment Court had made no judgment on SKB's siting decisions and their implications for the licence application according to the Environmental Code.

SSM has concluded that the consultation process undertaken by SKB in association with the EIA was acceptable in respect of issues relating to radiation safety. The Authority found that the consultation was timely, that it involved the correct parties and that it considered the issues that should be addressed. SSM noted that the Authority itself had the opportunity to submit comments during the consultation process, and that SKB responded to those comments. Prior to making its final pronouncement to the Government in relation to SKB's licence applications under the Act on Nuclear Activities, SSM plans to take into account any wider issues relating to the consultation process that may be raised in the Land and Environment Court's formal examination of SKB's licence application according to the Environmental Code.

G.3.4 Conclusion

Sweden complies with the obligations of Article 6.

¹⁶ Available at www.ssm.se

¹⁷ Consultation response on the licence application from the Swedish Nuclear Fuel and Waste Management Company (SKB) under the Environmental Code for a system for management and final disposal of spent nuclear fuel, SSM2016-546-5, available at www.ssm.se

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 decommissioning 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

The requirements for limiting the possible radiological impact on individuals, society and the environment, including impacts from discharges or uncontrolled releases, are founded upon the basic provisions contained in the Act on Nuclear Activities, Radiation Protection Act and Environmental Code.

G.4.1.1 Measures to limit radiological impact

The regulations concerning safety in nuclear facilities (SSMFS 2008:1) apply to the construction, operation and decommissioning of all types of nuclear installations, including facilities for the treatment, storage and disposal of spent fuel and radioactive waste. Furthermore, there are additional requirements in regulations concerning safety in connection with the disposal of nuclear material 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 latter regulations contain basic requirements regarding the protection of human health, expressed as a risk target for a representative individual in the most exposed group from potential future releases, and general criteria regarding protection of the environment.

A basic requirement is that nuclear accidents shall be prevented through a basic facility-specific design that shall incorporate 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, which still may occur as a result of extreme events, incidents and accidents, is prevented or, if this is not possible, controlled and mitigated through devices and prepared measures.

In addition to the above requirements, optimisation must be performed and Best Available Technique (BAT) shall be taken into consideration in the final management of spent nuclear fuel and radioactive waste. The objective is to ensure that all reasonable measures to improve the protective capability of a disposal facility are considered in all stages of the development, operation and decommissioning of a final repository system. When judging the practicability of different measures, both economical and societal factors should be taken into account.

G.4.1.2 Conceptual plans and provisions for decommissioning

The Act on Nuclear Activities states that the holder of a licence for nuclear activities is responsible for the safe decommissioning of facilities.

The Act on Nuclear Activities also states that licence holders shall make conceptual plans for decommissioning of facilities and ensure that comprehensive research and development activities are conducted in order to fulfil the requirements concerning decommissioning and waste management. Nuclear power companies are also obliged to finance the measures needed in order to manage and dispose of the nuclear waste and spent nuclear fuel and to decommission their facilities.

The regulations concerning safety in nuclear installations (SSMFS 2008:1) contain requirements regarding decommissioning plans for nuclear facilities, stating that decommissioning must be taken into account when designing a facility (see also section L.1).

G.4.1.3 Technology supported by experience

The general regulations concerning safety in nuclear installations (SSMFS 2008:1) specify requirements regarding design and construction. It is stated that the design of the facility, with adaptation to the specific conditions of each facility, shall:

- be able to withstand component and system failures;
- have reliability and operational stability;
- be able to withstand such events or conditions which can affect the safety function of the barriers or defence in depth; and
- have maintainability, controllability and testability of inherent parts as long as these parts are used for their intended purposes.

These are additional requirements relating to design and construction:

- The design principles and design solutions shall be tested under conditions corresponding to those that can occur during the intended application in a facility. If this is not possible or reasonable, they must have been subjected to the necessary testing or evaluation related to safety.
- The design solutions shall be adapted to the personnel's capability to manage the facility in a safe manner, under normal conditions as well as during abnormal events, incidents and accidents that might occur.
- Building components, devices, components and systems shall be designed, manufactured, installed, controlled and tested in accordance with requirements that are adapted to their importance for safety.

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 multiple barriers to prevent the release of radioactive material to the environment. These facilities are all designed to fulfil the intention of the requirements in the General Design Criteria. The foundation of the safety principle on defence in depth is emphasised and made clearer through the implementation of that principle in the general regulations SSMFS 2008:1.

G.4.2.2 Conceptual plans and provisions for decommissioning

According to the Act on Nuclear Activities, a licence holder for nuclear activities is responsible for ensuring that all measures are taken in order to ensure the safe decommissioning of facilities. The general regulations SSMFS 2008:1 set out a number of specific requirements relating to decommissioning, including a preliminary plan for future decommissioning to be compiled before construction of a facility, see section F.6.1.

Implications of reactor decommissioning for intermediate storage of spent fuel

Removal of reactor internals and defuelling comprise the first stage when decommissioning nuclear power plants, 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. According to decommissioning plans for Oskarshamn units 1 and 2 and Ringhals units 1 and 2 (section A.7.1), this stage is judged to take between one and two years, depending on reactor operating history, cooling requirements and the capacity for fuel transport. Dismantling and demolition of fuel storage pools on 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 in Clab. The licence for Clab today covers interim storage of 8,000 tonnes of spent nuclear fuel, which according to current forecasts will be reached in around 2023, i.e. close to the point in time when unloading the final cores from Ringhals units 1 and 2. As noted above (section G.1.2), SKB applied in spring 2015 for a licence to increase the maximum inventory in Clab to 11,000 tonnes.

The workload is expected to be high at Clab in the early 2020s since many activities at the facility are planned to be performed at the same time. Deliveries of fuel to Clab must therefore be carefully planned by SKB and the nuclear power companies so that shipments and reception are ensured. In the event of a relatively long interruption in fuel reception, the facilities that are finally shut down but have not yet been emptied of fuel will have to carry out extended defuelling. This will in turn lead to delays in decommissioning projects.

In the 2040s, when the younger reactors are being decommissioned, Clab is not assumed to constitute a limitation. This is because fuel will start to be encapsulated and transported to the spent fuel repository and thereby free up space in pools at the interim storage facility.

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 the licence application for Clink. 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 why the decommissioning should be more complicated than for the other nuclear facilities, whose decommissioning is closer in time.

Decommissioning of the spent fuel repository

A decommissioning plan has been 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. 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, for which reason demolition is 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 procedures for nuclear facilities in Sweden. As is evident from the applications submitted for Clink and the spent fuel repository, a reference design has been adopted for the repository barriers for long-term safety that fulfils the design premises for the KBS-3 system. At the same time, a feasible approach to production and a quality control programme has been presented.

The licence applications for Clink and the spent fuel repository were developed against the background of experience from a number of 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), and lastly SR-Can in 2006 (a ‘dress rehearsal’ for the development of the SR-Site safety analysis that supported SKB’s licence application). These iterative safety analyses have had 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 preliminary 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 Bentonite Laboratory have all been used for several years in developing 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 cooperation with Posiva, SKB’s sister organisation in Finland, at Posiva’s hard rock facility, Onkalo, situated in Olkiluoto, 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 is being and will continue to be used to move forward detailed design and construction work of the encapsulation plant and repository for spent nuclear fuel. Ongoing technological development is being pursued in order to proceed from the basis of schematic solutions to solutions tailored to an industrialized 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 which the KBS-3 facilities with their barriers must satisfy in order 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 underground openings.

An initial set of design premises and other requirements is specified in the applications for construction of the spent fuel repository and the encapsulation facility belonging to Clink. However, it is not possible to specify all detailed design premises for a given product or process from the outset. Requirements, technological development and safety assessment must instead be defined as the work proceeds. A revision of the design premises that were presented in the licence applications has been carried out together with Posiva (Posiva SKB report 01). These revisions will be used as input for the PSAR 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.
- Design premises that entail simple, robust and effective solutions are preferred.

These principles are used to consider 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 presented to SSM when the PSAR is submitted.

Further revision of the design premises will be performed in response to the 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 need to be done during detailed design or 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 results obtained should conform to acceptable values for properties that contribute to safety and radiation protection.

Planned production as well as quality control and inspections in the production of the barriers for long-term safety have been described in general terms in the production line reports. As development of production and testing methods progresses, the work on quality control and inspection will also progress. Systems for quality control and inspections will be established and implemented to quality assure the production of the barriers.

A number of 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, points in time when quality control and inspections are to be performed, and by whom in terms of first, second and third parties

- establish and qualify processes, methods, equipment and personnel for manufacturing and installation, testing and inspection
- 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 Clink's encapsulation plant is available prior to beginning the construction work. In the case of the spent fuel repository, this mainly refers to investigation methods and technology for construction of the repository accesses. This material is also needed for the document on handling of matters relating to nuclear safety 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 must be prepared by SKB prior to the start of construction. Technological development is also needed for the systems that must be in place in the repository area in order for SKB to be able to present and obtain approval of the PSAR prior to the start of construction.

After submission of the PSAR, there are several other milestones during the design and construction of the planned facilities where key input is needed from the technological development. This includes:

- When starting the detailed design of Clink's encapsulation plant, the component technical systems must have essentially passed the detailed design phase. When starting the detailed design of the canister factory, the technology and methods for production of canisters must be fully developed and work on an industrial scale.
- Prior to the start of construction of Clink's encapsulation plant and the canister factory, the systems that have undergone detailed design shall have been procured and plans for qualification shall have been 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 beneath the top seal. This means that it must be verified that excavation methods, inspection programmes and methods for rock support and grouting satisfy the requirements that apply to the level under the top seal.

- Detailed design of the production of buffer and backfill shall be completed as a basis for detailed design of the production building.
- Installation methods and methods for testing and inspection of 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 Clink must have been purchased, fabricated, installed, tested and qualified prior to commissioning tests of the KBS-3 system. Before commissioning tests can be conducted, methods and sub-processes for excavation of the spent fuel repository must have been devised and qualified. The deposition system must be put into 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 as compatible as intended before conducting the commissioning tests. Qualification of processes with appurtenant equipment, personnel and suppliers must have been completed and documented. A system 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 must be implemented.

Before a licence can be obtained for trial operation of Clink and the spent fuel repository, a renewed SAR must be submitted. Before an operating licence can be obtained, a supplemented SAR must be prepared and submitted to SSM. Results and experience from the implementation phase must be presented in this updated SAR, including the results of the commissioning tests in each facility. This means that the production reports will be updated using results from full-scale tests, qualification work and commissioning tests.

G.4.3 Regulatory control

The Swedish Radiation Safety Authority (SSM) and its predecessors (the Swedish Nuclear Power Inspectorate, SKI, and the Swedish Radiation Protection Authority, SSI) have over the past three decades reviewed SKB's development of the KBS-3 disposal method for spent nuclear fuel. The main instruments for regulatory control of SKB's design development work have been:

- regulatory review of the recurrent research, development and demonstration programmes (RD&D programmes),
- reviews and peer reviews of SKB's preliminary safety assessments presented during the development of the KBS-3 method, and
- consultation meetings between SKB and SSM (and its predecessors) concerning site investigations and the content of SKB's safety reporting.

The authorities have devoted considerable review resources over the pre-licensing period to evaluate the suitability of safety assessment methods used to underpin SKB's design development, scientific and technical issues relating to the engineered and natural barriers, including the long-term behaviour of copper canisters and the bentonite buffer, as well as construction activities in the bedrock. Based on these reviews, the authorities have regularly provided feedback to SKB on its development of a repository system for spent nuclear fuel.

As part of the review of the RD&D programmes, the authorities have also provided review comments and requested clarifications related to a gradual modification and refinement of barrier design and rock excavation and the reference methods utilized for construction and manufacturing activities. No definitive judgments regarding the acceptability of design

options and manufacturing processes were made during these pre-licensing reviews since the responsibility for development of the KBS-3 method rests entirely with the implementer.

In order to develop an independent safety assessment capability, SKI also carried out two safety assessments of the KBS-3 disposal method (Project-90 and SKI SITE-94, see www.ssm.se). The reports from these regulatory safety assessments and the report on SKB's preliminary safety assessment, SR-97, were subjected to international peer review organised by the OECD's Nuclear Energy Agency (NEA). For the regulatory review of SKB's SR-Can safety report,¹⁸ SKI and SSI set up three independent, external expert groups in 2006 covering the evaluation of different aspects, such as implementation of site-specific information, handling of engineered barrier issues, and the safety assessment methods utilized by SKB.

A key requirement imposed on the implementer, as stated in the Swedish Act on Nuclear Activities, is that the RD&D programmes should be sufficiently broad in scope. Based on this requirement and other regulatory requirements relating to the use of best available technique, SSM and its predecessors have requested additional reporting from SKB regarding alternative methods and disposal concepts, e.g. disposal of spent nuclear fuel in very deep boreholes as a basis for comparison with the KBS-3 method. Further requests were also made as part of the licensing review following SKB's submissions in March 2011.

When performing the licensing review (section A.8.1), SSM has given detailed consideration to SKB's rationale for the choice of the KBS-3 method for final management of spent nuclear fuel. The Authority's conclusion is that SKB has adequately complied with the requirement on demonstrating use of Best Available Technique, both in relation to the choice of technical solutions for each individual barrier and to the barriers' collective function in achieving a radiologically safe repository to protect people and the environment against harmful effects from releases of radioactive materials after closure.¹⁹ SSM recognises that extensive research and development, testing and analysis have been conducted with respect to KBS-3 as a method, as well as to increase understanding of the properties, events and processes of importance for assessing the repository's protective capability.

The Authority recognises that alternative concepts for disposal of spent fuel, such as very deep boreholes, might ultimately prove to have some advantages of significance to radiation safety by comparison with KBS-3. However, SSM's assessment is that SKB has shown that KBS-3 has the potential to meet regulatory requirements for radiation protection and safety (see also section G.5.3), and that SKB is capable of producing the more detailed underlying material that will be required at later stages of approval prior to operation. SSM assesses that extensive additional investigations and associated technological development would be required to bring the very deep borehole concept to the same level of technical maturity as KBS-3, with no guarantee of success in terms of meeting outstanding challenges, both as regards the technology's viability and the need to verify assumptions regarding hydrogeological isolation. Taking into account safety and other considerations linked to uncertainty in planning timescales and in the outcomes from an RD&D programme for deep borehole disposal of spent fuel, SSM considers it disproportionate to prolong the interim storage of spent fuel in Sweden with the aim of developing alternative solutions to KBS-3.

As regards the planned encapsulation facility to be operated in conjunction with Clab, SSM deems that SKB's design has the potential to meet requirements for limits, optimisation and Best Available Technique, for example through multiple systems and measures for treatment at source and limiting discharges of radioactive materials to air and water. The Authority considers that the Clink facility has the potential to be equipped with redundant

¹⁸ SR-Can was the last preliminary post-closure safety analysis of the KBS-3 disposal method carried out by SKB prior to developing the SR-Site safety analysis that supports the company's licence application for a spent nuclear fuel repository.

