

RADIOACTIVE WASTE MANAGEMENT AND DECOMMISSIONING IN SWEDEN

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

1.1 National framework

1.1.1 Overview of national policy

1.1.1.1 National infrastructure

At national level the Swedish people are represented by the Riksdag (Swedish parliament) which has legislative powers. Proposals for new laws are presented by the Government which also implements decisions taken by the Riksdag. The Government is assisted in its work by the Government Offices, comprising a number of ministries, and some 300 central government agencies and public administrations. The primary function of these bodies is to implement the decisions taken by the Riksdag and Government. The government agencies have an autonomous status, i.e. they operate on their own responsibility but in accordance with preconditions in appropriations directives and ordinances decided by the Government. The appropriations directives set out, among other things, the goals an agency is to reach in its operations, how much money the authority has at its disposal and how the money is to be distributed between its different activities. The ordinances contain various general administrative provisions concerning how the agencies are to carry out their work.

SSM operates under the auspices of the Ministry of the Environment.

1.1.1.2 Basis for spent fuel and radioactive waste management

Principles for the management of spent fuel and radioactive waste have evolved over the years and have been discussed by the Swedish parliament. The allocation of responsibilities is reflected in the Swedish legislation, and is further described in section 2. The principles can be summarised:

1. The expenses for the disposal of spent nuclear fuel and nuclear waste are to be covered by revenues from the production of energy that has resulted in these expenses.
2. The reactor owners are to safely dispose of spent nuclear fuel and nuclear waste.
3. The state has the ultimate responsibility for spent nuclear fuel and nuclear waste. The long-term responsibility for the handling and disposal of spent nuclear fuel and nuclear waste should rest with the state. After a disposal facility has been closed, a requirement should be established to ensure that some kind of responsibility for and supervision of the disposal facility can be made and maintained for a considerable time. A government authority could assume responsibility for a closed disposal facility.
4. Each country is to be responsible for the spent nuclear fuel and nuclear waste generated in that country. The disposal of spent nuclear fuel and nuclear waste from nuclear activities in another country may not occur in Sweden other than in an exceptional case.

The practical implication is that the NPP utilities are responsible for establishment of spent fuel and nuclear waste management and disposal facilities, as well as for the required research and demonstration activities.

The state, through the Government and the Ministry for the Environment and the regulatory authority, is responsible for the regulatory supervision of the implementers' activities and operations.

Sweden has ratified the Joint Convention, the London Convention, the OSPAR convention, the Espoo Convention and the Aarhus Convention.

1.1.2 Overview of relevant institutions

1.1.2.1 Policymaking institutions

The Ministry of Enterprise, Energy and Communications is responsible for matters relating to e.g. the business sector, energy and regional development. Thus the promotion of nuclear energy – if any – is the responsibility of the ministry of Enterprise, Energy and Communications.

The Ministry for the Environment is responsible for drawing up and implements legislation and state financing for nuclear safety including security and radiation protection as well as legislation on nuclear liability. The ministry is responsible for the regulatory policy for nuclear activities, including management and disposal of spent fuel and radioactive waste. The ministry has also the overall responsibility for coordinating the Government's work on sustainable development.

1.1.2.2 Implementing organisation

Main key organisations as regards direct responsibility for safe operation of nuclear facilities and activities as well as management and disposal of spent fuel and radioactive waste including decommissioning:

- The NPP utilities (Barsebäck Kraft AB, Ringhals AB, Forsmarks Kraftgrupp AB and OKG AB) are responsible for the safe management and storage of spent fuel and nuclear waste at the NPP sites, as well as decommissioning of the NPPs and associated facilities at the NPP sites. The NPP utilities are jointly responsible for establishing necessary management and disposal facilities and arrangements to accomplish safe disposal of spent fuel and nuclear waste.
- The Swedish Nuclear Fuel and Waste Management Co (SKB), is jointly owned by the NPP utilities and is responsible for management, including transports, and disposal of spent fuel and nuclear waste. SKB is responsible for organising and performing necessary research and technical development in order to accomplish safe disposal of spent fuel and nuclear waste from the NPPs.
- Studsvik Nuclear AB is tasked with managing institutional waste from medicine, research and non-NPP utilities and activities. Institutional waste is when applicable disposed of in disposal facilities for nuclear waste, operated by SKB.
- AB SVAFO is jointly owned by the NPP utilities and is responsible for decommissioning of old research and development facilities and for management and disposal of legacy waste. Legacy waste is when applicable disposed of in disposal facilities for nuclear waste, operated by SKB.

1.1.2.3 Regulatory control

Main key organisations as regards regulatory activities and responsibilities:

- The Parliament (Riksdag) promulgates laws.
- The Government promulgates ordinances that specify requirements in laws. The Government grants licences for facilities and activities. The Ministry of the Environment has the overall responsibility for compliance of operations with legislation and regulations.
- The Swedish Radiation Safety Authority (SSM) is the responsible regulatory authority as regards nuclear safety and radiation protection.
- The National Council for Nuclear Waste is an independent committee attached to the Ministry for the Environment. The Council’s mandate is to study issues relating to nuclear waste and the decommissioning of nuclear installations and to advise the Government and certain authorities on these issues. The Council reports to the Ministry of the Environment.

1.2 National, technical regulatory organisation(s)

1.2.1 Regulatory function

The Swedish Radiation Safety Authority (SSM) is responsible for the direct regulatory control of compliance of operations with legislation and regulations. SSM issues regulations that specify requirements in laws and ordinances. SSM is also responsible for the technical safety review of license applications and other important documentation. In addition, SSM is responsible for the review of the nuclear industry’s cost calculations and to suggest the level of fees to be paid by licensees to the Nuclear Waste Fund. SSM reports to the Ministry of the Environment.