¹⁹ Consultation response on the licence application under the Environmental Code from the Swedish Nuclear Fuel and Waste Management Company (SKB) for a system for management and final disposal of spent nuclear fuel, SSM2016-546-5, available at www.ssm.se

systems to protect the integrity of barriers and prevent releases in the event of faults and failures. At the same time, SSM has pointed out certain aspects where further clarity will be required in taking the detailed design forward in order to reinforce defence in depth at the existing Clab part of the facility and in order to comply with future nuclear safety requirements.

At the time of preparing this national report, the Land and Environment Court had made no judgment on SKB's design decisions for KBS-3 and their implications for the licence application according to the Environmental Code. SSM expects to deliver its final statement to the Government in early 2018 regarding licensing of the KBS-3 disposal concept according to the Act on Nuclear Activities.

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 listed in the regulations concerning safety in nuclear facilities (SSMFS 2008:1) and apply to the operation of all types of nuclear installations, including facilities for treatment, storage and disposal of spent fuel and radioactive waste. The basic provisions regarding safety assessment and review can be summarised in the following points:

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 such 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 in order to show how relevant safety requirements are met. The safety report (SAR) shall be updated to reflect the plant as built, analysed and verified before trial operation of the facility is allowed to start. The SAR must furthermore be supplemented on the basis of experience from trial operation before the facility is taken into routine operation. The safety report must be kept up to date thereafter. Before the facility is allowed to be constructed and taken into operation, 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. 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 corresponding modifications or other plant measures have been performed.

The content of the safety report is specified in the regulations SSMFS 2008:1. Not only the safety systems, but 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 determine or check that the applicable safety-related aspects of a specific issue have been taken into account and that appropriate safety-related requirements with respect to the design, function, organisation and activities of a facility are met according to SSMFS 2008:1. The review must be carried out systematically and be documented. A safety review is to be performed within those parts of the organisation responsible for the specific issues ('primary review'). A second safety review shall be performed by a safety review function appointed for this purpose and which has an independent position relative to those parts of the organisation responsible for the specific issues ('secondary review').

Safety programme

After it is 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 are required to perform a periodic safety review (PSR), i.e. an integrated analysis and assessment of the safety of a facility, see section E.2.2.5.

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. Before the modifications may be included in the report, SSM shall be notified. SSM has the powers to determine that additional or other requirements or conditions shall apply 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 concerning safety in connection with the disposal of nuclear material and nuclear waste (SSMFS 2008:21), as well as in the 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).

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 comprise features, events and processes that might lead to the dispersion of radioactive substances after closure. Such safety assessments are requested as a basis for applications for construction, operation and closure. 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 on application of optimisation and Best Available Technique (BAT). The corresponding guidance advises on

reporting for different time periods after closure, selection of scenarios, calculation of risk, dealing with uncertainty, and risk dilution.

G.5.1.2 Environmental assessment

According to the requirements of the Act on Nuclear Activities, an environmental impact assessment (EIA) shall be prepared for a licence application under the Act. These are the same requirements as stated in the Environmental Code.

The Environmental Code also contains detailed requirements stating what an EIA should contain and how it should be prepared, see also section E.2.2.2.

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 contain the following information:

- a description of the activity or measure with details of its location, design and scope;
- a description of the measures being 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 that is needed to establish and assess the major impact on human health, the environment and the management of land, water and other resources that the activity or measure 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.

G.5.1.3 The licensing procedure

Three different permits/licences are required for a nuclear facility: a permit under the Environmental Code, a licence under the Act on Nuclear Activities, and a building permit under the Planning and Building Act. A separate licence under the Radiation Protection Act is not needed for an activity that is licensed under the Act on Nuclear Activities.

Licensing for the development of a spent fuel management facility under the Environmental Code and the Act on Nuclear Activities takes place in parallel. Applications under both enactments must include an environmental impact assessment (EIA). Licence applications according to the Act on Nuclear Activities should be supported by a first/preparatory version of the preliminary safety report (F-PSAR).

According to the Environmental Code, the Government shall, following consideration of the licence application by the Land and Environment Court, first determine the permissibility of the proposed activity (under Chapter 17). After SSM's preparation of the matter, the Government also examines the licence applications under the Act on Nuclear Activities. If the Government finds that the siting, construction and operation of the facility is permissible according to the Environmental Code and grants a licence under the Act on Nuclear Activities, the next step is for the Land and Environment Court to grant a licence and stipulate conditions in accordance with the Environmental Code. After a licence has been granted by the Government according to the Act on Nuclear Activities, SSM may issue further conditions according to the Radiation Protection Act or the Act on Nuclear Activities.

G.5.2 Measures taken by the licence holders

G.5.2.1 Safety assessments

Background

For some 30 years, the Swedish Radiation Safety Authority and its predecessors (the Swedish Nuclear Power Inspectorate, SKI, and the Swedish Radiation Protection Authority, SSI) have been carrying out reviews of SKB's development work, and in particular, SKB's triannually submitted RD&D programme, which involves research, development and demonstration work. Results from the reviews of the RD&D programmes are delivered to the Government for decisions regarding the programmes. This iterative procedure has formed an open and transparent process for all the involved organisations and interested stakeholders. It has also given valuable feedback for the work of SKB and has increased the knowledge base for all involved actors.

In March 2011, SKB applied for a licence to develop a repository for spent nuclear fuel and an encapsulation plant, where the fuel will be encapsulated before being transported to the repository, see also section A.8.1. The application from 2011 and its supporting material have been supplemented with information requested by SSM during its review of the application. This included a comprehensive update of the safety assessment for the combined fuel storage and encapsulation facility (Clink), which is planned to encompass Clab, the existing central interim storage facility.

Construction of nuclear facilities requires licences in accordance with the Swedish Environmental Code and the Act on Nuclear Activities (1984:3). Both enactments require SKB to report on the planned operations. The Act on Nuclear Activities states that this report must address radiation protection and nuclear safety in both the short and long term. The Environmental Code specifically requires a description of the potential impact of the planned operations on humans and the environment. The Act on Nuclear Activities requires an equivalent impact assessment.

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, published in 2014. SKB is currently developing the basis for assessment so that the PSAR for the spent fuel repository and Clink can be submitted to SSM in support of an application to commence construction, provided that relevant licences for development of the facilities have been granted by the Government. SKB also plans to prepare and submit to SSM a PSAR for the existing Clab facility in support of measures to increase Clab's interim storage capacity.

Spent fuel storage and encapsulation facility

SKB's updated (January 2015) assessment for Clink was undertaken in response to SSM's request for an improved system description and correspondingly updated preliminary safety analysis report (F-PSAR). The scope was also expanded to account for the safety implications of increasing the interim storage capacity in the storage pools of Clab from 8,000 to 11,000 tonnes of spent fuel. Updating of supporting materials to the licence application according to the Act on Nuclear Activities also led to supplements made to the EIA submitted in support of the licence application under the Environmental Code.

The F-PSAR describes how nuclear radiation safety in Clink will be maintained. The design of the facility and description of how the requirements are met will gradually be clarified and specified in detail as technological development progresses and viewpoints are received from SSM during the licensing process.

SKB also provided an account of its assessment of the consequences of planned and potential discharges associated with operation of the Clink facility as part of the consultation

procedure undertaken by the Swedish Environmental Protection Agency in accordance with Article 5 of the Espoo Convention (see also G.3.1.3).

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 according to the Act on Nuclear Activities. The central conclusions of the safety analysis, 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, remain unaltered.

G.5.3 Regulatory control

Some key aspects of the regulatory review activities undertaken by SSM, including an account of the parallel procedures for licensing in accordance with the Swedish Environmental Code and the Act on Nuclear Activities (1984:3), were described in Sweden's fifth national report published in 2014.

G.5.3.1 Ongoing licensing review

SSM has undertaken a detailed and thorough investigation and review of the safety assessments and relevant supporting documentation submitted by SKB to SSM in support of SKB's licence applications for Clink and the planned repository for spent fuel. Preliminary reports describing the outcomes of these reviews were published in June 2016 as annexes to the Authority's statement as a consultee to the Land and Environment Court.

At the time of preparing the present sixth national report, it is expected that the main proceedings of the Land and Environment Court in assessing SKB's licence applications according to the Environmental Code will be conducted in September and October 2017. Both the Court and SSM are expected to submit their final recommendations to the Swedish Government by early 2018.

Spent fuel storage and encapsulation facility

SSM has concluded from its review of SKB's safety assessment documentation that the information provides a sufficient basis to demonstrate that the requirements for safety and radiation protection under the Act on Nuclear Activities and Radiation Protection Act can be expected to be fulfilled in relation to SKB's sought permission regarding the following:

- increased storage capacity at Clab
- siting and design of the encapsulation plant at the facility

- the operation of Clab throughout the construction period up to the point in time when Clab is joined together with the encapsulation plant to form a single facility, and
- the integrated Clink facility.

The Authority's assessment presupposes that SKB – in preparation for SSM's future examination at the next stage of authorisation following a Government licensing decision – rectifies identified shortcomings and takes into account the proposed improvements in presentation that SSM identifies in its review.

Repository for spent nuclear fuel

SSM has examined the parts of SKB's application for final disposal of spent nuclear fuel relating to the development, operation and decommissioning of the spent fuel repository at Forsmark. The preliminary review report, published together with SSM's statement to the Land and Environment Court, presents SSM's overall assessments relating to the potential for the facility and its operation to comply with the fundamental safety provisions as defined by SSMFS 2008:1. In summary, SSM concludes that requirements for safety and radiation protection under the Act on Nuclear Activities and Radiation Protection Act can be expected to be fulfilled in relation to the construction and operation of the facility. As stated above, the Authority's assessment presupposes that SKB – in preparation for SSM's future examination at the next stage of authorisation following a Government licensing decision – rectifies identified shortcomings and takes into account the proposed improvements in presentation that SSM identifies in its review.

SSM has also examined SKB's repository application in accordance with the requirements of the Authority's regulations (SSMFS 2008:21) on safety in connection with the final disposal of nuclear material and nuclear waste, and the regulations (SSMFS 2008:37) on protection of human health and the environment relating to final management of spent nuclear fuel and nuclear waste. In summary, SSM concludes that the safety assessment SR-Site presented by SKB, together with supporting materials submitted in support of the licence application, demonstrate that the barrier system proposed by SKB, comprising the canisters, buffer and bedrock, has the potential to fulfil the requirement for resilience against features, events and processes that might have an impact on radiation safety following repository closure. According to SSM's review, SKB's presentation of the barrier system's long-term integrity, in combination with estimates of the consequences associated with the spread of radioactive substances from the repository if one or more barriers should fail partially or completely, provide an acceptable basis for drawing this conclusion. In terms of the capability of a KBS-3 repository at the Forsmark site to protect people and the environment against harmful effects of ionising radiation, SSM deems that there is potential to limit risks in compliance with regulatory requirements by using the intended engineered barriers, placement of the repository at a suitable depth and, in conjunction with the position of deposition holes, avoiding unsuitable locations in the bedrock.

SSM's assessment of the potential for compliance is made on the basis that SKB will continue to further develop the detailed design of the disposal concept and to update SKB's safety analysis in subsequent stages of the authorisation process. The Authority considers that development, research and demonstration of the disposal concept during the construction and operation phases, and up until final closure, not only can reduce uncertainties, but also give rise to new understanding with significance for long-term safety. The stepwise authorisation process enables new scientific findings and more in-depth knowledge regarding implementation of the KBS-3 concept to be taken into account and assimilated. Against this background, SSM has identified a need for development in the presentation of SKB's safety

analysis, in particular with regard to how conceptual understanding of certain mechanical and corrosion processes is addressed, prior to the examination at subsequent steps. The Authority nevertheless assesses that these issues are not of such a magnitude that they prevent SSM from judging the application and conclusions presented by SKB regarding the repository's post-closure environmental impact, and thereby the potential for compliance with the Authority's requirements for long-term radiological safety.

In summary, SSM deems that the Authority's requirements for long-term radiological safety according to SSMFS 2008:21 and SSMFS 2008:37 can be expected to be fulfilled in connection with the development and operation of a repository facility for spent nuclear fuel at Forsmark. This assessment rests on the basis of detailed regulatory reviews of SKB's application, in particular the SR-Site safety analysis, site investigation results and SKB's research, as well as field measurements and test manufacturing of repository components. Moreover, SSM assesses that SKB has the potential for capability to further develop the final disposal concept and the detailed design of repository components on an industrial scale, as well as to address to the extent necessary remaining questions surrounding construction, installation and performance of the KBS-3 concept.

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

The general regulations concerning safety in nuclear installations (SSMFS 2008:1) contain legally binding requirements relevant for all the obligations of Articles 9 and 16. These requirements are summarised below.

G.6.1.1 Initial authorisation

A pre-licensing obligation ensues from the Act on Nuclear Activities. According to the Act, an RD&D programme must be carried out continuously. The programme is to contain an overview of all measures that may be necessary and must specify in detail the measures that are intended to be implemented. The programme is reported to the Authority and the Government every third year (see sections A.6.4 and E.2.1.1). An additional pre-licensing obligation is the requirement regarding environmental impact assessments (EIA). An EIA must be prepared before submitting an application and must account for alternative sites and methods for the planned activity.

When developing the EIA, the applicant is to consult with the relevant central and local authorities, the public and environmental organizations (see section E.2.2.2).

Also, a preliminary comprehensive safety report is required prior to construction of a nuclear facility (see section G.5). A complete safety report, which also takes into account the results from commissioning tests, is required before the facility may be taken into operation.

G.6.1.2 Operational limits and conditions (OLCs)

Documented and up-to-date Operational Limits and Conditions (OLCs) are required containing the necessary operational limits and conditions, as further specified in a separate

appendix to the regulations. 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 and submitted to the regulatory authority for approval. The licensee must notify the regulatory authority about any changes after they have been subjected to a two-fold safety review.

G.6.1.3 Established procedures

Suitable, verified and documented procedures are required for all operational states, including accidents. The procedures for operability verification and procedures 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 are required to be carried out according to qualified methods and verified procedures.

G.6.1.4 Engineering and technical support

The licensee shall ensure that adequate personnel are available with the necessary competence and suitability needed for those tasks that are important for safety, and also ensure that these aspects are documented. A long-term staffing plan is required. Use of contractors as opposed to own 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 which is of importance for safety.

G.6.1.5 Reporting of incidents in a timely manner

The general regulations concerning safety in nuclear installations (SSMFS 2008:1) contain a specific chapter about reporting requirements and an appendix specifying these requirements for various types of events. The following is a brief account:

- 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 daily reporting of the operational state and the occurrence of any abnormal events or disturbances, as well as requirements for a comprehensive annual report summarising all experience that is important for the safety of the plant. Specifications are given regarding the content of the different reports, and further interpretation of the reporting requirements is given in the general recommendations. One of the fundamental paragraphs of SSMFS 2008:1 specifies requirements for 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. A graded approach is allowed here.

In Appendix 1 of the regulations, events and conditions are specified which require different responses depending on the category of events that they belong to. Three categories are defined:

- Category 1: Severe deficiency observed in one or more barriers or in the defence in depth system, as well as a well-founded suspicion that safety is severely threatened. (In these cases, the facility must be brought to a safe state without delay.)
- Category 2: Deficiency observed in one barrier or in the defence in depth system, which is less severe than that referred to in category 1, in addition to a well-founded suspicion that safety is threatened. (In these 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, which arises when such an event or condition is corrected and which, without measures, could lead to a more severe condition, and which is documented in the technical specifications.

In all three cases, corrective measures will be subjected to a two-fold safety review by the licensee. The results of these reviews shall be submitted to SSM. As regards category 3 events, there is no requirement to submit a specific report to SSM. It is sufficient to provide a compilation of these events in the 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 (SSMFS 2008:1). It is further required that all events and conditions that are detected and which are important for safety are investigated in a systematic manner in order to determine sequences and causes, as well as to establish the measures needed in order to restore the safety margins and prevent recurrence. The results of the investigations are to be disseminated within the organisation and shall contribute to the development of safety at the facility. Under SSMFS 2008:1, it is the responsibility of the licensee, for as long as a disposal facility is in operation, to keep itself continuously informed of conditions that can be of importance to the assessment of disposal facility safety, including after closure.

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 a number of 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;
- 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

The general safety regulations (SSMFS 2008:1) contain legally binding requirements relevant to all obligations of Article 9. These requirements are summarized below.

G.6.2.1 Initial authorisation

The siting and licensing processes for the encapsulation plant and repository for spent nuclear fuel (section A.7.4) were initiated in accordance with the procedures outlined in this report (see section E.2.4.1).

G.6.2.2 Operational limits and conditions (OLCs)

The operational limits and conditions for nuclear facilities are described in the OLC, a document which is 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 licensing conditions.

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, either from research, tests or operational experience. Suggestions for changes in OLC are reviewed carefully from the point of view of safety at different levels in the operating organisation, and are ultimately approved by the regulatory body before being included in the 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 in particular. An essential part of the OLC is a general clause stating '...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 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 procedures of different kinds covering normal operation, emergency operation and functional testing. Maintenance activities in accordance with a maintenance programme approved by the licence holder are also to a great extent 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 according to the procedures is mandatory in most cases in order 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 in order 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 F2.1.1. Competencies that might not be completely available within the licensee's own organisation at all plants for example include 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 in particular are normally outsourced, though are still available onsite. The intention is always to possess purchasing competence within the operating organisation, as well as 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

Incidents significant to safety are reported according to the non-routine reporting requirements stated in the technical specifications, see section G.6.1.5. There are two types of licensee event reports (LER). The more severe one, called abnormal event, requires the facility 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 is 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 so as to warrant reporting in accordance with the International Nuclear Event Scale (INES).

The other type of LER, called 'RO' (Reportable Occurrence), 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 standardized 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 document 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 by 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. 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 presented to SSM together with the periodic safety reviews.

Among other things, the decommissioning plan contains 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 presented to SSM. The safety analysis report for the facility must be supplemented according to the activities planned at the facility. The revised safety analysis report is reviewed and approved by SSM.

SKB is the licensee for Clab and is the prospective licensee for the integrated facility called 'Clink' when the planned encapsulation plant has been completed. The preliminary decommissioning plan for Clink was updated in combination with the updated supporting materials for SKB's licence application in December 2014 (see also section G.5.2.1). A decommissioning plan has been prepared for the spent fuel repository and was included in the application under the Act on Nuclear Activities (1984:3) for disposal of spent nuclear fuel and under the Environmental Code for the KBS-3 system.

G.6.3 Regulatory control

G.6.3.1 Initial authorisation

Regulatory control in relation to licensing and the steps up to and including initial authorisation for operation is achieved through the procedures described in section E.2.4.1. SSM submitted a statement to the Land and Environment Court in June 2016 in its role as a key regulatory authority concerning the determination under the Environmental Code of the permissibility

of SKB's plans for encapsulation and disposal of spent fuel. At the time of preparing the present report, it is expected that the main proceedings of the Land and Environment Court will be conducted in September and October 2017. Both the Court and SSM are then expected to submit their final recommendations to the Swedish Government by early 2018.

G.6.3.2 Operational limits and conditions

SSM reviews applications for changes to the OLC, and for exemptions from the OLC. Based on the application and information provided by the licensees, plus the associated safety analyses, assessments are made on how the proposed changes or exemptions contribute to the risk profile of the facility.

During 2016, SSM carried out a major review of SKB's comprehensively revised criticality analyses for Clab, taking into account increased fuel enrichment limits and the application of burnout credit. The regulator concluded that the results illustrated satisfactory maintenance of safety against criticality events.

G.6.3.3 Procedures

Operational and maintenance procedures are normally not reviewed by SSM. Only in connection with event investigations would SSM ask for a procedure to be submitted for review. SSM has looked into the routines used for updating procedures in the framework of quality assurance inspections or reviews of quality audits made by the licensees (see section F.3.3).

As a follow-up of an inspection carried out in 2015, further surveillance was undertaken by SSM in 2016 relating to maintenance at the interim storage facility for spent fuel, Clab. A regulatory review has also been undertaken of SKB's investigations into cracking that was observed in one of Clab's storage ponds. SSM has required SKB to develop and implement a control programme to ensure that possible structural changes within the fracture area are detected and evaluated in time.

G.6.3.4 Engineering and technical support

SSM has not thus far specifically inspected the engineering and technical support available at the facilities. In connection with other inspections and reviews, the staffing situation has occasionally been commented upon. During 2016, SSM carried out follow-up inspections of SKB's management and control at its operational facilities, including Clab, reviewing the safety improvement measures that are being implemented as a result of previous injunctions. See also sections G.1.3.2 and K.2.6.

G.6.3.5 Incident reporting

Licensee event reports are reviewed upon arrival by the site inspector in charge, who asks the facility for clarification if necessary. As a routine, all LERs are screened once a week by a permanent group of inspectors and specialists in order 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.6.3.6 Experience feedback analysis

Regulatory control in this area is achieved through the procedures described in section E.2.2.5. The experience feedback programme is followed up by SSM in connection with event investigations and other inspections and reviews.

G.6.3.7 Decommissioning plans

Regulatory requirements (G.6.1.7) entail that updates of the decommissioning plan are reported to SSM and reviewed by the regulatory authority alongside related updates of and supplements to the facility's safety analysis report. The revised safety analysis report is reviewed and approved by SSM before dismantling and demolition are allowed to commence. However, no final decision is expected in several decades regarding dismantling and demolition of SKB's spent fuel management facilities.

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, as described in section C, and the policy and practices for management of spent nuclear fuel are direct disposal, as described in 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 the manner in which they are conducted, and
- ensuring the safe handling and 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 is de facto treated as high level radioactive waste.

G.7.3 Conclusion

Sweden complies with the obligations of Article 10.

Section H – Safety of Radioactive Waste Management

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 section G and section H is presented in full in section G only. Where appropriate, 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 safety of radioactive waste management, this is stated in the respective section. The programme for radioactive waste repositories is described in this section, whereas the issues relevant to the development of a geological disposal facility for spent nuclear fuel are described in 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

See section G.1.1.1.

H.1.1.2 Basic provisions and licence obligations

As regards regulations applying to both spent fuel and radioactive waste from nuclear facilities, see section G.1.1.2. The requirements below only apply to radioactive waste from nuclear facilities.

Identification of radioactive substance content in nuclear waste

The radioactive substance content of nuclear waste that is to be transferred to a repository without further handling, or which is intended to be stored for a period of time exceeding two years, shall be identified through nuclide-specific measurement. In cases where this is neither feasible nor possible, the radioactive substance content may be determined in some other way. Prior to measurement and registration, the waste is to be classified into items corresponding to waste packages, components, containers or other units matching the material in question in order to enable reliable identification of the activity content.

Records of nuclear waste

The facility shall have records available on the items of nuclear waste generated at the facility or present at the facility. To the extent that is feasible and possible, these records must be kept up to date. Each registered waste item is to be clearly marked for identity purposes. The records must also contain information about the management of each waste item that has left the facility. For each waste item, the records must provide information about:

- the waste item's identity (marking),
- the corresponding type description or separate description of the waste (when applicable),
- the origin of the nuclear waste or from which part(s) of the facility the nuclear waste has come,
- the nuclear waste's previous treatment, if any, and its present physical and chemical form,
- quantity,
- nuclide-specific content of radioactive substances, with reference date and uncertainty in terms of the nuclide content,
- external radiation level, with distance and reference date,
- position in the storage facility or repository, and
- the date of treatment performed: in the case of nuclear waste intended to remain at the facility for a period of time exceeding two years, the records must also provide information about the time schedule for the ongoing management.

Reporting

A report concerning the past calendar year must be submitted to SSM. This report is to comprise a summary account of the following:

- the amount of waste that has arisen or has by other means been brought to the facility;
- waste that has been transferred to a disposal facility or has been transported from the facility for treatment or storage in another facility, or that has been cleared;
- waste that at the turn of the year is present at the facility, the nuclide inventory of the waste and information on its location; and
- experiences from handling of the waste and a follow-up of established plans.

Discharges to air and water from a facility to the surrounding environment are regulated in accordance with SSMFS 2008:23, see section F.4.1.2.

Regulations concerning clearance of nuclear and non-nuclear waste have been issued in the form of SSMFS 2011:2 and SSMFS 2010:2, respectively (section L.1).

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

The fact that licence holders are responsible for the handling and disposal of the radioactive waste that they generate provides an incentive to consider all steps from waste generation to disposal. Detailed requirements are stipulated in SSM's regulations as follows:

- An up-to-date inventory of all radioactive waste on-site shall be available at all times (SSMFS 2008:1).
- Measures for the safe on-site handling, storage or disposal of waste shall be analysed and included in the safety report of the facility. The measures for on-site handling shall take into account the requirements for safety posed by the continued handling, transport and disposal of the waste. The safety report shall also include measures that need to be taken on-site to prepare for the safe transport to, or storage or disposal in, a nuclear waste facility (SSMFS 2008:1).
- Plans shall be drawn up providing a general description of management, including disposal, of all waste types that are likely to be generated while operating the facility. The plan for management of such materials shall also state the measures being taken to limit the quantity of nuclear waste and its content of radioactive substances. The plans must be reported to the authorities before the waste is generated (SSMFS 2008:1).
- As regards waste whose type or quantity deviates from that specified in the plans as stipulated above, all necessary measures for management of the non-conforming material must be explained and documented in a separate plan. The separate plan shall be reported to the authorities before the waste is handled (SSMFS 2008:1).
- Acceptance criteria shall be derived, stating the properties of the material that can be received for storage, disposal or some other management. Acceptance criteria shall, to the extent that is feasible and possible, be formulated while taking into account safety and radiation protection throughout all stages of the ongoing management. Procedures must

be in place for management of material that does not meet the acceptance criteria in that it is returned to the consignor or by taking measures to rectify identified deviations (SSMFS 2008:1).

- 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).

H.1.1.5 Protection of individuals, society and the environment

See section G.1.1.5.

H.1.1.6 Biological, chemical and other hazards

Biological, chemical and other hazards are addressed in the licensing process of an activity. Any such risks that might be associated with the activity should be reported in the corresponding Environmental Impact Assessment (EIA). The EIA should also include a description of the measures envisaged to prevent, reduce or remedy adverse effects. During operation the licensee is required to continuously take protection measures, issue restrictions and take precautions in order to prevent or hinder the activity from causing detriment to human health and/or the environment from chemical, biological and other hazards as well as from a radiological point of view.

Supervision of activities that deal with chemical and biological hazards is primarily exercised by county administrative boards.

Chemical and biological hazards in the context of radioactive waste management

As stated in section H.1.1.2, SSM requires updated registers to be kept for all waste and spent nuclear fuel at a nuclear facility. The registers for every waste item (e.g. package or component) shall include information on, among other things, any treatment that has been applied and the physical and chemical form of the waste.

The question of chemical and biological hazards with regard to the long-term performance of a repository is addressed in the Swedish Radiation Safety Authority's regulations concerning safety in connection with the disposal of nuclear material and nuclear waste (SSMFS 2008:21).

Only packages approved by SSM are allowed to be transported to a repository. This approval presupposes compliance of the waste management with the conditions stated in the safety report of the repository. Furthermore, the licensee must submit documentation showing that due regard has been taken to all relevant aspects, including biological, chemical and other hazards with regard to the long-term performance of the repository.

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 reactors affect the action plan for low and intermediate level waste by increasing the need for interim storage as well as the need for decommissioning planning to be developed and concretised sooner, see also section F.6. The final repositories that SKB plans to establish for low and intermediate level waste include an extension of SFR to accommodate short-lived decommissioning wastes, and constructing SFL for long-lived low and intermediate level waste. Some of the nuclear power companies also have the intention of arranging for temporary interim storage of short-lived decommissioning waste until the extension of SFR is commissioned. Long-lived wastes from decommissioning will be interim stored at the power plants or at centralised facilities until SFL is ready for operation.

AB SVAFO currently operates an interim storage facility for low and intermediate level waste (AM, an active interim storage facility) storing not only its own long-lived waste, including legacy waste, but also waste from other licensees such as Studsvik Nuclear AB. AB SVAFO is planning to construct a new building for interim storage of low and intermediate level waste. This interim storage facility will be located at the Studsvik site and be in operation around 2019.

RD&D programme 2016

Through its co-owned company, SKB, the nuclear industry has since the mid-1970s conducted research on long-term management of spent fuel and final disposal of radioactive waste. The formal requirement for RD&D programmes to be submitted for regulatory evaluation was established in 1984 when the Act on Nuclear Activities was promulgated.

In September 2016, SKB submitted the eleventh RD&D programme to the regulator, SSM, for review and a public consultation.²⁰ In RD&D Programme 2016, SKB presents its plans for research, development and demonstration during the period 2017–2022. The programme consists of four parts:

- Part I SKB's activities and plan of action
- Part II Waste and final disposal
- Part III Decommissioning of nuclear facilities
- Part IV Other issues

The programme for low and intermediate level waste includes day-to-day management of existing waste as well as work to realise the remaining parts of the system that are needed for safe and long-term management and disposal of low and intermediate level waste. The programme is primarily led by SKB, but in some respects also by the nuclear power companies.

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. The licensing process is currently underway (see also section A.8.1). In preparation for extending SFR, issues concerning licensing are being dealt with, and in parallel, continuing technological development, design and building preparations.

An evaluation of post-closure safety of the proposed repository concept for SFL (the repository for long-lived low and intermediate level waste) started during the spring of 2015

²⁰ SKB Report 2016, TR-16-15 (in English), can be downloaded at www.skb.se

and is expected to continue until mid-2018. The safety evaluation will constitute an important basis for continued development of the disposal system. An initial study has been carried out of the process that will lead to the future selection of a site for SFL. Further studies will refine this planning and identify needed expertise and resources.