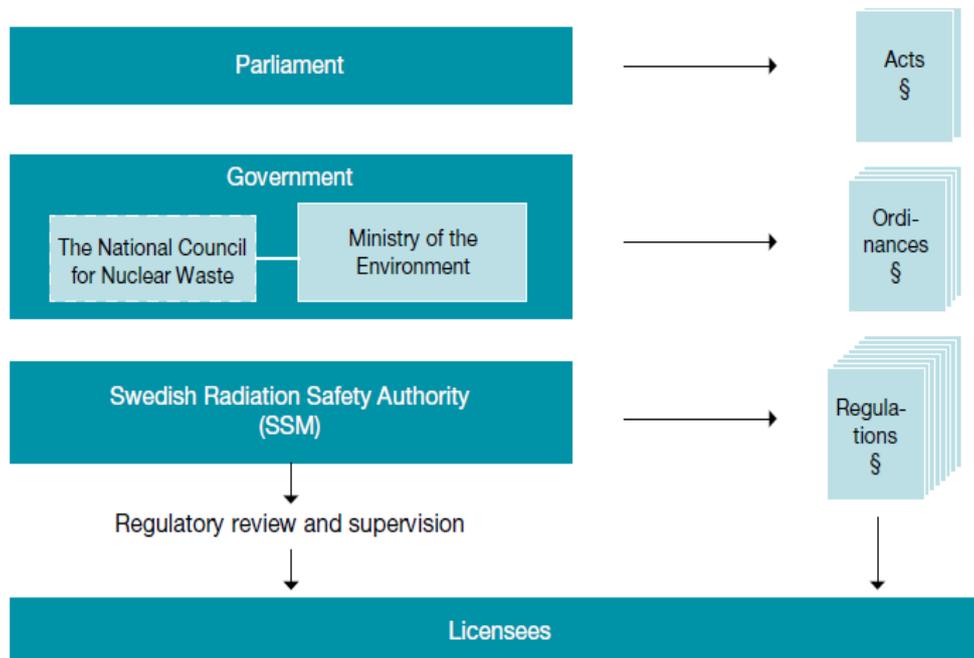


Figure 1. Legislative and regulatory framework, and organisational structure

1.2.2 Organisation and resources

SSM has a staff of about 300 (2012). Of these, about 40 are directly involved in regulating management of spent fuel and radioactive waste and decommissioning. Another ten persons are involved in financial issues and cost calculations for management and disposal of nuclear waste and for decommissioning. The budget for SSM for 2012 was about SEK 400 million (equivalent to € 47 million).

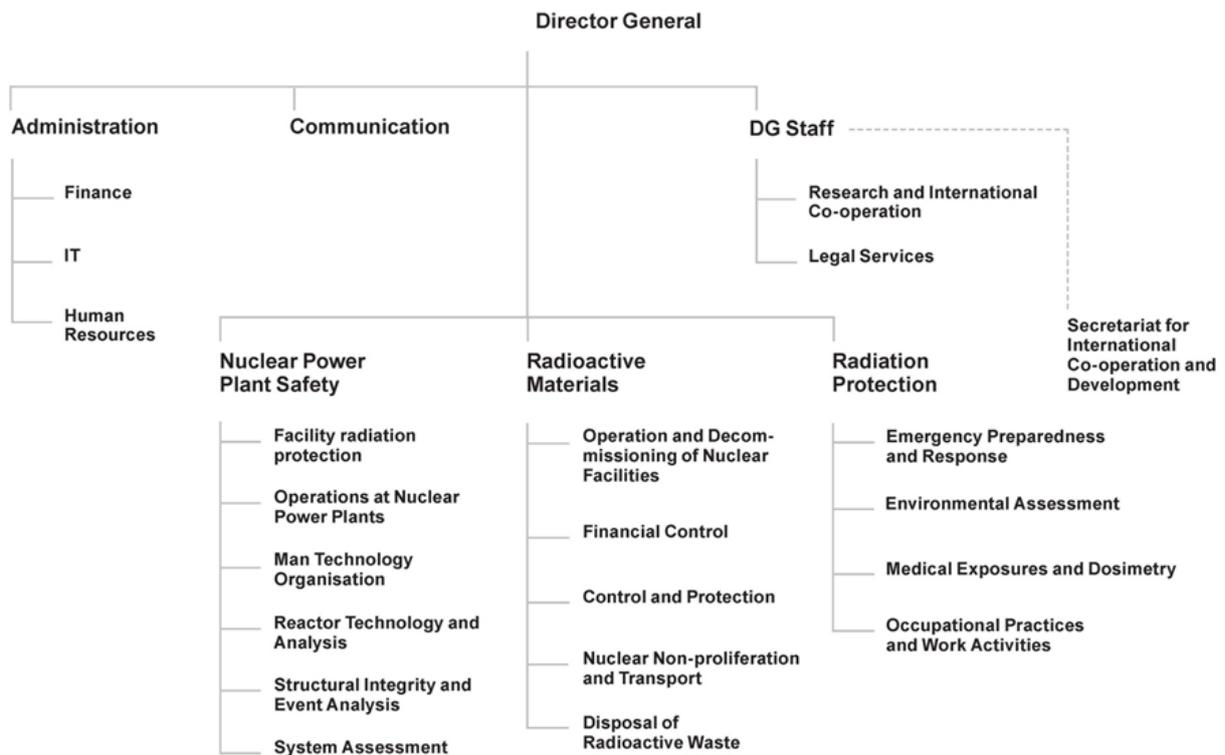


Figure 2. Swedish Radiation Safety Authority - organisational chart per 2012.

1.3 National implementing organisations

1.3.1 Scope of responsibility

Under Swedish law, the holder of a licence to operate a nuclear facility is primarily responsible for the safe handling and disposal of spent nuclear fuel and radioactive waste, as well as decommissioning and dismantling of the facility. The four NPP utilities operating nuclear power reactors in Sweden have formed a special company, the Swedish Nuclear Fuel and Waste Management Co (SKB), to assist them in executing their responsibilities.

SKB has been tasked with the responsibility for all handling, transportation and storage of spent fuel and radioactive waste outside the nuclear power plants, as well as for disposal of spent nuclear fuel and nuclear waste. This includes the responsibility to carry out necessary research and development activities and the compilation of the R&D-program required to be submitted to the Government for review every

three years. SKB is also tasked with the responsibility to perform the nuclear industries cost estimates for management and disposal of spent fuel and nuclear waste, as well as for decommissioning of NPPs and other nuclear facilities.