In the above-mentioned work, experience from the operation of SFR constitutes an important knowledge base for the development and construction of new repositories.

Future handling and interim storage of BWR control rods have been studied. To ensure availability of interim storage capacity for fuel in Clab (see also section G.1.2.2), more efficient interim storage of BWR control rods in Clab may be necessary eventually.

Cost calculations

See section G.1.2.1.

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, H.4.2, H.5.2 and H.6.2.

H.1.3 Regulatory control

H.1.3.1 The general obligations of licence holders

Evaluation of the RD&D programme

In September 2016, SKB submitted RD&D Programme 2016, the nuclear reactor owners' eleventh programme for research, development and demonstration since 1986, to SSM for review and broad consultation with national stakeholders. In March 2017, SSM submitted the results of its evaluation and a statement to the Government with a recommendation to approve SKB's programme.

The overall conclusion from the regulatory review as regards radioactive waste management was that the programme was assessed to be fit for purpose. The evaluation was however constrained so as not to forestall the eventual outcome of the ongoing review of SKB's licence application for extension of SFR to accommodate decommissioning waste. Nevertheless, SSM agreed with SKB's description of the changed conditions for management of low and intermediate level waste in the light of the early decommissioning of four reactors as well as the initiation of actual decommissioning activities at Barsebäck and the Studsvik research reactors, set against the background of delays to the commissioning of the planned SFR extension.

The main conclusions that SSM drew from the regulatory review with regard to the safety of radioactive waste management were:

- The measures taken at the reactor sites and by SKB to respond to changed circumstances are appropriate. SSM nevertheless deemed that the account provided of SKB's and the reactor owners' plans, for example with respect to ensuring sufficient capacity for interim storage, needs to be further developed in future RD&D programmes.
- Whereas the programme for development of a repository for long-lived waste (SFL) had been delayed, the basic principles and direction for the work reported in RD&D Programme 2013 remained essentially unchanged. Nevertheless, SSM emphasized the importance of SKB developing, as soon as it is feasible to do so, a sufficiently justified and detailed

repository concept as a robust starting point for the next phase in the development process. In this respect, SSM stressed the need to ensure that the outcomes of safety assessment are of sufficient quality to support guiding decisions about the direction of future activities (for example, with respect to requirements for barrier functions and their influence on concept development, as well as ensuring that safety is given due priority in a future siting process).

- It was judged as particularly important that SKB should work on development of preliminary acceptance criteria for the SFL wastes (particularly legacy wastes) that are intended to be treated and conditioned in the near future so that licence holders are able to undertake the work in an appropriate manner.
- SKB's initiation of activities to develop an improved methodology for estimation of radio-nuclides that are difficult to measure was deemed a positive development.
- Emphasis was placed on the importance of ensuring that new types of waste containers are developed in cooperation and coordination with the decommissioning projects.

Nuclear waste fees and guarantees

See section G.1.3.1.

H.1.3.2 Basic provisions and licence obligations

Regulatory control of 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.

See also the description of the outcome of SSM's integrated evaluation of radiation protection and safety for SKB's facilities, contained 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 Regulatory requirements

H.2.1.1 Existing facilities

By the time the Joint Convention entered into force on the part of Sweden, the situation was satisfactory as regards the safety of radioactive waste management facilities. For a long time now, the elements of the Joint Convention have been implemented in the form of requirements imposed by the legal and regulatory framework, and implemented in the management of radioactive waste in Sweden. The fact that the licensees' activities are in conformance with the legal and regulatory requirements is something that constantly needs reaffirming through inspection and review activities.

At least once every ten years, licensees are required to perform a Periodic Safety Review (PSR), i.e. a new and integrated analysis and assessment of the safety of their respective facilities. The PSR should cover both nuclear safety and radiation protection, with the purpose of clarifying how requirements stated in relevant legislation as well as issued in the form of regulations and conditions are met and are expected to be met for an existing nuclear facility over the following period of ten years. Periodic safety reviews are submitted to the regulatory authority, which conducts a comprehensive review and assessment of the submitted review and its references.

H.2.1.2 Past practices

As described in sections A.6.5.3 and E.2.1.4, a special fee is levied on the nuclear power utilities in accordance with a special enactment, the Studsvik Act, in order to cover expenses for managing nuclear waste from old experimental facilities, in particular the facilities at Studsvik, the Ågesta reactor and the uranium mine in Ranstad. The special fee is the same for all four nuclear power utilities, currently SEK 0.003 per kilowatt-hour. The fee is reassessed annually based on a proposal by the regulatory authority.

H.2.2 Measures taken by the licence holders

H.2.2.1 Past practices

The four utilities operating nuclear power reactors in Sweden (Sydkraft, Vattenfall, Forsmark and OKG) formed a special company in 1992, AB SVAFO, to deal with their responsibilities according to the Studsvik Act, see section E.2.1.4. During the period May 2003-March 2009, AB SVAFO was owned by Studsvik Nuclear AB. Its ownership has since then returned to the nuclear power producers in Sweden. AB SVAFO deals with most of the past practices involving nuclear waste. These activities are closely monitored by SSM.

H.2.2.2 Periodic Safety Reviews

The Swedish Radiation Safety Authority (SSM) decided in March 2014 that AB SVAFO (Svafo) should perform a periodic safety review and, no later than December 2015, submit the PSR for its waste management facilities covering the period up to 2025. Facilities under decommissioning, i.e. connected to the research and materials testing reactor R2/R2-0, were exempted from the requirement.

In April 2013, SSM decided that Studsvik Nuclear AB (SNAB) should perform a periodic safety review and, no later than December 2015, submit the PSR for its waste management and treatment facilities covering the period up to 2025. The incineration, decontamination and smelting facilities for waste minimisation and conditioning were subsequently taken over by a separate licence holder, Cyclife Sweden AB, in 2016. In November 2016, Cyclife confirmed that SNAB, in its reporting, had adequately addressed Cyclife's current facilities and activities and recognized that the overall assessment in principle applies.

SSM decided in June 2015 that Westinghouse Electric Sweden AB (WSE) should perform a periodic safety review and, no later than July 2017, submit the PSR for its fuel manufacturing facility and other nuclear activities in Västerås covering the period up to 2027. The performed safety review now constitutes the basis for WSE's internal programme for safety improvement measures. The new safety review will also form an integral part of the application for a renewed permit for continued nuclear activities on the site, as WSE's licence under the Act on Nuclear Activities expires on 31 December 2019.

For information on the regulatory review and findings, see section H.6.2 on operational limits and conditions.

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
 - (v) to evaluate all relevant site-related factors likely to affect the safety of such a facility during its operating lifetime;
 - (vi) to evaluate the likely safety impact of such a facility on individuals, society and the environment;
 - (vii) to make information on the safety of such a facility available to members of the public;
 - (viii) 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 planned extension of the SFR disposal facility, which is currently the subject of the licensing review process (section A.8.2), 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 General information

See section G.3.2.

H.3.2.2 Consultations and environmental impact statement

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 licence applications under the Environmental Code and the Act on Nuclear Activities was submitted in December 2014. The applications are currently the subject of formal review processes in preparation for Government decision. Partly in response to concerns raised by the local municipality, 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 wastes, pending the final repository for such wastes (SFL). Intermediate storage of long-lived low and intermediate waste will now occur at the nuclear facilities during the period until the final repository is operational (see also sections A.7.1, F.6.2.1 and K.3.2.1).

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

The last facility that will be built in the LILW programme is SFL, the repository for long-lived low and intermediate level waste. According to current plans, a decision on the siting of this facility will be made in approximately ten years. The development of the repository concept is presented in SKB's RD&D programme and successively reviewed by SSM every third year (see also sections H.1.2.1 and H.1.3.1).

H.3.3 Regulatory control

As the national regulatory authority with responsibility for matters of radiation protection and nuclear safety, SSM has participated in the stakeholder consultation process undertaken by SKB surrounding the planned extension of the SFR facility. At the time of preparing the present national report, SSM had not formally published its assessment of SKB's choice to extend SFR rather than to site a separate disposal facility elsewhere.

SSM's most recent public statement regarding the status of SKB's plans for development of a repository for long-lived low and intermediate level waste is summarised in section

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

As a result of the review of the industry's RD&D programme, it was decided by the Government that consultation was needed between SSM and SKB regarding development of the design of a facility for long-lived waste. A forum has been established so that SSM can provide guidance to SKB on regulatory expectations relating to concept development for such a facility, and to ensure that long-term safety and radiation protection issues are accorded due priority in a future siting process.

See also section G.4.1.

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, the Swedish Radiation Safety Authority determines whether these obligations are fulfilled. With respect to a repository, this can be achieved only after the Swedish Radiation Safety Authority has approved the final closure of the repository. Closure is defined to entail backfilling of tunnels and shafts up to ground surface level in accordance with the safety analysis which, in accordance with SSM's regulations concerning safety in connection with the disposal of nuclear material and nuclear waste (SSMFS 2008:21), 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 multiple barriers to prevent the release of radioactive material to the environment. All the facilities are designed to fulfil the intention of the requirements in the general design criteria. The foundation of the safety principle based on defence in depth is emphasized and defined more clearly through the implementation of this principle in the Authority's general regulations concerning safety in nuclear installations (SSMFS 2008:1).

H.4.2.2 Conceptual plans and provisions for decommissioning of radioactive waste management facilities

Aside from existing facilities (the decommissioning plans for these are addressed in section H.6.2.8), current planning relating to new waste processing facilities focuses mainly on alternative storage and disposal solutions for long-lived wastes, including those arising from decommissioning of nuclear power plants as well as legacy wastes from past practices. Conceptual plans for decommissioning are taken into account in facility design and in accordance with SSM's regulations (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.

Outline decommissioning plans for the new interim storage facility for low and intermediate level waste on the Studsvik site, to be developed by AB SVAFO (see section H.1.2.1), were submitted together with the licence application under the Environmental Code. Detailed design plans, showing how decommissioning, dismantling and demolition as well as final land restoration will be carried out, are to be submitted to SSM before construction begins, currently scheduled for summer 2018.

H.4.2.3 Technology provisions for closure of repositories

An account of the current 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.

Ongoing activities relating to areas such as the development and verification of plugs for closure of deposition tunnels in the spent fuel repository, including full-scale tests, are summarised in SKB's RD&D Programme 2016. Within the same programme, a simplified design for overall closure of the facility has been proposed based on performed sensitivity analyses. It is noted that the size and function of closure components may ultimately have an impact on details of the repository design, which means that continued efforts are needed in this area.

Analyses in support of the proposed extension of SFR to accommodate short-lived wastes from decommissioning have resulted in updated requirements for the closure components for SFR and the development of a coordinated closure plan with respect to constituent closure components and their installation and sequence. Closure is currently described on the conceptual level, with an updated closure plan scheduled for submission as part of the more

detailed design (including materials and approach to installation) in support of the PSAR. SKB is planning for continued technological development of concrete plugs to achieve a robust design that does not require extensive rock works.

H.4.2.4 Technology supported by experience

General information

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 functioning of safety-related systems and components under emergency conditions.

A comprehensive programme for environmental qualification has been carried out. Research and development are continuing. In the modernisation work, specification of all new installations is carefully checked with respect to environmental requirements.

H.4.3 Regulatory control

In performing reviews of licence applications for both the KBS-3 final repository for spent nuclear fuel and the proposed extension of the SFR facility to accommodate short-lived low and intermediate level wastes from decommissioning (section A.8), SSM has given consideration to SKB's reference designs, including plans and provisions for final closure. In declaring to the Land and Environment Court the Authority's (SSM) assessment that SKB has the potential to meet regulatory requirements for operational and long-term safety for the disposal of spent fuel,²¹ SSM has concluded that the facility can be constructed in accordance with a detailed design that provides for protection of the environment and human health. The Authority has also identified during its review a range of issues that will need to be addressed as the repository design and construction work progress in detail and safety analyses are updated ahead of future decision stages. At the time of preparing the present national report, SSM had not yet published conclusions drawn regarding the design and construction of the proposed extension of SFR.

The programme for development of a repository for long-lived waste (SFL) has been delayed, and acceptance criteria are not expected to be presented in 2017, as anticipated in Sweden's fifth national report. In its review of SKB's RD&D Programme 2016, SSM emphasised the importance of SKB developing, as soon as it is feasible to do so, a sufficiently justified and detailed repository design concept as a robust starting point for the next phase in the development process. In this respect, SSM stressed the need to ensure that the outcomes of safety assessments are of sufficient quality to support guiding decisions about the direction of future activities (for example, with respect to requirements for barrier functions and their influence on concept development). It was judged to be particularly important that SKB should work to develop preliminary acceptance criteria for those SFL wastes (especially legacy wastes) that are intended to be treated and conditioned in the near future, so that other licence holders are able to undertake the work in an appropriate manner. A forum has been established so that SSM can provide guidance to SKB on regulatory expectations relating to concept and design development, and to ensure that long-term safety and radiation protection issues are accorded due priority in a future siting process.

²¹ Consultation response on the licence application under the Environmental Code from the Swedish Nuclear Fuel and Waste Management Company (SKB) for a system for management and final disposal of spent nuclear fuel, SSM2016-546-5, available at www.ssm.se

SSM expects in due course to receive and assess construction licence applications for new waste processing and storage facilities to be operated by AB SVAFO at Studsvik.

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

Short-lived operational and decommissioning waste

In the wake of a review of the safety analysis report for the final repository for low and intermediate level radioactive waste (SFR), conducted by SSM's two predecessors, the former Swedish Radiation Protection Authority (SSI) and former Swedish Nuclear Power Inspectorate (SKI), an updated long-term safety assessment was submitted by SKB in 2008. Following review of the updated report by SSM, a more detailed assessment of SFR was submitted in March 2014, addressing in particular the long-term performance of the rock vault for intermediate level operational waste (BMA). During 2016, SKB submitted the results of further investigations into cracking in the concrete structures associated with BMA and the safety significance.

In December 2014, SKB submitted parallel applications to SSM and the Land and Environment Court for permission to develop an extension of SFR (see section A.8.2). The purpose of the expansion is to accommodate disposal of additional short-lived wastes, including those generated by demolition of Swedish nuclear reactors. The licence application includes 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), submitted in support of SKB's licence application, will be further updated and detailed so that it can be submitted for approval by SSM prior to construction of the 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 SFR will, at this point, be replaced

by the updated safety analysis report describing trial operation of the extended facility. Before the extended facility will then be allowed to begin routine operation, the safety analysis report must be supplemented with experience gained from trial operation.

Long-lived operational and decommissioning waste

An account of different repository concepts for the repository for long-lived waste (SFL), including a qualitative assessment of alternative barriers and their long-term safety function, was presented by SKB in 2013. As noted earlier (section H.1.2.1), SKB is carrying out an updated evaluation of post-closure safety for its preferred concept for SFL, to be published in 2018, with the intention that this will constitute an important basis for continued development of the disposal system.

H.5.3 Regulatory control

Short-lived operational and decommissioning waste

At the time of preparing the present report, SSM's examination of the supporting safety assessments and analyses in relation to SKB's licence application for the extension and continued operation of SFR had not yet been completed. Questions surrounding the role of structural concrete in rock vaults in both the existing facility and the planned new extension of SFR, taking into consideration factors such as swelling waste forms and the potential role of gas transport, are being addressed as part of SSM's regulatory review.

By mid-2017 SSM had submitted a preliminary opinion to the Land and Environment Court regarding the completeness of the application according to the Environmental Code, and had sought and examined supplementary material provided by SKB on a range of technical topics relating to the assessment of radiation safety. Three compilation reports covering these topics, encompassing a total of 13 technical reviews undertaken by external consultants, had been published. Further technical reports by SSM's external experts relating to the outcome of more substantive reviews of the safety assessment and its conclusions were also under development.

According to SSM's current plans for examination of SKB's licence application according to the Act on Nuclear Activities (1984:3), and taking into account the parallel process of review in relation to the requirements of the Environmental Code as well as the Authority's requests for supplementary information, the regulatory opinion on the safety assessment may be submitted to the Government in 2018.

Long-lived operational and decommissioning waste

As mentioned earlier (section H.1.3.1), SSM has noted that the programme for development of a repository for long-lived waste (SFL) is delayed. The Authority is seeking to ensure that ongoing safety assessments conducted by SKB are of sufficient breadth and quality to support guiding decisions relating to the direction of future activities in concept development and siting, as well as to provide appropriate guidance to waste producers regarding waste acceptance criteria.

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, which is described in detail in section D.1.4.5, must conform to predefined waste acceptance criteria. The characteristics of each waste type are documented in a Waste Type Description (WTD). The WTDs are prepared by the waste producer in close contact with the licence holder 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 WTDs. Wastes to be disposed of in shallow landfill facilities are specified and described in the licences (see section D.1.4.6). 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 contain several requirements relating to safety and radiation protection after closure (see sections G.3.1 and G.4.1). There are no specific requirements concerning the closure of repositories for spent nuclear fuel or radioactive waste; however, as noted earlier (section H.4.1), licensees retain their obligations for safe management until they are judged to have been fulfilled, which in practice entails approval by the Swedish Radiation Safety Authority of the final closure of the repository. This, in turn, means that the plans and technical provisions for closure need to be developed at the design stage and updated during the operational lifetime of the disposal facility.

In the case of the SFR facility, the existing repository for short-lived low and intermediate level operational waste, requirements regarding closure are issued as a licence condition. According to this licence condition, SKB is required to have a developed plan for the future closure of the facility. The requirement is important as future closure might entail different restrictions imposed on the operation of the facility, such as on the mechanical performance, physical dimensions or chemical characteristics of the waste and waste containers. The closure plan may be modified as long as all relevant requirements are still 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, and a repository for the disposal of long-lived low and intermediate level waste.

The general regulations concerning safety in nuclear installations (SSMFS 2008:1) contain 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 submitted parallel applications to SSM and the Land and Environment Court in December 2014 regarding development of an extension to SFR, see also section A.8.2. The purpose of the expansion is to accommodate disposal of additional short-lived wastes including those generated by demolition of Swedish nuclear reactors. According to current plans, which have been adjusted from those described in Sweden's previous national report in order to take account of the extended timescales for licensing, it is expected that construction can start in 2022, with operation commencing in 2028.

Also according to SKB's current plans, outlined in the RD&D programme for 2016, it is anticipated that licence applications for the repository for long-lived low and intermediate level waste (SFL) will be submitted around 2030. This presupposes that a suitable siting process, in consultation with SSM and affected communities, can be undertaken resulting in the identification of a preferred location by the end of the 2020s.

Wastes that will ultimately be consigned to SFL are currently stored at Studsvik, at nuclear power plants and at Clab. Conditioning and packaging facilities will need to be developed to meet identified waste acceptance criteria for SFL before disposal can take place. For example, as noted previously (section H.4.2.2), AB SVAFO plans to develop a facility for conditioning and repackaging of certain legacy wastes currently in storage at the Studsvik site. Additional interim storage arrangements are also likely to be required, for example to accommodate long-lived wastes from reactor decommissioning (including core and other internal components) as well as future wastes arising from research, industry and medical applications.

H.6.2.2 Operational limits and conditions

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

See 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 the 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. In addition to remedial and preventive maintenance, the maintenance programme includes identification, handling and prevention of age-related deterioration and damage. In recent years, a number of maintenance projects have been carried out in SFR. These have included installation of a waterproofing membrane to protect barriers and waste in the rock vault for intermediate-level waste (1BMA) and the silo, as well as the addition of a sprinkler in the operations building. Within the parameters of renovation work, projects continue for 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 concerning safety in nuclear installations (SSMFS 2008:1) 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.

AB SVAFO has finalized and communicated the complete decommissioning plan for the R2 and R2-0 research reactors at Studsvik as part of the process of dismantling the plant. Dismantling of the reactors commenced in 2015.

A preliminary decommissioning plan for the extended SFR facility has been prepared for the application under the Act (1984:3) and under 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 item for future safety assessments. Planning for closure has been performed for SFR and is reported as part of the supporting material for the ongoing licence application for permission to extend the facility.

H.6.3 Regulatory control

H.6.3.1 Initial authorisation

See section G.6.3.1.

H.6.3.2 Operational limits and conditions

The Swedish Radiation Safety Authority (SSM) reviews applications for changes in the OLC and for exemptions from the OLC. Based on the individual application and respective body of information provided by the licensees, plus associated safety analyses, assessments are made on how the proposed changes or exemptions contribute to the risk profile of the facility.

Since the previous Joint Convention review meeting, AB SVAFO, Cyclife Sweden AB and Studsvik Nuclear AB (SNAB) have conducted and submitted periodic safety reviews (PSRs) for their respective waste management and treatment facilities located on the Studsvik site. SSM completed its regulatory review of the reported safety reviews in April 2017, finding in its overall assessment that the organisations comply with the requirements for periodic reporting. Nevertheless, certain shortcomings were identified. In the case of Svafo, this related in particular to the need for management action to ensure that appropriate levels of competencies and resources are applied to safety and radiation protection work. In the cases of Cyclife and SNAB, this related to a need for improvements in relation to safety, operational conditions and procedures for the various waste facilities. SSM requires that these issues be addressed in a plan of action that must be presented to the Authority no later than September 2017.

H.6.3.3 Procedures

Operational and maintenance procedures are normally not reviewed by SSM. SSM might only in connection with event investigations request that a procedure be submitted for review. SSM has looked into the routines used for updating procedures in the framework of quality assurance inspections or reviews of quality audits conducted by the licensees (see section F.3).

H.6.3.4 Engineering and technical support

During 2016, SSM carried out follow-up inspections of SKB's management and control at its operational facilities, including SFR, reviewing the safety improvement measures that are being implemented as a result of previous injunctions, see also section G.1.3.2 and section K.2.6.

SSM has also carried out follow-up reviews of SKB's plans for engineering counter-measures relating to degradation of the structural concrete in the BMA vault at SFR, but has yet to take a final decision regarding the proposals that have been submitted.

H.6.3.5 Characterisation and segregation of waste

As described in section H.6.1.5, 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, e.g. SFR or shallow landfill facilities. These inspections for instance cover administrative routines, documentation, equipment and radiological measurements.

In late 2012, SKB informed SSM that errors could have arisen in documentation relating to the material content of a certain type of waste package from Studsvik that had been accepted for disposal at SFR. The following year, SKB reported its intention to retrieve the waste (up to 2,800 barrels in 75 containers) at an appropriate time, but that a decision would be taken only after further investigations had been undertaken. Although SSM accepted that the wastes did not represent an immediate hazard to the workforce or wider environment, the regulator ordered in March 2015 that SKB provide an analysis of available options and the rationale for the actions SKB intended to undertake, based (among other things) on analysis of the potential for enhanced rates of corrosion of the waste packages. At the time of preparing the present report, SSM had not yet taken a final decision regarding SKB's plans.

In 2016, SSM carried out a surveillance inspection of SKB's activities relating to the identification of difficult-to-measure radionuclides in operational wastes from Clab, which are sent to SFR for disposal.

H.6.3.6 Incident reporting

See section G.6.3.5.

H.6.3.7 Experience feedback analysis

See section G.6.3.6.

H.6.3.8 Decommissioning plans

Regulatory requirements (G.6.1.7) entail that updates of the decommissioning plan are reported to SSM and reviewed by the regulatory authority alongside related updates of, and supplements to, the facility's safety analysis report. The revised safety analysis report must be reviewed and approved by SSM before dismantling and demolition are allowed to commence. However, no final decision on dismantling and demolition is expected for several decades in respect of SKB's disposal facilities or other waste treatment facilities.

H.6.3.9 Plans for closure of disposal facilities

Detailed planning for the closure of repositories is still an R&D issue, and SKB has to date presented preliminary plans for closure, including in support of licence applications for the repository for spent fuel and the proposed extension of SFR. Development of such plans is part of SKB's RD&D programme, which is subject to regulatory review every third year. For more information, see section H.4.3.2.

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 on information archiving at nuclear facilities (SSMFS 2008:38) contain requirements for record management, under which specified documents concerning location, design and inventory of waste are required to be kept in archives for more than 100 years. Moreover, the general advice to the regulations SSMFS 2008:37, which concern protection of human health and the environment in connection with final management of spent nuclear fuel and nuclear waste, states that the implementer should produce a strategy for preservation of information so that appropriate measures can be undertaken before closure of the repository. Examples of information that should be taken into consideration include information about the location of the repository, its content of radioactive substances, and its design. Relevant records are to be transferred to national and regional official archives when facilities are decommissioned or closed. The Swedish Radiation Safety Authority's documents are regularly transferred to national archives as regulated by the Act on Archives (1990:7) and regulations issued by the National Archives of Sweden. This general type of regulatory mechanism has been in place in Sweden since 1618.

Both SKB and SSM participate in the OECD/NEA working group on Records, Knowledge and Memory across Generations, phase 2 of which is expected to be completed in April 2018. SKB also participates in another OECD project, Radioactive Waste Repository Metadata Management (RepMet), which aims to develop a common vision regarding which metadata should be preserved.

H.7.2 Measures taken by the licence holders

Generally, licence holder organisations are responsible for the development and management of records, and they carry out the necessary RD&D on these subjects. The RD&D activities performed by SKB as a basis for the design work on repositories are based on the fact that the design is to be such that the safety of a closed repository is not dependent on surveillance or monitoring, though assuming the presence of some institutional controls even after closure, safeguards, for example.

Monitoring programmes, covering both geoscientific and ecological parameters, were already initiated at the time of the site investigations of the proposed site for the repository 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 proceeds there will be a need to regularly reassess the selection of monitoring parameters, monitoring objects and measurement frequencies. If judged useful, long-term experiments carried out underground to explore impacts on key barrier functions may be included.

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 work and for the operations. Safeguards control will be implemented to the degree needed. The control programme with its quality documentation is the basis for assessing whether the construction and operational work conform 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 only accessible from underground will be decommissioned successively. The extent to which the closure process itself needs to be monitored must be considered at that time.

The surface-based monitoring system may in principle be in operation even after repository closure. The extent of the post-closure monitoring programme will essentially be determined by decisions made at, or shortly before, closure. It is appropriate that any decisions on post-closure monitoring are taken by the decision-maker at the time of closure. If monitoring after closure is considered, the applicable regulations issued by SSM should be considered (SSMFS 2008:21, Section 8):

The impact on safety of such measures that are adopted to facilitate the monitoring or retrieval of disposed nuclear material or nuclear waste from the repository, or to make access to the repository difficult, shall be analysed and reported to the authority.

Furthermore, the guidance to this paragraph states:

The safety report for the facility in accordance with 9§ should show that these measures either have a minor or negligible impact on repository safety, or that the measures result in an improvement of safety, compared with the situation that would arise if the measures were not adopted.

H.7.3 Institutional control

Requirements for institutional control after closure of a waste repository are neither established nor formally decided. The general regulations concerning safety in nuclear installations (SSMFS 2008:1) stipulate that a facility for the disposal of nuclear waste shall be designed so that the barriers provide the required safety without monitoring or maintenance after the disposal facility is closed. This is specified further in the regulations concerning safety in connection with the disposal of nuclear material and nuclear waste (SSMFS 2008:21), in which it is stipulated that safety after closure of a disposal facility shall be maintained through a system of passive barriers. Also, the regulations for protection of human health and the environment in connection with the final management of spent nuclear fuel and nuclear waste (SSMFS 2008:37) require that the long-term performance of a disposal facility should not rely on any active measures.

In the case of SFR, the relevant authorities have not yet decided what measures for institutional control, either active or passive, will apply to post-closure. However, the basic philosophy is applicable: that high levels of safety and radiological protection of public health and the environment shall be independent of institutional control.

The four shallow landfill facilities for short-lived very low-level waste (Oskarshamn, Forsmark, Ringhals and Studsvik) are located within the premises of the power plant or industrial facility at that location. Therefore, access restrictions for the repositories are maintained through the access restrictions that apply for the entire facility. Institutional control is requested for a period of up to 50 years after closure of the disposal facility. It is the task 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 of time, it is foreseen that the environmental hazard and risk are principally of a non-radiological nature. Prolonged requirements for institutional control may be issued by county or municipal administrations. 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.

Exempt waste may be deposited on municipal disposal sites and will be subject to institutional control as decided by county or municipal authorities.

According to the regulations on the protection of human health and the environment from discharges of radioactive substances from certain nuclear facilities (SSMFS 2008:23), the holder of a licence shall conduct environmental monitoring. Nuclide-specific measuring programmes shall be conducted to monitor all discharges from facilities for the storage or disposal of radioactive waste for as long as the licence is in force.

H.7.4 Intervention measures

As described above, the regulations (SSMFS 2008:1, SSMFS 2008:21) stipulate that a facility for disposal of nuclear waste must be designed so that safety after closure of a disposal facility is provided by a system of passive barriers. Prior to disposal facility closure, the final safety assessment must be renewed and approved by the regulatory authority. Based on a regulatory review, the Government makes a decision on final closure of the disposal facility and whether the licence holder may be relieved from its responsibilities and obligations. Thus, if intervention measures need to be taken after the licence is surrendered, these will be the responsibility of the State.

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 enactments that must be considered in order to obtain a complete picture of the Swedish regulatory requirements regarding transboundary movement of spent nuclear fuel and radioactive waste:

- the Radiation Protection Act (1988:293);
- the Act on Nuclear Activities (1984:3);
- Council Regulation (EC) No 428/2009; and
- the Act on the Control of Dual-use items and Technical Assistance (2000:1064).

Sweden has implemented Council Directive 2006/117/Euratom of 20 November 2006 on the supervision and control of shipments of radioactive waste and spent fuel in the national legislation, i.e. the Radiation Protection Act and the Act on Nuclear Activities (1984:3).