SKB is the licensee and the operator of the central interim storage for spent fuel (Clab) and the disposal facility for operational waste (SFR). SKB also owns and operates the transport ship, M/S Sigyn, a custom-made ship to transport spent fuel and radioactive waste from nuclear power plants to Clab and SFR. SKB has recently commissioned a new ship, MS Sigrid, to eventually replace MS Sigyn.

1.3.2 Organisation and resources

SKB has a staff of about 500. SKB cooperates with leading experts and other companies outside SKB. In total, approximately 800 persons are working full time with management and disposal of spent fuel and waste. The main office is located in Stockholm and there are site offices in the municipalities of Oskarshamn and Östhammar.

The budget for SKB for 2011 was about SEK 1 457 million (equivalent to € 171 400 million), according to table 1.

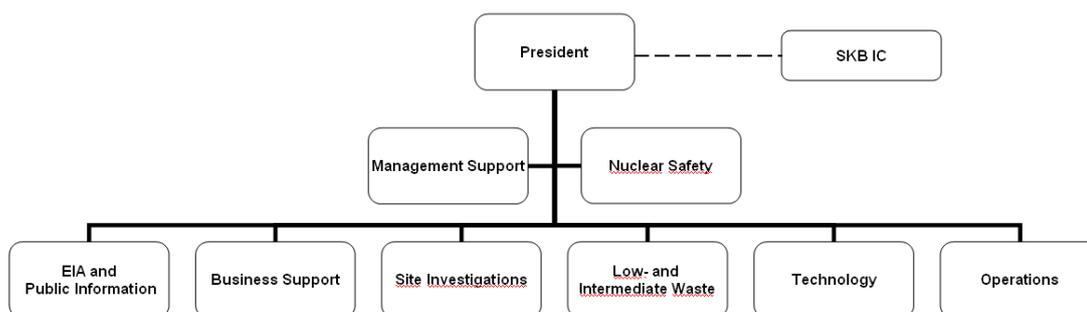


Figure 3. Swedish Nuclear Fuel and Waste Co (SKB) - organisational chart

Area	Budget 2011 (SEK million)
SKB's central function	312
RD&D	378
Transport system	85
Clab	321
Encapsulation plant	27
Disposal facility for spent fuel	185
SFR and LILW program	149
SFR total:	1 457

Table 1: SKB, budgeted costs for 2011

2. LEGAL FRAMEWORK

2.1 Primary Legislation and General Regulations

2.1.1 Primary legislation

The framework of Sweden's legislation in the field of waste management, nuclear safety and radiation protection, is to be found in four Acts:

- The Act (1984:3) on Nuclear Activities, which defines the licensing requirements for the construction and operation of nuclear facilities and for handling or using nuclear materials (including radioactive waste).
- The Radiation Protection Act (1988:220), which defines the licensing requirements for radiation protection and for radiological work.
- The Act on Financing of Management of Residual Products from Nuclear Activities (2006:647) which deals with the main financial aspects, and defines the responsibilities pertaining to the management and disposal of spent nuclear fuel and radioactive waste.
- The Environmental Code (1998:808) is also of great importance, in particular for the siting and construction of new facilities since amongst other things it regulates the environmental impact statement that must accompany a licence application.

The Acts are supplemented by a number of ordinances and other secondary legislation, which contain more detailed provisions for particular aspects of the legal framework.

Any new nuclear facility must be licensed according to both the Act on Nuclear Activities and the Environmental Code. In both cases the Government grants the licence on the basis of recommendations and reviews of the competent authorities. A licence according to the Radiation Protection Act is not required for activities licensed according to the Act on Nuclear Activities.

2.1.1.1 Nuclear safety

The Act (1984:3) on Nuclear Activities contains provisions for management of spent fuel and radioactive waste management as well as decommissioning on e.g. definitions, basic requirements on safety, licensing, general obligations of the license holder, general obligations of licensees and licence conditions, environmental impact assessment (EIA) and general rules of consideration, safe management and disposal of nuclear waste, supervision, inspection, documentation and reporting, revocation and prohibition, sanctions, and public insight.

The Ordinance (1984:14) on Nuclear Activities contains detailed provisions on such matters as definitions, applications for licences, reviewing, evaluations and inspections. The Ordinance also specifies that the regulatory authority assigned by the Government is authorised to issue permits for transportation of nuclear materials and nuclear waste. The authority is in addition authorised to impose licence conditions and to issue general regulations concerning measures to maintain the safety of nuclear activities.

The Regulations Concerning Safety in Certain Nuclear Facilities (SSMFS 2008:1) contains the most important regulations for management and disposal of spent fuel and nuclear waste. The regulations are also applicable for decommissioning.

The general regulations is written for nuclear power reactors but is applicable in a graded way on all licensed nuclear facilities, no matter 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 regulations aim at specifying measures needed for preventing and mitigating radiological accidents, preventing illegal handling of nuclear material and nuclear waste and for conducting an efficient supervision. The regulations also contain general recommendations concerning the application of the regulations, with comments on certain paragraphs.

The regulations cover e.g. application of multiple barriers and defence-in-depth, handling of detected deficiencies in barriers and the defence-in-depth, organisation, management and control of safety significant activities, actions and resources for maintaining and development of 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, final closure and decommissioning.

2.1.1.2 Radiation protection

The radiation protection in Sweden is based on the International Radiation Protection Commission's (ICRP) internationally recognised principles, i.e. justification, optimisation and dose limitations.

The framework for all radiation protection is defined in the Radiation Protection Act (1988:220) and in the Radiation Protection Ordinance (1988:293) and applies to all activities involving radiation. These are defined to include all activities involving radioactive substances or technical devices capable of generating radiation.

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 the proper handling and disposal of the radioactive waste produced.