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 which 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.

If the export involves radioactive waste that is intended for final disposal in an EU Member State or a third country, further restrictions apply as a consequence of the implementation in Swedish legislation of Directive 2011/70/Euratom establishing a community framework for the responsible and safe management of spent fuel and radioactive waste.

The Swedish Radiation Safety Authority has the jurisdiction to decide on the export of nuclear material and nuclear equipment as defined in Annex 1, Category 0 of the Council Regulation (EC) No 428/2009 of 5 May 2009. Export cases that are of principle importance can be decided by the Government. An application for the export of spent fuel of Swedish origin must include an assurance that the material will be returned to Sweden if it cannot be taken care of as planned.

SSM's regulations and general advice on control of nuclear material, etc. (SSMFS 2008:3) contain stringent national requirements in the field of nuclear non-proliferation. They for example establish the procedure for fulfilling the requirement contained in Council Regulation (EC) No 428/2009.

I.1.2 Regulatory control

Sweden follows the administrative procedures set forth in Directive 2006/117/ Euratom in order to ensure that states of destination and states of transit have the opportunity to give their prior consent, and are notified as is stated in the directive.

I.1.3 Experience of transboundary movements

Cyclife Sweden AB carries out volume reduction of radioactive waste on a commercial basis by incinerating combustible waste and melting scrap metal. The activities are to a certain extent based on services to companies abroad, and Cyclife Sweden AB imports radioactive waste and scrap metal for the purpose of volume reduction. Remaining radioactive waste is re-exported to the country of origin. Approximately two hundred transboundary shipments of this kind are carried out each year.

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

All management of disused sealed sources is covered by the Radiation Protection Act (1988:220). According to the Act, anyone who has conducted activities involving sealed sources must ensure the safe management and disposal of the disused sealed sources, including securing of financial resources. The Radiation Protection Act allows the re-entry of disused sealed sources into Sweden for return to Cyclife Sweden AB. Detailed requirements for the management of disused sealed sources are found in regulations issued by SSM, see Annex L. In addition to the regulations, SSM can also issue licence conditions concerning the management of disused sealed sources.

Two ordinances establish producer responsibility for disused sealed sources: the Ordinance on Producer Responsibility for Electrical and Electronic Equipment (2005:209) and the Ordinance on Producer Responsibility for Certain Radioactive Products and Orphan Sources (2007:193). In effect, the licensee can fulfil the responsibility established in the Radiation Protection Act regarding safe management and disposal of a disused sealed source by delivering it to a producer (i.e. a Swedish manufacturer or supplier).

J.1.2 Measures taken by the licence holders

The licensee is required to 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 the Swedish radioactive waste management system 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 recognized radioactive waste management facility in Sweden, Cyclife Sweden AB, for treatment and storage before disposal. Cyclife Sweden AB receives approximately 250 disused sealed sources on a yearly basis, to which can be added approximately 130,000 discarded smoke detectors and a number of radiation sources from already disassembled smoke detectors.

In connection with Cyclife Sweden AB accepting a disused sealed source for treatment and disposal, the company assumes the ownership of the sealed source. However, Cyclife Sweden AB is not required to accept disused sealed sources. The company operates on a commercial basis. Hence, problems may arise if Cyclife Sweden AB for some reason does not accept disused sealed sources for treatment.

After treatment, the disused sealed sources are stored by Cyclife Sweden AB pending disposal in either the disposal facility for short-lived low and intermediate level waste, SFR, or the disposal facility for long-lived low and intermediate level waste, SFL. During storage, the sources are retrievable.

Orphan sources

Licensees are required to take all the measures necessary so as not to allow for sealed sources to fall outside of regulatory control. Nevertheless, on rare occasions, orphan sources are found, usually at scrap metal recycling facilities. If the licensee responsible cannot be identified, the State will provide financial resources for the management and disposal of the orphan source. This is made possible through a special governmental funding arrangement that allows SSM to cover the costs up to a certain amount for the management and disposal of orphan sources and legacy radioactive waste.

Several orphan sources are found and taken care of every year, using the financial resources provided by the State. To date, no orphan high activity sealed sources have been found. The orphan sources are managed by Cyclife Sweden AB at the Studsvik site, near Nyköping. 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. In connection with Cyclife Sweden AB accepting the responsibility to manage and dispose of orphan sources, the company assumes the ownership of the sources. The orphan sources are transported to the Studsvik site, where they are treated, conditioned and stored pending disposal. Short-lived disused sealed sources, including orphan sources, can be disposed of in SFR, the existing repository belonging to SKB which is used for operational waste. Disused sealed sources must meet the same criteria as any item of short-lived LILW in order to be disposed of in SFR. The majority of disused sealed sources, including orphan sources, are long-lived. These sources are stored at the Studsvik site until SKB's planned disposal facility for long-lived low and intermediate level waste, SFL, is in operation.

J.1.3 Regulatory control

SSM plans and performs inspections regularly at research centres, hospitals and non-nuclear operations, such as scrap metal recycling facilities. 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 in general are usually brought to the attention of SSM in connection with inquiries made by licensees about these issues.

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

K.1.1 Updating of regulations

As mentioned in Section A.3, there have been a number of reasons for the review and revision of SSM's Regulatory Code (SSMFS); e.g. implementation of different Euratom directives and IRRS recommendations. Further reasons for the revision are supervisory experiences that SSM has gained over the years as of the Authority's establishment in 2008. One lesson learned is that a graded regulatory approach should be introduced. A graded approach is also recommended by Directive 2013/59/Euratom (BSS). Another important goal of the regulatory revision is to create more predictability for the licensees and to improve the regulatory support for SSM in its supervisory activities.

K.1.1.1 Graded approach based on risk assessment

In order to determine the level of requirements to be adapted to various activities, SSM has developed a set of criteria for assessing the risks involved in different types of uses of radiation sources. The assessment is based on a risk model comprising a comprehensive set of assessment criteria used for considering different radiological consequences (public, worker and patient health, effect on the environment and infrastructure), as well as other consequences such as cost and societal trust in operations involving radiation, or the supervision of such operations. In addition, the probability of events is considered. The results of the assessment are used for strategic planning as to whether an activity requires authorisation, notification, or if it may be exempted from further regulation. In the IRRS follow-up mission of 2016, SSM's risk model was acknowledged as a good practice.

K.1.1.2 Regulatory structure

The above-mentioned revision also involves arranging the regulations into three hierarchical levels below the Acts and Ordinances. This structure has the aim of ensuring that certain basic requirements do not need to be repeated at lower levels, and making it easier for licensees to understand and apply the provisions. The hierarchical levels are as follows:

1. Regulation (one) on fundamental obligations for all activities involving ionising radiation, nuclear activities, as well as other activities involving ionising radiation;
2. Regulations (several) on facility or activity level for nuclear facilities and other activities involving radiation, e.g. construction and operation of nuclear power plants, use of radiography, medical exposures, etc.; and
3. Regulations (several) on specific radiation safety aspects, e.g. lifting equipment at nuclear power plants.

In connection with this revision of SSM's regulations, the Authority also prepares a supporting document for each set of regulations that describes the rationale behind the regulations and the interpretations of each regulatory section.

K.1.2 Managing stepwise licensing

As reported in Sweden's fifth national report and discussed in connection with its country group presentation, a stepwise licensing process presents challenges for the developer, the regulatory authority as well as other stakeholders. This includes the need to assess safety and make licensing decisions at early stages of a repository licensing process when information about the technical solutions may not be complete and review issues may remain. The following examples illustrate some measures taken to address these challenges.

K.1.2.1 Resolution of scientific issues in the licensing review

At the current stage of SSM's licensing review of SKB's application for construction of a spent nuclear fuel repository, the repository design and associated technical solutions are not yet fully developed. Furthermore, the information on rock conditions at repository depth is based only on surface-based investigations. In order to develop and produce a review statement with a recommendation for a Government decision, SSM has developed a strategy for managing the resulting uncertainties in the ongoing licensing review.

Identification of critical review issues was initially performed based on both external and in-house expert reviews, as well as based on the outcome of a national consultation. The issues were subsequently divided into three priority categories. Remaining review efforts were devoted to the subsequent handling of the critical review issues through the following:

- requests for further information from the applicant for either clarification of existing information or complementary analyses,
- assignments to external experts for in-depth analyses of specific technical or scientific review issues, and
- independent modelling activities both to facilitate phenomenological understanding and estimate impacts using dose and risk assessment calculations.

A critical element for confidence building is the evaluation of limiting and improbable unfavourable circumstances as less likely and residual scenarios.

In the concluding states of SSM's review, resolution of critical issues was achieved by means of interdisciplinary expert group meetings. Such discussions promote an understanding of the entirety of the repository system status and long-term evolution in relation to a specific review issue. This in turn creates a basis for determination of the acceptability of remaining uncertainties at the current licensing step. For practical reasons some uncertainties need to be successively eliminated in the continued repository development programme, however it is necessary to at least broadly understand their potential safety impact to be able to arrive at a well justified review statement. In the current licensing review, SSM has taken into consideration SKB's plans for continued development of repository components, as well as further safety assessment development and integration.

K.1.2.2 Development of regulatory requirements for the next stages of the licensing process

In parallel with the licensing review of SKB's application for an encapsulation plant and a spent nuclear fuel repository, SSM is providing SKB with information on the regulatory requirements necessary for the design phase that follows a Government licensing decision. This is mainly done by providing guidance for the interpretation of the general regulations SSMFS 2008:1 as well as the disposal-specific regulations SSMFS 2008:21 and SSMFS 2008:37, and their applicability for the further development of the disposal facility in moving from concept to design and industrial implementation. Important guidance to SKB is also provided in the technical and scientific review reports of the ongoing licensing process, from which remaining uncertainties that have to be addressed in the design phase are evident.

SKB's preliminary safety assessment reports (PSAR) produced after a Government licensing decision will be reviewed by SSM. SSM also authorises SKB's continuation to the subsequent stages of preparing the SAR and to start the construction of the facilities.

SSM is also preparing to provide SKB with specific licensing conditions for operating Clink and the spent fuel repository.

K.1.2.3 Licensee's preparation of a PSAR for a spent fuel repository

Based on the review by SSM of the licence applications for the spent fuel repository and the encapsulation plant, plus the review comments on the RD&D Programme 2016, SKB is planning and conducting development activities needed for the preparation of the PSAR followed by the preparation of the SAR.

K.1.3 Management of human resources and maintaining knowledge

In order to maintain knowledge and ensure adequate human resources comprising competent staff over long time periods, SSM uses a competence supply model. This model includes a documented recruitment procedure, systematic skills mapping and GAP analysis, a competent leadership programme and a skills transfer concept to maintain knowledge within the Authority, see also section E.3.2.1.

A new and comprehensive analysis of competence and resources was carried out in 2016 with the aim of reassessing the Authority's needed competence and financial and human resources on a yearly basis until 2022 in order to fulfil its assigned responsibilities. The analysis particularly took into account the impact on SSM's activities and funding that occurs when nuclear power plants are shut down and being decommissioned, but also e.g. the transition from the ongoing licensing review of disposal facilities to the stepwise authorisation in establishing the facilities that follow a Government licensing decision. This strategic review is updated annually and is based on the results of the Authority's systematic competence mapping and GAP analysis.

In December 2016, SSM also received a Government assignment to investigate the conditions for maintaining national competence in the Authority's areas of responsibility. A progress report with a special focus on shutting down and decommissioning of reactors is to be submitted in September 2017. The final findings and recommendations on necessary measures to ensure the long-term availability of competencies are to be reported on in September 2018.

A compulsory training programme for all personnel with supervisory tasks is operational since 2012. The aim is to ensure the appropriate level of competence for all supervisory personnel and inspection leaders, resulting in more consistent supervisory inspections, regardless of organisational department performing the supervision or the licence holder being super-

vised. The responsible officer in charge of the programme is also the Authority's process leader for regulatory supervision. Work is ongoing to strengthen the programme through the further development of the Authority's management system, including process and information modelling with the objective of providing more streamlined supervisory tools and work processes.

K.2 Other measures taken to improve safety

K.2.1 Licensing of an encapsulation plant and a disposal facility for spent fuel

In June 2016, SSM submitted a statement to the Land and Environment Court based on the outcome of the Authority's review of SKB's licence applications under the Act on Nuclear Activities, pronouncing that both the proposed encapsulation facility and the geological repository have the potential to comply with radiation safety requirements according to pertinent regulations. At the time of preparing the present report, it is expected that the main hearings of the Land and Environment Court in assessing SKB's licence application under the Environmental Code will be conducted in September and October 2017. Both the Court and SSM are expected to submit their final recommendations to the Swedish Government by early 2018. See also section A.8.1.

K.2.2 Licensing of an extension of SFR

SKB applied for permission in December 2014 to extend the final repository for short-lived low and intermediate level waste at Forsmark (SFR) so that it can also accommodate decommissioning waste. SKB's applications are being reviewed in parallel by the Land and Environment Court and by SSM. SSM has undertaken an initial review of the completeness of the application and has issued a number of requests to SKB for supplementary information. When the applications are deemed complete, they will be announced publicly by both the Court and SSM, as of which the general public can submit their opinions. The Court will hold hearings in preparation for the statement to the Government. The Court's and SSM's statements to the Government are expected to be issued in 2018. See also section A.8.2.

K.2.3 Licence conditions for decommissioning

SSM decided in June 2017 to issue specific licence conditions for the decommissioning of the Barsebäck units 1 and 2, Oskarshamn units 1 and 2, Ringhals units 1 and 2, and the Ågesta reactor. The purpose of the licence conditions is to provide the licensees with a clear set of requirements at an early stage with respect to the decommissioning and dismantling of their plants. The need to regulate decommissioning activities has emerged over a relatively short period of time due to the utilities' decisions in 2015 to shut down the four oldest reactors in operation at Oskarshamn and Ringhals before 2020 and to bring forward dismantling of the previously shut down Barsebäck reactors. Due to the resulting time constraints, SSM has opted for issuing licence conditions for the individual licence holders rather than developing new regulations. Besides being more time effective, this approach is more flexible in that it can be adapted to different licensing situations. As a regulatory basis, the requirements contained in SSM's regulations on safety in nuclear facilities (SSMFS 2008:1) also apply to decommissioning. SSM's requirements as applied to decommissioning fulfil IAEA safety standards and WENRA safety reference levels.

K.2.4 Development of waste acceptance criteria for long-lived waste

In their latest RD&D programme from 2016, SKB announced that they will present a safety evaluation for the planned repository concept for long-lived nuclear waste. This evaluation will provide an important basis for establishing a technical development programme for further development of the repository concept and defining siting factors and waste acceptance criteria.

K.2.5 Development of national database

Sweden communicated in the national report to the 5th Joint Convention review meeting about an initiative to establish a database tool for supporting international reporting on the status of management of spent fuel and radioactive waste.

SSM has since then, with support from the IAEA, initiated a dedicated project to develop the database tool. Based on a customized version of the IAEA database NewMDB,²² it is adapted to specific national needs. The inventory part of the database will be designed for the national classification system for radioactive waste. The tool will however be designed to encompass a specific reporting module to allow for customized reporting of inventories to international fora, i.e. Joint Convention, IAEA, OECD-NEA and the European Commission according to internationally agreed classification of radioactive waste.²³

K.2.6 Operational safety improvement programme for SKB's existing facilities

In late 2014 SKB launched a programme for improvement of operational safety at its existing facilities, Clab and SFR. The programme was initiated in response to an injunction from SSM emphasising the need to more clearly define the distribution of responsibilities, safety management routines, control of requirements, handling of deviations, and the methods for continuous improvements in general.

Soon the programme was extended to cover monitoring of progress of improvements being made in other areas related to safety. The extended programme was given the campaign name *Säkerhetslyftet* ('Safety boost').

As of the launch of *Säkerhetslyftet*, the progress of activities covered by the programme has improved considerably and is now at an acceptable level. Work on measuring these effects continues to strengthen SKB's efforts to achieve continuous improvements.

K.2.7 Ageing management programme

SKB has been hard at work developing a new ageing management programme for Clab and SFR to meet the challenges entailed by long-term operation of existing facilities. Both SSM's supervision and the WANO peer review had pointed out this area as weak at SKB. The programme in place will continue and is at this stage established in the organisation. The programme serves as important input for SKB's long-term planning and will be a part of its on-going periodic safety review, which will be reported to SSM in October 2018.

²² Net Enabled Waste Management Data Base.

²³ IAEA General Safety Guide No. GSG-1, Classification of Radioactive Waste.

K.2.8 Periodic Safety Reviews

At least once every ten years, licensees are required to perform a Periodic Safety Review (PSR), i.e. a new and integrated analysis and assessment of the safety of their facilities. The PSR should cover both nuclear safety and radiation protection with the purpose of clarifying how requirements stated in relevant legislation as well as in issued regulations and conditions are met, and are expected to be met, on the part of an existing nuclear facility over the following period of ten years.

Since the previous Joint Convention review meeting, the licensees AB SVAFO (Svafo), Cyclife Sweden AB and Studsvik Nuclear AB (SNAB) have conducted and reported periodic safety reviews (PSR) covering the period up until 2025 for their respective waste management and treatment facilities located on the Studsvik site. The Swedish Radiation Safety Authority (SSM) completed its regulatory review of the reported safety reviews in April 2017, finding in its overall assessment that all three licensees comply with the requirements for periodic reporting. Nevertheless, certain shortcomings were identified. In the case of Svafo, this was in particular related to the need for management action to ensure that appropriate levels of competencies and resources are applied to safety and radiation protection. As regards Cyclife and SNAB, this related to a need for improvements in relation to safety, operational conditions and procedures for the various waste facilities. SSM has required that these issues be addressed in a plan of action that must be presented to the Authority no later than September 2017.

In July 2017, Westinghouse Electric Sweden AB (WSE) submitted a periodic safety review for its fuel manufacturing facility and other nuclear activities in Västerås, covering the period up to 2027. The performed safety review constitutes the basis for WSE's internal programme for safety improvement measures and will also form an integral part of its application for a renewed licence to continue nuclear activities on the site as WSE's licence under the Act on Nuclear Activities expires on 31 December 2019.

K.3 Strong features, major challenges and areas for improvement identified by the Contracting Party

K.3.1 Strong features

In its fifth national report under the Joint Convention, Sweden reported on strong features relating to continuity of the waste management programme, allocation of responsibilities, the functions of the regulatory authority and a stepwise licensing process with provisions for stakeholder involvement. These features in Sweden, which were recognised by the country group at the fifth review meeting as a good practice, remain in place as summarised below.

K.3.1.1 Continuity in the waste management programme

Building confidence in the safety of spent nuclear fuel and radioactive waste management benefits strongly from a national system involving consistent long-term strategies and planning. In Sweden, the financial arrangements are in place and have been working for nearly 30 years now; also, a research and development programme on waste management and disposal has been ongoing continuously for more than 30 years.

Sweden's long-term strategies are also being implemented in practice. The Clab and SFR storage and disposal facilities, respectively, have been in operation since the 1980s. Licensing reviews of applications for a spent fuel repository and an encapsulation plant, and of an application for extension of the SFR facility to accommodate decommissioning wastes, are expected to be completed in 2018.

K.3.1.2 Stepwise licensing process with early regulatory involvement

Through the mandatory review of the RD&D programmes and cost estimate reports of SKB and the nuclear power plant owners, SSM and the predecessor regulatory authorities have since the 1980s been able to supervise the development of management and disposal solutions in the pre-licensing process. The authorities have monitored SKB's siting process, performed pilot safety assessments, taken part in pre-licensing consultations, participated in international projects and carried out independent research on geological disposal. The pre-licensing review process has also included broad and long-term public participation, supported by the regulatory authorities, in the development of a Swedish management system for spent fuel and radioactive waste.

A key element in Sweden's regulatory framework is the clearly defined and stepwise licensing process. A licence application for the construction, possession and operation of a nuclear facility is reviewed by the regulatory authority, SSM, and the Land and Environment Court, and decided on by the Government. Following Government approval, SSM – as part of a stepwise process – authorises the start of construction, the start of trial operation, the start of routine operation, and the eventual decommissioning of the facility. A Government decision is once again needed for de-licensing and exemption from responsibilities. The Authority reviews an application to ensure that all obligations and licensing conditions have been fulfilled.

K.3.1.3 Clear division of roles and responsibilities

The division of responsibilities is clear in the regulatory framework, with an effective separation between the functions of the regulatory body and those of the nuclear energy industry. The nuclear facilities' licensees have the prime responsibility for the safe operation of their facilities and transports as well as the safe disposal of spent fuel and radioactive waste. Swedish nuclear power plant licensees also have a common obligation to conduct research and development of disposal solutions and to carry out cost calculations as a basis for payments to the Swedish Nuclear Waste Fund.

The legislation provides the regulatory authority with a strong mandate as well as extensive supervisory and enforcement powers. As a regulator, SSM is authorised to issue legally binding requirements regarding all aspects of nuclear activities and radiation protection. SSM supervises SKB, the power plant operators and other licensees of nuclear activities in fulfilling their responsibilities for safe operation of facilities and transports as well as in planning for decommissioning and disposal.

K.3.1.4 Independence and competence of the regulatory authority

SSM is the national regulatory body with mandates in the areas of nuclear safety, radiation protection and nuclear non-proliferation. SSM is provided with the adequate authority, competence and financial and human resources to fulfil its assigned responsibilities. The independence of the regulator is stated in Swedish legislation, but it is also a matter of public service culture and values. As a strong, independent and fully accountable national authority, SSM is also confident and trustworthy in upholding high safety standards. The integrity of the regulator has become increasingly crucial with the progression of the licensing review of SKB's application for a spent fuel repository.

K.3.1.5 Provisions for stakeholder involvement

The ongoing licensing review for a spent fuel repository has benefited from the provisions for a transparent and predictable siting and licensing process, with active involvement of stakeholders. Key contributing features include:

- the nuclear industry's shared obligation for the development of waste management and disposal solutions, manifested in the tri-annual RD&D programmes with associated regulatory reviews, public consultations and Government decisions,
- the local communities' voluntary participation in the siting process and right to veto a Government licensing decision,
- the Environmental Impact Statement that a prospective licensee is required to submit according to the Environmental Code, containing a plan for the formal process of consultation with stakeholders, and
- the financial support to stakeholders through the Nuclear Waste Fund that has made it possible for local communities and environmental organisations to build capacity for active participation in formal consultations.

Several stakeholders, both in the form of local communities and environmental organisations, have been involved for a long time, are well informed and have built a good capacity for dialogue with the authorities. In practice, the provisions for stakeholder involvement have been very beneficial to the overall quality and public acceptance of the licensing process for a spent fuel repository.

The Swedish approach to building trust in the high-level waste management system as well as in the integrity of the regulator was credited as a good practice in the 2011 IAEA IRRS review.

K.3.1.6 Openness and transparency

Swedish official documents are public.²⁴ This means that no one needs to explain a request to view a public document, or is required to reveal his or her identity in order to gain access to a document. All SKB report series (except for work documents in progress) are public and can be downloaded from SKB's website, www.skb.se.

SSM provides information services to the public concerning its regulatory activities and regularly publishes reports to inform interested parties and stakeholders. The SSM website is used to provide information on current events and Authority decisions.

²⁴ This applies unless a decision has been made to classify them under the Public Access to Information and Secrecy Act (SFS 2009:400). Reasons for secrecy might include interests of national security, international relations, commercial relations, or individuals' right to privacy.

K.3.2 Challenges

Sweden presented a number of challenges in its fifth national report. While the measures taken to address these challenges are described in the present report (section K.1), new challenges have emerged relating to recent decisions on shutting down nuclear reactors and accelerated decommissioning plans. These new challenges are described below.

K.3.2.1 Decommissioning

The NPP licensees' decisions in October 2015, to close down the four oldest reactors in operation at Oskarshamn and Ringhals before the end of 2020 and to advance the dismantling of the Barsebäck and Ågesta reactors, are described in detail in sections A.7.1 and F.6.2.

The transition from having nuclear power plants in operation to their decommissioning, with immediate dismantling as a strategy, represents both a regulatory and an industry challenge in the coming years. Decommissioning and dismantling require the permission of the Land and Environment Court as well as the approval of SSM on the safety assessment report (SAR). The nuclear waste management programme will be under strain as the changed plans affect the handling, transport and final disposal of radioactive waste. Radiation safety must be maintained in situations where there may be reactors in operation and under decommissioning concurrently at the same sites. Measures for development of regulatory requirements for decommissioning are described in section K.2.3.

The accelerated timetable for decommissioning poses several challenges for management of wastes arising from decommissioning. In SSM's review of the nuclear industry's RD&D Programme 2016 (prepared by SKB), and SSM's statement to the Government in March 2017, the Authority concludes that there is a need for an overarching systems perspective on the logistics for managing the volumes of different waste categories. This would need to take into account the changes in decommissioning strategy and timing, and the extent to which this waste will be placed in existing or planned intermediate storage facilities pending final disposal in an extended SFR (for short-lived waste) or the planned SFL (for long-lived waste).

In addition, SSM has noted the delay mentioned in SKB's report regarding the development of SFL. SKB's revised timetable implies that the safety evaluation of the conceptual design for SFL will be finalised during 2018 and thus accounted for in the RD&D Programme 2019. SSM stressed the importance of the evaluation being of sufficient scope, level of detail and quality in order to underpin guiding decisions on the orientation of ongoing activities. Consequently, SSM intends to closely monitor SKB's continuing work on refining the conceptual design and siting of SFL during the preparation of future RD&D programmes and in the future licence application.

It is also of importance to develop preliminary acceptance criteria for wastes arising from decommissioning, particularly long-lived decommissioning waste destined for disposal in the future SFL. These criteria are needed to enable the licensees to handle and condition the waste in an appropriate way in the near term, see section K.2.4.

In December 2014, the Government decided on nuclear waste fees and guarantees to be provided by the NPP licensees for the period 2015–2017 based on SSM's review of the industry's cost calculations. The utilities' decisions in 2015 on early shutdown of four reactors represents a significant deviation from the conditions that formed the basis for the Government's decision on nuclear waste fees. In SSM's statement to the Government in October 2017, the Authority will propose a substantial increase in the fees for the remaining reactors in operation for the period 2018–2020 in order to finance decommissioning of nuclear power plants and disposal of spent nuclear fuel and radioactive waste.

Figure K1 Calculated remaining costs (reference costs) for the nuclear waste programme
in SEK million at 2016 price level

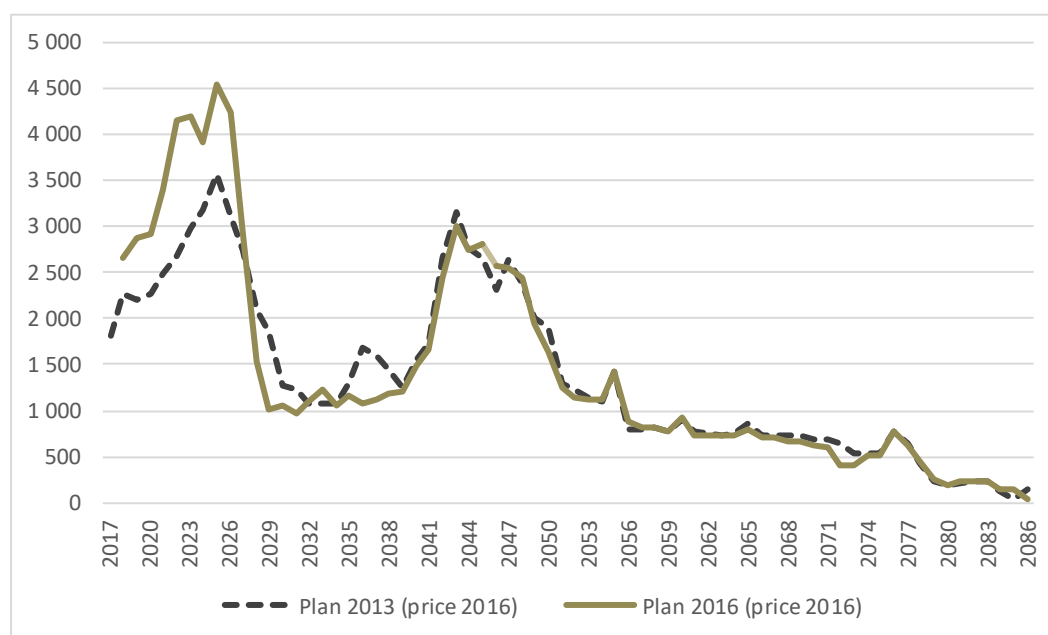


Figure K1 shows calculated reference costs for the nuclear waste programme, as provided by the industry in January 2014 (Plan 2013) and 2017 (Plan 2016), respectively. The Ringhals and Oskarshamn utilities' decisions on shutting down four reactors are projected to result in an increase in decommissioning costs for the period 2018–2027.

K.3.3 Areas for improvement

K.3.3.1 Overview of the Act on Nuclear Activities

In June 2017, the Swedish Government decided to establish a committee (Dir. 2017:76) to examine the need for amendments to the Act (1984:3) and Ordinance (1984:14) on Nuclear Activities. If necessary, changes to the Radiation Protection Act or other consequential amendments to environmental and financing legislation will also be proposed. The committee will, among other things:

- investigate opportunities and advantages in coordinating responsibilities according to the Act on Nuclear Activities and Environmental Code,
- analyse advantages and disadvantages of separating the responsibility for nuclear safety and radiation protection from the long-term responsibility for decommissioning and waste disposal,
- analyse potential requirements to be imposed in the event of a change of licensee, and pre-conditions for review and authorisation in connection with changed company ownership of nuclear power plants,
- review the definitions of nuclear waste and radioactive waste and look into how a more effective distinction between Swedish and foreign waste may be designed, and
- propose regulation of ultimate liability following the closure of a repository.