The Radiation Protection Act (1988:220) contains provisions for both radioactive waste management and decommissioning on e.g. definitions, basic requirements on radiation protection, licensing, general obligations of licensees and licence conditions, environmental impact assessment (EIA), supervision, inspection, documentation and reporting, revocation and prohibition, sanctions, and public information about radiation protection.

Currently there are about 50 regulations in force covering all the areas in which radiation can occur. In general these requirements and regulations are in agreement with recommendations by international organisations such as IAEA, ICRP, EU. There are 15 regulations of particular interest for nuclear and radioactive waste management.

2.1.2 Government investigation on possible changes to the legislation

On 11 December 2008 the Government decided to appoint an inquiry chair to review the legislation in the area of nuclear technology and radiation protection. One of the main drivers was to consider conditions to establish coordinated regulation of nuclear activities and radiation protection and propose necessary amendments to acts and ordinances and investigate possibilities of bringing together the provisions of the Nuclear Activities Act and the Radiation Protection Act and also consider possibilities for better coordination with the provisions of the Environmental Code. The final report was submitted to the Government in March 2011 and is currently under consideration by the Government.

2.2 Regulations concerning specific activities or facilities

2.2.1 *Radioactive waste management*

Regulations concerning Safety in connection with the Disposal of Nuclear Material and Nuclear Waste (SSMFS 2008:21) contain specific requirements on design, construction, safety analysis and safety report for final repositories, in view of the period after closure of the facility. For the period before closure, the general safety regulations (SSMFS 2008:1) apply (cfr 2.1 above). These regulations, concerning the post-closure safety for disposal of spent nuclear fuel and nuclear waste, cover specifically:

- qualitative requirements on the barrier system,
- scenario definitions and classifications,
- time scales for the safety assessment (as long as barrier functions are needed to isolate and/or to retard dispersion of radio nuclides, but for at least 10 000 years), and
- topics to be covered in the safety report

Regulations 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), contain provisions on that human health and the environment shall be protected from detrimental effects of ionising radiation, during the time when the various stages of the final management of spent nuclear fuel or nuclear waste are being implemented as well as in the future. The regulations also contain general recommendations concerning the application of the regulations, with comments on certain paragraphs. The regulations cover the following areas:

- BAT and optimization,
- the risk criterion and most exposed group,
- time periods for the risk analysis and,
- reporting of the risk analysis and compliance demonstration for different time periods.

2.2.2 *Decommissioning*

Regulations on decommissioning are found in the general safety regulations (cfr 2.1 above).

2.3 Guidance on implementation

Regulations generally also contain general recommendations concerning the application of the regulations, with comments on certain paragraphs. The licensee shall comply with these recommendations unless alternative solutions are developed for which a comparable level of safety can be demonstrated.

2.3.1 *Radioactive waste management*

There are no regulatory guides on radioactive waste management in addition to the general recommendations in the regulations.

2.3.2 Decommissioning

There are no regulatory guides on radioactive waste management in addition to the general recommendations in the regulations.

2.4. Licensing procedure

The licensing is issued in accordance to several acts with different purposes and involves a number of authorities. A general permissibility consideration has to be made as to whether to grant a permit for the activity or not. Furthermore the activity shall be approved according to aspects of nuclear safety, and the protection of human health and the environment. Finally licensing conditions are set up according to the various acts by the responsible authorities.

According to the Environmental Code (1998:808) the Government shall consider the permissibility of certain activities such as interim storage or the disposal of spent fuel or waste. An environmental impact statement (EIS) shall be submitted for the permissibility assessment. The Environmental Court reviews an application on permissibility, which thereafter is handed over to the Government for the final consideration.

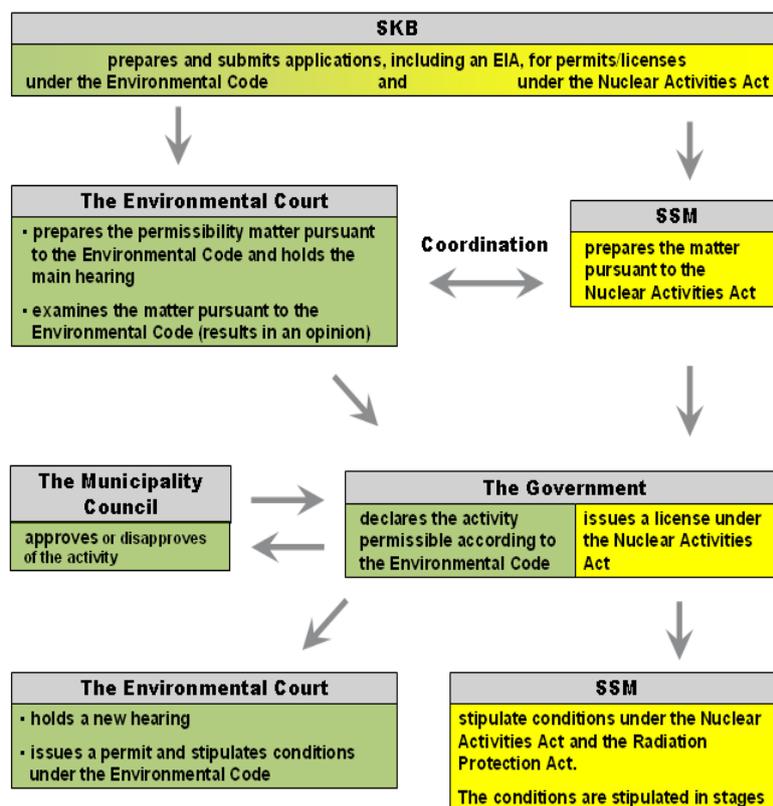


Figure 4: Licensing procedure for nuclear facilities (based on RD&D-program 2007).

The Government may only permit an activity if a municipal council has already approved it (municipal veto). But without prejudice to a municipal approval the Government may permit an activity that involves interim storage or disposal of spent fuel or waste, if the activity is of the utmost importance with regard to the national interest.

If the Government grants permissibility, licensing approval has to be issued for the nuclear activity according to the Act on Nuclear Activities and 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. The application is reviewed by the regulatory authority assigned by the Government and thereafter handed over for the Government's decision. Finally the Environmental Court grants the licence on environmentally hazardous activities according to the Environmental Code.

In addition, the licensee has to apply for a permit according to the Planning and Building Act by the Municipality. This process does not involve the SSM.

3. WASTE MANAGEMENT STRATEGY AND CURRENT PRACTICE

3.1 Waste classification and quantities

3.1.1 Waste classification

There is no legally defined waste classification system in Sweden for nuclear or radioactive waste. There are, however, established waste acceptance criteria for different disposal routes of nuclear and radioactive waste. These disposal routes differ between the nuclear field and the non-nuclear field depending both on the different types of material being handled and also on which of the different routes that have been established by taking repositories into operation.

For the established disposal routes (see section 3.2) including clearance, waste acceptance criteria have been set up that are being expressed as dose rate limits and activity concentration.

Waste category	Origin	Endpoint
VLLW	Operational waste	Cleared for unrestricted use
	Decommissioning waste	Cleared for disposal at municipal landfills, or disposed of at shallow land burials at nuclear sites
	Waste from fuel fabrication	
LILW – shortlived	Operational waste	Disposal facility for short-lived waste (SFR)
	Decommissioning waste	
	Disused sealed sources	
	Institutional waste	
LILW - longlived	Internal parts	Disposal facility for long-lived waste (SFL)
	TRU-waste	
	High-activity sealed sources	
Spent fuel	Spent nuclear fuel	Disposal facility for spent fuel (SFK)

Table 2: Disposal routes in the Swedish spent fuel and waste management and disposal system

3.1.2 Spent fuel and waste quantities

The long-term planning for the waste management programme is based on a reference scenario where the reactors in Ringhals and Forsmark are assumed to have an operating time of 50 years and OKG's reactors 60 years. The quantity of spent fuel to be disposed of amounts to about 12,000 tonnes of uranium (counted as uranium).

The total volume of decommissioning waste for all NPPs as well as from research and demonstration facilities is estimated to about 160 000 m³.

The LILW programme is aimed at disposing of all the low- and intermediate-level operational and decommissioning waste from the Swedish nuclear power programme. The reference scenario gives rise to a total of about 200 000 m³ of short-lived waste and about 10 000 m³ of long-lived waste from the nuclear power plants.

3.2 Waste management strategy

3.2.1 Very low level waste (VLLW)

3.2.1.1 Clearance

Clearance is an important component in the waste management system. Material may be cleared for unrestricted use or for disposal as conventional non-radioactive waste. For example in 2004 approximately 600 tonnes were cleared for disposal at municipal landfills. In addition 500 tonnes of melted scrap metal (<500 Bq/kg) were cleared for recycling.

3.2.1.2 Shallow land burials

The nuclear power plants at Ringhals, Forsmark and Oskarshamn as well as the Studsvik site have shallow land burials for solid short-lived low-level waste (<300 kBq/kg). Each burial 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).

Site	License conditions			Waste disposed of 2010-12-31		
	License valid until (*)	Volume (m3)	Max activity/ max alpha	Mass (ton)	Volume (m3)	Total activity/alpha activity (GBq)
Forsmark	2040/2070	17 000	200/0.2	3 415	5 231	35 / 0.004
Oskarshamn	2025/2075	10 000	200/0.2	3 768	7 346	38 / 0.0028
Ringhals	2030/2060	10 000	1100/0.1	3 640	5 942	181 / 0.046
Studsvik	2010/2050	1 540	100/0.1	1 151	1 140	39 / 0.055

(*) Disposal authorised until/ Licence valid until.

Table 3: Inventories of disposed waste in shallow land burials.

3.2.2 Short-lived low- and intermediate level waste (LILW)

3.2.2.1 Operational waste

For low and intermediate level waste being disposed in the disposal facility for radioactive operational waste (SFR), a separate permit is needed for each category of waste before disposal is allowed. The permit is based on a waste type description (WTD) comprising detailed specifications on waste treatment, composition and conditioning, etc. Furthermore, for each subsystem, such as the different rock caverns of the SFR facility, dose rate criteria have been established. In addition, total dose and/or nuclide specific activity limits have been established for SFR as a whole and for each section of the facility.

Thus, a tailor-made management system for production and disposal of waste packages has been developed. Waste packages are produced according to detailed specifications in the WTD's. These are

developed in close co-operation between the waste producer (the NPPs) and the disposal facility licensee (SKB). Treatment and conditioning at the NPPs, is governed by the management systems at the NPPs and subject to the general regulations and requirements for quality assurance. This is also the case for handling and disposal at SFR. All documentation concerning a single waste package is documented locally in databases at the producers. Basic information concerning a package has to be transferred to a waste database at the disposal facility before a waste package may be transported to SFR. The system checks the incoming information to make sure criteria from the WTD's are fulfilled, and that the package is suitable for emplacing in the predestined part of the disposal facility. After transportation to SFR all documentation is transferred to the database in order to store the information over a long period ahead.

Principal data and waste disposed of (2012-12-31)

Operator: Swedish Nuclear Fuel and Waste Management Co (SKB)
 Start of operation: 1988
 Total storage capacity: 63 000 m³
 Disposal capacity: 6 000 m³/year
 Current disposal rate: 1 000 - 1 500 m³/year

Storage section	Volume (m ³)	Activity (Bq)
Silo	5 355	5,1E14
BMA (rock vault for intermediate level waste)	9 234	2,6E14
1 +2 BTF (rock vaults for concrete tanks)	9 567	2,0E12
BLA (rock vault for low level waste)	10 200	1,6E11
SFR total:	34 356	7.9E14

Table 4: Inventories of disposed waste in SFR 2011-12-31

3.2.2.2 Decommissioning waste

So far no disposal facility for decommissioning waste exists. SKB plans to dispose of shortlived decommissioning waste in an extension to the existing disposal facility for operational waste (SFR). Long-lived decommissioning waste is destined for the future disposal facility for long-lived low- and intermediate level waste (SFL).