The committee is to submit a report on its findings and proposals by 1 June 2018.

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 with the aim of ensuring 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.9.4.1, a follow-up IRRS mission was carried out in Sweden in 2016. Sweden is planning for a new full-scope IRRS mission to be carried out in 2022.

Utilities in Sweden are traditionally quite active as part of international cooperation to enhance nuclear safety by sharing experiences, contributing to work on international regulation and guidelines, and participating in safety assessments and peer reviews such as e.g. IAEA OSART missions and WANO peer reviews. SKB is since 2011 a member of the World Association of Nuclear Operators (WANO) and participates actively in WANO programmes. A follow-up WANO peer review was carried out in 2016 of SKB's operation of the Clab and SFR facilities (see section A.9.4.2).

As described in Sweden's fifth national report under the Joint Convention, the regulatory authorities and nuclear industry in Sweden also have a long tradition of using the peer review instrument in the pre-licensing phase. For example, in support of regulatory reviews conducted since 1983, SSM and its predecessors have on several occasions arranged for international peer reviews of SKB's preliminary safety analyses of the KBS-3 method for the disposal of spent nuclear fuel.

K.5 Actions to enhance openness and transparency in the implementation of the obligations under the Convention

K.5.1 General

The legal framework for the licensing and supervision of nuclear activities in Sweden also stipulates provisions on transparency, openness and public participation. As an example, the regulatory review of SKB's and the power plant owners' tri-annual RD&D programmes, as well as SKB's and the authorities' consultation with stakeholders on the licence application for a spent fuel repository, provide opportunities for broad public participation in the development of a Swedish management system for spent fuel and radioactive waste.

Furthermore, according to the Ordinance with instructions for the Swedish Radiation Safety Authority (2008:452), SSM is required to ensure that a current national plan is in place for the management of spent fuel and radioactive waste corresponding with the content required under Article 12 of Council Directive 2011/70/Euratom. In the process of developing or amending this plan, SSM should give appropriate representatives of relevant agencies, local authorities, the public and industry an opportunity to comment.

SSM publishes and makes the Swedish national reports of the Joint Convention publicly available on SSM's official website. SSM is also planning to publish questions and comments received from other contracting parties, including the responses to these questions. All documentation filed that relates to the production of each national report from Sweden is obtainable from SSM upon request in accordance with the Swedish principle of public access to official records.

K.5.2 Licensing of a spent fuel repository

The ongoing licensing review for a spent fuel repository has benefited from the provisions for a transparent and predictable siting and licensing process, with active involvement of stakeholders since the early 1980s. Key contributing features include:

- the nuclear industry's shared obligation for the development of waste management and disposal solutions, manifested in SKB's RD&D programmes and cost calculations, with associated regulatory reviews, public consultations and Government authorisation,
- the local communities' voluntary participation in the siting process and their right to veto a decision by the Government to grant a licence,
- the Environmental Impact Statement that a prospective licensee is required to submit according to the Environmental Code, also containing a report on the formal process of consultation with stakeholders, and
- the financing provided to stakeholders through the Nuclear Waste Fund, which has made it possible for local communities and environmental organisations to build their capacity to participate actively in formal consultations.

Several stakeholders, both in the form of prospective host municipalities and environmental organisations, have been involved over a long period of time, are well informed and have built a good capacity for dialogue with Swedish public authorities. In practice, the provisions in place for stakeholder involvement in the pre-licensing phase have been very beneficial to the overall level of quality and public acceptance as well in the licensing process for a spent fuel repository.

Since the receipt of SKB's application in March 2011, public participation during the parallel licensing reviews conducted by SSM and the Land and Environment Court has been ensured through formal consultations with stakeholders, continuous information exchange with interested parties, and open access to all official records. In 2012, the results from an international peer review of SKB's post-closure safety case, organised by the OECD Nuclear Energy Agency, were presented to SSM and to the public, including a local presentation given in Östhammar Municipality. From the continuing SSM review, available records include about 70 technical notes from SSM's external experts, around 80 requests for and deliverables of supplementary information from SKB, minutes from review dialogue meetings between SSM and SKB, and the publication by SSM of several preliminary reports between June 2015 and March 2016, followed by a review statement to the Court in June 2016.

The Court's main proceedings will be held as a public hearing between September and October 2017, with opportunities for all stakeholders to be heard. After the proceedings, both the Court and SSM will issue their final pronouncements with recommendations to the Government. The Government, preceding its licensing decision, must consult with the municipal authorities concerned. Local councils have the right to exercise a veto against establishment of nuclear activities in their communities. The council of Östhammar, host municipality of the planned spent fuel repository, recently decided to hold a local referendum in March 2018 in order to provide guidance on whether to support or reject the establishment of the facility.

Section L – Annexes

L.1 Summary of applicable regulations

A brief description is provided below of SSM's regulations with relevance to the safe management of spent fuel and radioactive waste, presented by main areas of application. As mentioned above in the present report, considerable work is underway on revising the content and overall structure of SSM's Code of Statutes (see sections A.4 and K.1.1). The progress of this work will be reported on further at the forthcoming review meeting in 2018.

L.1.1 General safety and administrative regulations

Regulations and general advice concerning safety in certain nuclear facilities (SSMFS 2008:1)

These general regulations are primarily worded to apply to nuclear power reactors. However, because the application of the regulations is subject to a graded approach, the regulations are also applicable to all licensed nuclear facilities. 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 handling of nuclear material and nuclear waste, and conducting efficient supervision. The regulations cover the following areas:

- Application of multiple barriers and defence in depth
- Handling of 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
- On-site management of nuclear materials and waste
- Reporting to SSM of deficiencies, incidents and accidents
- Documentation and archiving of safety documents
- Final closure and decommissioning
- For most of the requirements, general advice on their interpretation has been issued.

Regulations on radiation protection managers at nuclear power plants (ssmfs 2008:24)

According to these regulations, a licence holder is required to appoint a radiation protection manager at the facility in order to implement radiation protection conditions issued by the authorities and to supervise compliance with these conditions.

Regulations on filing at nuclear power plants (ssmfs 2008:38)

These regulations apply to filing of documentation that has been drawn up or received in connection with the operation of nuclear power plants. Certain documentation must be filed. If the practice ceases, the archives are required to be transferred to the National Archives of Sweden.

L.1.2 Regulations on final disposal**Regulations concerning safety in connection with the disposal of nuclear material and nuclear waste (ssmfs 2008:21)**

These regulations, in force since 2002, contain 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) apply.

The regulations concerning long-term safety for disposal of spent nuclear fuel and nuclear waste specifically cover:

- 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)
- 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 apply to the disposal of spent nuclear fuel and nuclear waste. They 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 contain 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.

L.1.3 Regulations on or related to non-nuclear radioactive waste**Regulations on radioactive waste not associated with nuclear energy (ssmfs 2010:2)**

These regulations apply to the handling of solid and liquid wastes from medical care, laboratories and scientific applications.

Regulations on the control of high activity sealed radioactive sources (ssmfs 2008:9)

These regulations, which implement Council Directive 2003/122/Euratom on the control of high activity sealed radioactive sources and orphan sources, stipulate that high activity sources for which no further use is foreseen must be sent within six months either to the supplier, to the manufacturer or to an approved facility for waste management. The holder must notify SSM, which maintains a register.

Regulations on radiation therapy (ssmfs 2008:33)

These regulations stipulate that in the case of the purchase of radioactive sources, or equipment which contains such sources, a plan shall be drawn up for the future handling of the radioactive waste.

Regulations on accelerators and sealed sources (ssmfs 2008:27)

These regulations stipulate that the licence holder shall ensure that an up-to-date and documented plan is in place for decommissioning of the facility. The plan must include an analysis of the resources needed to take care of all radioactive substances and radioactive demolition waste in a safe way from a radiation protection point of view.

Regulations on the use of equipment in industry containing sealed sources or x-ray tubes (ssmfs 2008:40)

These regulations stipulate that equipment containing a radioactive source for which no further use is foreseen shall be sent to a radioactive waste management facility within six months.

Regulations on smoke detectors for domestic use containing radioactive sources (ssmfs 2008:47)

These regulations stipulate that the discarded units are to be collected and shipped for disassembly.

Regulations on smoke detectors for industrial use containing radioactive sources (ssmfs 2008:44)

These regulations stipulate that the disused units should 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 contain 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 contain provisions on limitation of exposures as far as reasonably achievable while having taken into account 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.

Regulations on basic provisions for the protection of workers and the public in connection with work involving ionising radiation (ssmfs 2008:51)

These regulations are general in nature and apply to the exposure of workers and the public in both planned and emergency exposure situations. Based on European provisions in the EU's BSS,²⁵ the regulations impose fundamental requirements on the licensee/operator for justification of the activities, optimisation of the radiation protection and limitation of individual doses (dose limits). They address the categorisation of workers and workplaces, stipulate Swedish dose limits for workers (including apprentices) and the public, and address the information required to be provided to pregnant or breastfeeding women, as well as their protection.

The regulations address dose limitation in connection with emergency exposure situations. They also stipulate rules for measurements, registration of individual radiation doses, and how these should be reported to the national dose register.

The regulations contain provisions on medical surveillance, classification and medical records of workers as well as on rules for the accreditation of laboratories for individual dose monitoring and performance requirements of individual dose meters. The regulations also refer to the European technical recommendations for monitoring individuals exposed to external radiation (EUR 14852 EN, 1994).

Regulations on outside workers in work involving ionising radiation (ssmfs 2008:52)

These regulations apply to outside workers of category A working within controlled areas in Sweden, and when Swedish workers of category A perform similar tasks in other countries. The regulations impose obligations on both the licensee (e.g. operator of a nuclear facility) and the outside worker's undertaking. The regulations contain provisions on procedures to be followed by SSM for issuing individual radiological monitoring documents to outside workers in accordance with the EU Directive (90/641/Euratom).

²⁵ Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the health protection of the general public and workers against the dangers of ionising radiation [O. J. L-159 of 29.06.1996].

L.1.6 Regulations on emergency preparedness, physical protection and safeguards

Regulations on emergency preparedness at certain nuclear facilities (ssmfs 2014:2)

These regulations apply 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 contain 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 contain 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 are to 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 apply to the measures required to meet the obligations resulting from Sweden's agreements in order 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 and general advice concerning clearance of materials, rooms, buildings and land in practices involving ionising radiation (ssmfs 2011:2)

These regulations contain provisions on the clearance of materials, rooms, buildings and land that have been used in practices involving ionising radiation. These regulations replace the former regulations governing clearance of goods and oil from nuclear facilities (SSMFS 2008:39).

Regulations on the management of contaminated ash (ssmfs 2012:3)

These regulations apply to the production of energy by using forest biofuels in incineration facilities producing 30 tonnes or more of ash in yearly volume. The regulations contain precautionary provisions regarding the handling of ash for different options, such as returning the ash to the forests for nutrition, spreading the ash on agricultural and grazing land for nutrition, and reusing the ash as roadfill or landfill, also governing the design of the waste disposal site if the ash is deposited.

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 apply 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 implement Council Directive 2006/117/Euratom, require prior authorisation for moving radioactive waste and spent fuel across borders if the item is being sent from, through, or to an EU country.

Regulations on import, export and reporting on radioactive substances (ssmfs 2008:10)

These regulations, which implement the IAEA Code of Conduct on the Safety and Security of Radioactive Sources, stipulate that in order to import or export disused sealed sources, a licence is needed and such import/export must be reported to the competent authorities.

L.2 List of acronyms

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 site)
AU	Storage facility for radioactive waste (Studsvik site)
AV	Swedish Work Environment Authority
BAT	Best Available Technique
BFA	Rock Cavern for Waste (Oskarshamn site)
BKAB	Barsebäck Kraft AB
BLA	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
DG	Director General
ECURIE	European Community Urgent Radiological Information Exchange
EIA	Environmental Impact Assessment
ENSREG	European Nuclear Safety Regulators Group
EU	European Union
FA	Storage facility (Studsvik site)
FR0-A	Treatment facility for radioactive non-nuclear waste (Studsvik site)
HA	Incineration facility (Studsvik site)
HCL	Hot Cell Laboratory (Studsvik site)
HELCOM	The Helsinki Commission
HERCA	Heads of European Radiation Control Authorities
HM	Treatment facility for intermediate level waste (Studsvik site)
HRL	Hard Rock Laboratory
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiation 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	Proposed method for disposal of spent nuclear fuel
KTH	Kungliga Tekniska Högskolan (Royal Institute of Technology)
LER	Licensee Event Report
LILW	Low and Intermediate Level Waste
LLW	Low Level Waste
MOX	Mixed oxide fuel
MSB	Swedish Civil Contingencies Agency
MTO	Interaction between Man, Technology and Organisation

NEA	Nuclear Energy Agency within the OECD
NGO	Non-Governmental Organisation
NORM	Naturally Occurring Radioactive Materials
NPP	Nuclear Power Plant (including all nuclear power units at one site)
OECD	Organisation for Economic Cooperation and Development
OKG	Oskarshamns Kraftgrupp AB
OLC	Operational Limits and Conditions
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
QA	Quality Assurance
R0-A	Treatment facility for radioactive non-nuclear waste (Studsvik site)
RD&D	Programme for Research, Development and Demonstration
RO	Reportable Occurrence
SAR	Safety Analysis Report/Safety Report
SFL	Disposal facility for long-lived low and intermediate level waste
SFR	Disposal facility for short-lived low and intermediate level waste
SFS	Swedish Code of Statutes
SKB	Swedish Nuclear Fuel and Waste Management Company
SKI	Swedish Nuclear Power Inspectorate
SMA	Melting facility (Studsvik site)
SMHI	Swedish Meteorological and Hydrological Institute
SNAB	Studsvik Nuclear AB
SR-Site	Long-term safety assessment for the spent fuel repository
SSI	Swedish Radiation Protection Authority
SSM	Strålsäkerhetsmyndigheten (Swedish Radiation Safety Authority)
SSMFS	SSM's Regulatory Code
STUK	Finnish Nuclear and Radiation Safety Authority
TSO	Technical Support Organisation
WANO	World Association of Nuclear Operators
WENRA	Western European Nuclear Regulators' Association
VLLW	Very Low Level Waste
WTD	Waste Type Description

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25. Nya ungdomspåföljder. Ju.
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51. Sweden's sixth national report under the Joint Convention on the safety of spent fuel management and on the Safety of radioactive waste management. M.

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Systematisk förteckning

Arbetsmarknadsdepartementet

ILO:s konvention om anständiga
arbetsvillkor för hushållsarbetare. [10]

Utstationering och vägtransporter. [22]

Ett entreprenörsansvar i bygg-
och anläggningsbranschen. [30]

Anpassningar till dataskyddsförordningen
av registerförfattningar inom
Arbetsmarknadsdepartementets
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Körkortslån. [35]

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rådgivning. [13]

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