3.2.3 Long-lived low- and intermediate-level waste (LILW)

The final disposal facility for long-lived low- and intermediate-level waste (SFL), is mainly intended to contain core components and reactor internals, plus long-lived LILW from Studsvik. SFL may be co-sited with one of the other final repositories. SKB plans to locate the disposal facility at a depth of 300 metres with connection to existing ramps.

3.2.4 Spent nuclear fuel

The spent nuclear fuel from all Swedish nuclear power reactors is stored in a central interim storage (Clab) situated at the Oskarshamn nuclear power plant. The fuel is stored in water in storage pools in caverns in bedrock with a rock cover of about 25 m. Construction started in 1980 and it was taken into operation in 1985 with a storage capacity of 5000 tonnes of spent fuel. Clab has been expanded with a

second rock cavern with storage pools. The current total storage capacity is approximately 8 000 tonnes of spent fuel, and 5 222 tonnes were being stored at the end of 2011.

Principal data for Clab (2012-12-31):

Operator:	Swedish Nuclear Fuel and Waste Management Co (SKB)
Start of operation:	1985
Licensed storage capacity:	8 000 tonnes of uranium
Receiving capacity:	300 m ³ /year

3.3 Waste management issues at national level

3.3.1 Spent nuclear fuel

SKB submitted in November 2006 a license application under the Act of Nuclear Activities for the construction of an encapsulation plant. Extensive supplements were submitted in September of 2009.

In March 2011 SKB submitted a license application under the Act of Nuclear Activities for a disposal facility for spent nuclear fuel. At the same time SKB submitted also a license application for establishment of the KBS-3 system for disposal of spent nuclear fuel, i.e. the application under the Environmental Code covers both the encapsulation plant and the disposal facility for spent fuel.

The regulatory review of the applications under the Act on Nuclear Activities is co-ordinated with the review of the application under the Environmental Code by the Environmental Court.

3.3.2 Long-lived low and intermediate level waste

3.3.2.1 Disposal facility for long-lived low- and intermediate level

According to current plans, a disposal facility for long-lived low and intermediate level waste will be sited in about 2035 and taken into operation in 2045. The origin of this waste is primarily research, industry, medical applications, core-components and certain internal components from nuclear power reactors. The waste is currently stored at Studsvik, the nuclear power plants and Clab.

3.3.2.1 Disposal facility for decommissioning waste

SKB has initiated the consultation process to site a disposal facility for short-lived low and intermediate level decommissioning waste as an extension to the existing disposal facility for short-lived operational waste (SFR). Investigation of the bedrock started in 2008. SKB plans to submit an application late 2013 and to start operation of the extended part of the disposal facility in 2023.

3.4 Research and Development

3.4.1 Research infrastructure

3.4.1.1 Responsibilities

The Nuclear Activities Act (1984:3) requires that the holder of a licence for the operation of a nuclear power reactor shall - in co-operation with the other holders of a licence for the operation of nuclear power reactors - establish and carry out an R&D-programme for the safe handling and disposal of spent fuel and nuclear waste, including decommissioning. Every third year the programme shall be submitted to the

¹ E.g. approval status of major national programmes such as the RD&D programme in Sweden.

Government, or an authority assigned by the Government, for evaluation. The most recent program, RD&D-program 2010 was submitted to the Government in September 2010.

SKB:s budget for RD&D-activities for 2011 was SEK 378 million (equivalent to € 44 millions). In addition, SEK 185 million (equivalent to € 22 millions) was spent on site investigations and design.

3.4.1.2 Research and demonstration facilities

In order to carry out research and demonstration activities needed to support an application for the construction of a disposal facility for spent nuclear fuel and an encapsulation plant, SKB has established research- and demonstration facilities as per below:

The Äspö Hard Rock Laboratory

An important step in the disposal facility development programme was the construction of the Äspö hard rock laboratory in the 1990's. The laboratory is situated close to the Oskarshamn nuclear power plant at a depth of 460 meter. At the laboratory methods are developed and tested for such things as site characterisation, deposition and retrieval of canisters, as well as methods for excavation of tunnels and shafts.

The Canister Laboratory

In 1998 a canister laboratory was commissioned. It is mainly used for development of welding techniques and methods for non-destructive testing of canisters and welds.

The Bentonite Laboratory

In 2007 a bentonite laboratory was inaugurated, co-located to the Äspö-laboratory. The bentonite laboratory will make it possible to conduct large-scale tests of the properties of the bentonite and to further develop the industrial handling process.

3.4.2 Contents of R&D plans

The most recent program, RD&D-program 2010 covered all necessary activities required for safe management and disposal of all spent fuel and nuclear waste including decommissioning. Next program, RD&D-program 2010, will focus on management and disposal of low- and intermediate level waste, including decommissioning and disposal of decommissioning waste.

RD&D Programme 2010 consists of six parts:

- Part I Overall plan of action
- Part II The LILW Program
- Part III The Nuclear Fuel Program
- Part IV Research for assessment of long-term safety
- Part V Social science research

SKB's plans for the future development of the spent fuel and nuclear waste management program are presented below.

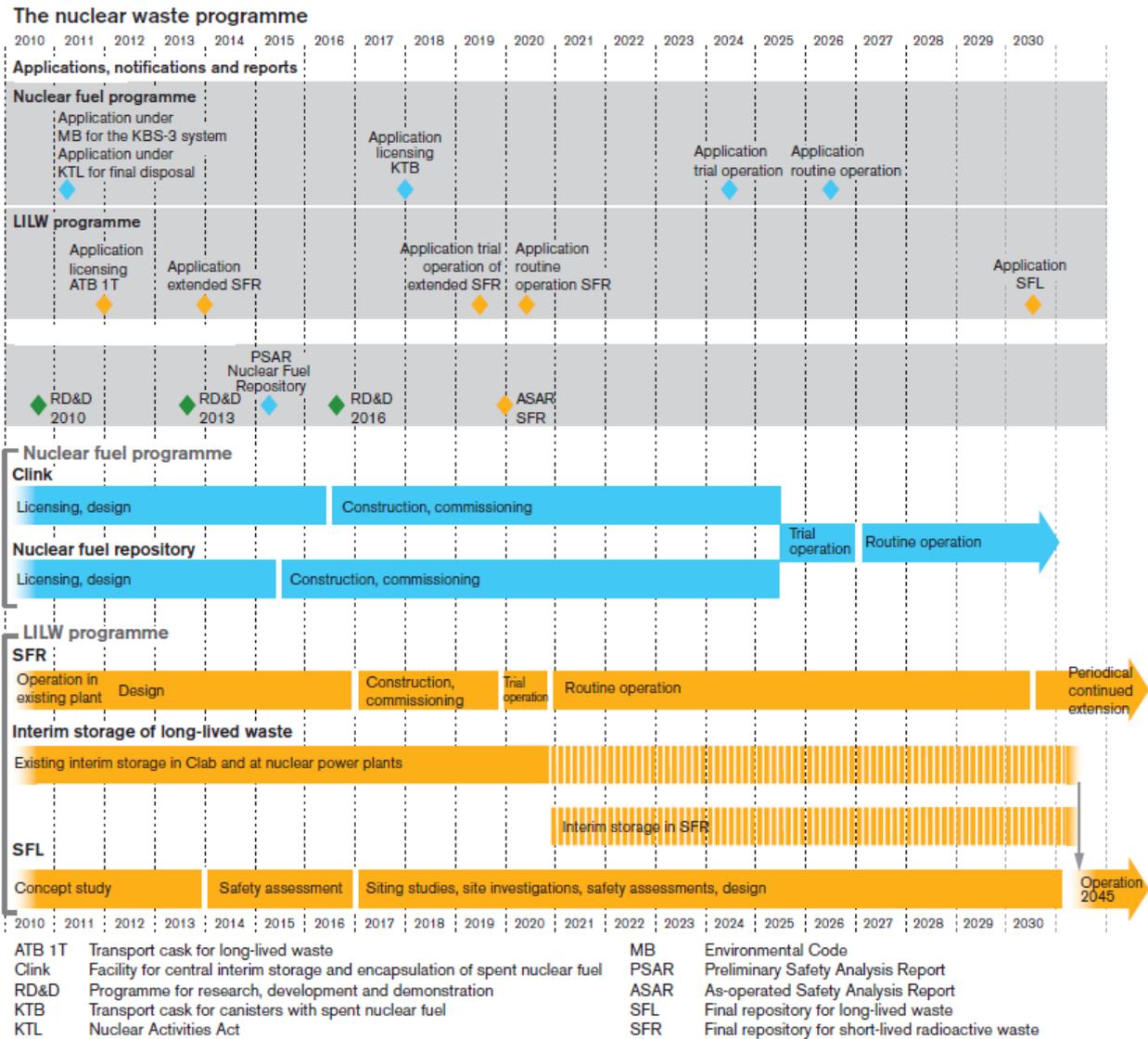


Figure 6: Time overall time schedule (from RD&D-program 2010)

3.5 Financing of Radioactive Waste Management

3.5.1 Framework and responsibilities

3.5.1.1 Legal requirements

The licensee of a nuclear facility which generate or has generated residual products must pay a nuclear waste fee. The fee shall cover the licensee's share of the total costs for management and disposal of all spent fuel and nuclear waste generated from all nuclear facilities. The licensee of a nuclear power reactor must pay a nuclear waste fee. For other licensees there is the possibility to allow exemption to the obligation to pay a nuclear waste fee on the condition that the licensee provides a guarantee to cover its costs.

The review of cost calculations takes place every three years and is coordinated with the periodic review of the R&D-program.

In addition to the obligation to pay a nuclear waste fee, the licensees must also provide guarantees for the costs the fee shall cover but which have not yet been paid. The purpose of the guarantees is to ensure adequate reserves for future financing if funded means should be proven inadequate.

The funded means shall be used for the reimbursements of costs which the nuclear waste fee is meant to cover. If the Nuclear Waste Fund is proven inadequate the guarantees shall be used to cover the costs.

The obligation to pay the nuclear waste fee and provide guarantees will end when the licensee have accomplished its obligations according to the nuclear activities act or been given deliverance from them.

3.5.1.2 Costs for waste from past practices

As of 1989, a special fee has been levied on the nuclear power utilities according to a special law, the Studsvik Act (1988:1597). This fee is intended to cover expenses for the management of nuclear waste from older experimental facilities, in particular the facilities at Studsvik, the Ågesta reactor and the uranium mine in Ranstad, and for dismantling these facilities.

3.5.1.3 Regulatory supervision

The Swedish Radiation Safety Authority reviews the cost estimates submitted by the nuclear industry and suggests the size of fees to be paid to the Nuclear Waste Fund by the NPP utilities. SSM also decides on the reimbursement from the Nuclear Waste Fund.

The Government sets the fees and guarantees for the licensees of nuclear power reactors. The regulatory authority sets fees and guarantees for the licensees of nuclear facilities other than nuclear power reactors.

The Swedish Nuclear Waste Fund administrates and manages the collected fees.

The Swedish National Debt Office administrates and manages the guarantees.

3.5.1.4 Recent development of the financing system

The Parliament decided in 2011 that the period for payment of fees under the Studsvik Act should be extended until at least 2017.

3.5.2 Status of financing schemes

3.5.2.1 Scope of expenses

The sum of the future expenses and of those already accrued on various nuclear waste projects, are estimated to approximately SEK 123 billion (approximately € 14 500 million). The sum of the future expenses from 2012 onwards are estimated to approximately SEK 92 billion (approximately € 10 800 million). The average fee to be paid to the Nuclear Waste Fund by the licensee of a nuclear power reactor is currently SEK 0,022 (equivalent to 0.26 euro cent) per kilowatt-hour energy (2012-2014) based on the assumption that each reactor will generate electricity for 40 years but with a minimum remaining operating time of six years.

To date, the Nuclear Waste Fund has covered the expenses for:

- the central interim storage for spent nuclear fuel (Clab);
- the transport system, i.e., the ships MS Sigyn and MS Sigrid, containers, special trucks, etc;
- the Canister Laboratory, the Äspö Hard Rock Laboratory, the Bentonite Laboratory; and
- SKB's research and development costs, including siting activities.

The Nuclear Waste Fund will eventually cover expenses for:

- encapsulation of spent nuclear fuel;
- disposal facilities for spent nuclear fuel and long-lived low and intermediate level waste;
- dismantling of nuclear power plants and the disposal of decommissioning waste;
- continuing research and development work; and
- expenses for regulatory control and supervision after closure of the reactors.

The disposal facility for radioactive operational waste (SFR-1) has been paid for by the nuclear power utilities and not by the Fund. Costs for management of operational waste are paid for directly by the nuclear power utilities.

3.5.2.2 Costs for waste from past practices

According to estimates, SEK 1.7 billion (approximately € 200 million) will be needed up to the year 2030 to meet these expenses. The special fee is the same for all four nuclear power utilities, currently SEK 0.003 (equivalent to 0.035 euro cent) per kilowatt-hour, which has been reassessed on a yearly basis. These assets are administered together with the Nuclear Waste Fund.

3.5.2.3 Management of funds

The fees are collected in a fund, the Nuclear Waste Fund. The Nuclear Waste Fund is an external and fully ringed-fenced governmentally controlled and administered fund. The funds are managed through a suitable combination of deposits in accounts at the National Debt Office or in nominal and real interest rate government bonds on the regular domestic market.

3.5.2.4 Reimbursements to licensees

The licensees are entitled to reimbursement, on a continuous basis, for expenses which they have already incurred for measures to achieve 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. The financial resources should only be used for the purpose they have been established and managed.

3.5.2.5 Reimbursements to municipalities

Municipalities that might host a spent nuclear fuel or nuclear waste facility, including a disposal facility, are reimbursed for their information to the public. Currently the municipalities of Östhammar and Oskarshamn are receiving reimbursements from the Nuclear Waste Fund.

3.5.2.6 Reimbursements to non-profit-making organisations

Since 2005, non-profit-making organisations may apply for financing from the Nuclear Waste Fund to make it possible for them to participate in the consultation process during the Environmental Impact Assessment process.

3.5.2.7 Regulatory supervision

The Swedish Radiation Safety Authority reviews the cost estimates submitted by the nuclear industry. SSM sets fees and guarantees for the licensees of nuclear facilities other than nuclear power reactors. SSM also decides on the reimbursement of funds to the nuclear licensees, the municipalities and the non-profit organisations. However, certain minor amounts are decided by the Government. Furthermore, SSM is responsible to control that the nuclear utilities has made the payments to the Fund and also to audit the disbursements.

The Swedish Nuclear Waste Fund administrates and manages the collected fees.

The Swedish National Debt Office administrates and manages the guarantees.

4. DECOMMISSIONING STRATEGY AND CURRENT PRACTICE

4.1 Decommissioning strategy

A working group consisting of representatives from SKB and the power companies has developed strategies for decommissioning and dismantling of the nuclear power plants.

The main strategy is to start dismantling a plant as soon as it has been taken out of service. In this way a long period of shutdown operation is avoided. The power companies' common goal for decommissioning of the nuclear power plants is that the site should be used for future energy production after decommissioning, since there is extensive and valuable infrastructure there including power lines, roads, harbours, cooling water channels etc. Certain buildings will also be able to be used after being released for unrestricted use.

The dismantling process is begun about two years after the unit has been shut down. With a decommissioning period of about five years, a unit can be expected to be released for other use about seven years after shutdown.

Decommissioning waste can not be disposed of until a SFR has been extended and re-licensed for short-lived low- and intermediate-level decommissioning waste from decommissioning, which is expected in 2023. The main strategy can thus not be applied to the Barsebäck plant.

4.2 Status of decommissioning projects

Barsebäck nuclear power plant

The two BWR units in Barsebäck were permanently shut down 1999 and 2005, respectively. The facility has been prepared for a period of care and maintenance awaiting dismantling (off-site shipment of fuel, downsizing of organization, adjustment of supervision and maintenance, energy saving measures etc). Primary system decontamination of both units was performed during the winter 2007/08. Processing of the wastes from operation and decontamination is proceeding. Dismantling of internal parts is planned to start

2015. Comprehensive dismantling activities are planned to commence 2022, pending the extension and relicensing of the existing SFR facility to accommodate also decommissioning waste.

Studsvik material test reactors

The two material test reactors in Studsvik (one tank type and one mobile pool type) were permanently shut down in 2005. Preparations for dismantling of the reactors are ongoing. Decontamination of two test loops was performed early 2008. Dismantling of the reactors is planned to start 2013 and to be completed by 2017. Radioactive waste will be treated and stored on site awaiting disposal.

Ågesta PHWR

The pressurized heavy water reactor in Ågesta was permanently shut down 1974. A license according to the Environmental Code for continued care and maintenance until 2020 was issued by the local environmental court in November 2008.

Old installations in Studsvik

Decommissioning of minor nuclear installations in Studsvik is being performed by the licensee AB SVAFO. The projects are more or less completed for two of the facilities. Dismantling of two old underground silos for liquid intermediate level waste is proceeding.

4.3 Decommissioning issues at national level

See 3.3.

4.4 Research and development

4.4.1 *Research Infrastructure*

See 3.4

4.4.2 *Contents of R&D plans*

See 3.4

4.5 Financing

4.5.1 *Framework and responsibilities*

See 3.5.1

4.5.2 *Status of financing schemes*

See 3.5.2

ACRONYMS AND ABBREVIATIONS

SSM Swedish Radiation Safety Authority

SKB	Swedish Nuclear Fuel and Waste Management Co
RD&D	Research and development program
Clab	Central Interim Storage Facility for Spent Nuclear Fuel
SFK	Disposal facility for spent nuclear fuel
SFL	Disposal facility for long-lived low- and intermediate level waste
SFR	Disposal facility for short-lived low- and intermediate level waste